Facial Plastic and Reconstructive Surgery

A Comprehensive Study Guide

Brian J.-F. Wong
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Editors

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Illustrated by Bryan Lemieux
and Aaron Lemieux

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Introduction

This review book was undertaken as a project designed to address a need in the specialty of Facial Plastic and Reconstructive Surgery. There are many wonderful textbooks available in print and hard copy that are exhaustive and detailed on all aspects of this specialty. However, as a resource for review and a guide for study, we found no comprehensive text. In North America and now globally, certifying board examinations in the specialty of Facial Plastic and Reconstructive Surgery are gaining broad acceptance as a metric of certification, professional excellence, and achievement. Hence, an aim of this book is to aid those who wish to pursue these standardized examinations.

Admittedly, part of our motivation was selfish. Each of us will have to take Maintenance of Certification Examinations in the near future, and we recognized a need for a concise study guidebook for Facial Plastic and Reconstructive Surgery. A study guide is softcover and something that lives in your backpack. It is designed to be annotated with notes and scribbled on. It needs to be light and easily carried. And there is something ethereal about paper that remains transcendent at least for the current rising generation of Facial Plastic Surgeons. Otolaryngology—Head and Neck Surgery has such guides with K.J. Lee's Essential Otolaryngology or Reza Pasha's Clinical Reference Guide serving as excellent examples. Hence, we felt there was a need and thus addressed it. Our approach toward developing this review book and study guide is rather novel, and we took our inspiration from "crowdsourcing" and reached out to others for content. Naturally, we focused on those who had a vested interest in producing a practical review book, the actually examinees. For the most part, with this first edition, we identified fellows in training, who would soon take a board certification examination in Facial Plastic and Reconstructive Surgery, and asked them to write the chapters. These are individuals who, at this point in their careers, are focused and most directed at understanding the subtlety as well as esoterica that permeates this field. We feel this multitude of voices and perspectives, though it does lend to some variability in content and organization, provides a richer, more constructive and informed read.

This is the first edition, and with the support of our managing editors at Springer, the first of what we hope to be many yearly revisions. As such, each chapter was written de novo, and each author had a unique view with respect to identifying, structuring, and presenting material pertinent for the advanced reader. This was not designed as a textbook or introductory volume for beginners. Significant base knowledge and understanding is critical and important. This book was conceived as concise resource that would allow someone to review quickly relevant information in this specialty.

Each year, we will recruit a new set of authors, who will edit and revise each and every chapter. Over time, this iterative approach hopefully will result in an exhaustive and succinct survey of the specialty, and evolve into the ideal preparatory text for the various board examinations in North America and abroad. While we feel it will take one or two more iterations before this edition hits its stride, we believe we have a solid foundation. To that end, in this inaugural edition, we are very fortunate to have as contributing authors three AAFPRS Anderson Prize winners, and their chapters are elegantly written, concise, and to the point.

This project has been our labor of love and the product of thousands of emails, innumerable late night phone calls, and brainstorming sessions. We also worked closely with two artists who illustrated this book and generated over 90 % of the original artwork contained herein. Brian and Aaron Lemieux are identical twin brothers, and in addition to being first-rate medical illustrators, they also happen to be brilliant medical students. We feel this is yet another reason why our book stands apart.

We believe this review book to be living body of work, as each year it will be updated and reviewed by a new set of 15–20 surgeons pursuing advanced training in Facial Plastic and Reconstructive Surgery. We are grateful and appreciative of the efforts of Daniel Dominguez and Rebecca Amos at Springer, who have shepherded us through this process and provided guidance along every step of the way.

Lastly, we dedicate this book to our spouses and our mentors.

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Part I

Basic Principles, Perioperative Management, and Miscellaneous Topics

1 Analgesia and Conscious Sedation

Christian P. Conderman

Sedation and Analgesia

- **Sedation is a Continuum** of states from minimal sedation (anxiolysis) to general anesthesia; depth of sedation can be fluid and a patient's clinical status can quickly go from a state of lighter to deeper sedation and vice versa; sedative-analgesics can be given in combination with local and regional anesthesia for greater effect and a reduction in the overall amount of sedative-analgesic medication that may be necessary.
- **Purpose**: (1) allows patients to tolerate unpleasant procedures by relieving anxiety, discomfort, or pain (2) may expedite conduct of procedures in children and uncooperative adults that are not particularly uncomfortable, but that require the patient not to move.
- Sedation can never compensate for an inadequate local anesthetic block; if the regional or local block is deemed inadequate it should be repeated prior to administration of further sedative-analgesic medication.
- Sedation practices may result in **cardiac or respiratory depression** resulting in hypoxemia and must be appropriately recognized and treated to avoid the risk of hypoxic brain injury, cardiac arrest, and/or death.
- **Primary causes of morbidity** associated with sedation-analgesia are drug-induced respiratory depression and airway obstruction.
- Sedatives and analgesics tend to **impair airway reflexes in proportion to the degree** of sedation-analgesia achieved.
- Practitioners must be able to "**rescue**" patient from a deeper state of sedation than anticipated, i.e., for moderate sedation may include managing a compromised airway or hypoventilation and for deep sedation may include need to manage respiratory or cardiovascular instability with appropriate medications or interventions.
- Four variables are used to define the level of sedation: (1) level of responsiveness, (2) airway function, (3) spontaneous ventilation, and (4) cardiovascular function (Fig. 1.1).
- Reflexive withdrawal from stimulus is **not a purposeful response** and indicates a state of **deep sedation or general anesthesia.**

Minimal Sedation—drug-induced state facilitating performance of a procedure that maintains normal responsiveness and doesn't impair airway, ventilation, or cardiovascular function. Cognition and coordination may be impaired. For example, single oral sedative or analgesic or application of <50 % nitrous oxide with no other sedative or analgesic.

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Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia

	Minimal Sedation (Anxiolysis)	Moderate Sedation/Analgesia (Conscious Sedation)	Deep Sedation/Analgesia	General Anesthesia
Responsiveness	Normal Response to Verbal Stimulation	Purposeful Response to Verbal or Tactile Stimulation	Purposeful Response after Repeated or Painful Stimulation	Unarousable, even with Painful Stimulus
Airway	Unaffected	No Intervention Required	Intervention may be Required	Intervention often Required
Spontaneous Ventilation	Unaffected	Adequate	May be Inadequate	Frequently Inadequate
Cardiovascular Function	Unaffected	Usually Maintained	Usually Maintained	May be Impaired

Fig. 1.1 Depth of sedation from minimal to a state of general anesthesia is dependent on four variables (figure taken from ASA practice guidelines for sedation/analgesia by non-anesthesiologists). Used with permission

ASA Physical Status Classification

ASA PS Classification	Definition	Examples including, but not limited to:
ASA I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use
ASA II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 < BM < 40), well-controlled DM/HTN, mild lung disease
ASA III	A patient with severe systemic disease	Substantive functional limitations; One or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI^{3}40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.
ASA IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to): reptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes	

Fig. 1.2 ASA guidelines. Used with permission

Moderate (Conscious) Sedation—depressed state of consciousness with patients remaining purposefully responsive to verbal commands alone or accompanied by light tactile stimulation. **No intervention required to maintain a patent airway.** Ventilation and cardiovascular (CV) function adequate/maintained.

- Example of moderate sedation regimen: initial IV doses of 2 mg versed and 50 mcg fentanyl with titration doses of 0.5–1 mg for versed (up to 1 mg/kg) and incremental doses of 25 mcg of fentanyl until suitable level of sedation is reached.

Deep Sedation—Depressed state of consciousness during which patients not easily aroused, even by (repeated) painful stimulation**.** Purposeful response may be elicited with repeated or painful stimulation, however. **Ability to maintain ventilatory function and a patent airway may be impaired.** CV function usually maintained.

General Anesthesia—state in which patients are not arousable, even by painful stimulation. Ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and **positive pressure ventilation may be required** because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. **Cardiovascular** (**CV**) **function may be impaired**.

ASA Classification Chart

The ASA (American Society of Anesthesiologists) guidelines are used to measure a patient's overall health and tolerance for procedures (Fig. 1.2). In general, patients with more severe systemic disease (III and higher) should have a preoperative anesthesia evaluation. Consideration should be given to performing the procedure under general anesthesia as they may be at higher risk of complication(s) during sedation.

Summary of Task Force Recommendations for Sedation-Analgesia by Non-anesthesiologists

Patient Evaluation—pre-procedure H&P increases likelihood of satisfactory sedation and decreases likelihood of adverse outcomes; components of H&P assessment of major organ system abnormalities, previous adverse experiences with sedation-analgesia, allergies, current meds and potential drug interactions, time and nature of last oral intake (see table below), history of tobacco, alcohol, or substance abuse. Exam should include vital signs (VS), auscultation of heart and lungs, and evaluation of airway, head, and neck (see below).

Assessment of Airway—Anatomic features related to difficult tracheal intubation predisposed to upper airway obstruction: Hx of previous difficult intubation, stridor, snoring or sleep apnea, advanced rheumatoid arthritis or cervical abnormality, chromosomal and other developmental abnormalities; **OSA and obesity increase the risk of airway obstruction during sedation.**

- **Exam findings portending difficult airway**: significant obesity, short neck, limited neck extension, decreased hyoid-mental distance (<3 cm in adults), neck masses, cervical spine disease, tracheal deviation, facial dysmorphia
- Oral evaluation: small opening/trismus, edentulous, protruding incisors, loose or capped teeth, dental appliances, high-arched palate, macroglossia, tonsillar hypertrophy, non-visible uvula (**Mallampati classification**), micrognathia, retrognathia, malocclusion.
- In general, obstruction of the airway during sedation is the result of lost muscle tone, especially at the level of the velopharynx; sedation produces loss of wakefulness and cortical influence on the maintenance of airway tone; sedatives can also preferentially depress airway neuromuscular function.

Airway Management—Acute airway obstruction or excessive ventilatory depression mandates emergent management—(1) determination that airway obstruction or ventilatory depression exists: presence of hypoventilation, significant decrease in SpO_2, or lack of patient responsiveness (2) use of verbal and tactile stimuli to prompt patient to breathe and reassess degree of airway obstruction or ventilatory depression (3) if obstruction or ventilatory depression is present, give supplemental O_2, give further verbal and tactile prompting to breathe, jaw-thrust, manual bag mask ventilation, pharmacologic antagonists, calling for help (4) readily available equipment (see below), seal btw mask and face, gently ventilate, and insert oral airway.

Pre-procedure Preparation—Labwork should be guided by a patient's medical condition and should only be considered if results would affect management of sedation-analgesia; counsel and consent patient before moderate/deep sedation; fasting decreases risks during sedation (see below) (Fig. 1.3). In emergency situations (fasting not practical)—consider potential for pulmonary aspiration to determine target level of sedation (less sedated) and consider delaying procedure or protecting trachea with intubation.

Monitoring—Appropriate and effective monitoring is key to safe sedation and monitoring based on four physiologic variables used to define the level of sedation. Parameters below should be recorded during sedation **at minimum** (1) before beginning the procedure, (2) after administration of sedative-analgesic, (3) regular intervals during procedure (q 5 min once stable), (4) during initial recovery, and (5) immediately

Fasting Protocols for Sedation and Analgesia for Elective Procedures

	Solids and Nonclear Liquids*	Clear Liquids
Adults	6-8 hours or NPO after midnight	2-3 hours
Children older than 36 months	6-8 hours	2-3 hours
Children aged 6-36 months	6 hours	2-3 hours
Children younger than 6 months	4-6 hours	2 hours

* Includes Milk, formula, and breast milk (high fat content may delay gastric emptying)

Fig. 1.3 Fasting guidelines for sedation/analgesia in the ambulatory setting (From Sedation and Analgesia in Ambulatory Settings). Used with permission

prior to discharge. Importance of respiratory function highlighted by the fact that two of the four characteristics used to define sedation are respiratory in nature and experts agree that **ventilation and oxygenation** are related, albeit different processes, and **should be monitored separately.**

- **Level of responsiveness**: A patient's response serves as a guide to their level of consciousness and should be routine during all procedures. Many published scales exist and most rely on two variables—a stimulus (e.g., verbal or painful stimulation) and the patient's response to determine the level of sedation. Patients who can communicate verbally likely have an adequate airway and sufficient ventilatory drive. A thumbs-up or similar nonverbal communication can be used in lieu of a verbal response when not feasible (e.g., upper endoscopy) and indicates moderate sedation. Reflex withdrawal indicates deep sedation or general anesthesia.
- **Pulmonary ventilation**: Observation of ventilatory function (removal of CO_2) by auscultation or observation (i.e., watching chest rise) reduces the risk of adverse outcomes and is a means to monitor respiratory rate. This should be continually monitored and $ETCO_2$ monitoring should be considered in all patients undergoing deep sedation and those who cannot be monitored directly during moderate sedation; respiratory disturbances detected by capnography were found to **precede hypoxemia** and serve as an early warning for impending ventilatory compromise.
- **Oxygenation**: Pulse oximetry should be used to monitor **all patients** undergoing sedation-analgesia. Early detection of hypoxemia reduces the risk of adverse events during sedation-analgesia as signs of hypoxemia (e.g., cyanosis, and tachycardia) can be unreliable. SpO_2 in the 80s places a patient's oxyhemoglobin dissociation curve at a tenuous point and further declines can lead to a rapid decline in saturation levels resulting in low and dangerous oxygen levels. Monitoring oxygenation by pulse ox **is not a substitute for monitoring ventilation.**
- **Hemodynamics**: Sedation-analgesia can produce significant autonomic and hemodynamic reflexes or disturbances including hypo- and hypertension, tachy- and bradycardia, arrhythmias, and myocardial ischemia. BP and HR should be recorded prior to initiating a procedure and **VS** should **be monitored at 5-min intervals** once a stable level of sedation is established for both moderate and deep sedation. Electrographic monitoring can be used to detect more than 80 % of ischemia with proper use of modified V5 electrode-chest lead at fifth intercostal space, anterior axillary line. **Continuous EKG** should be provided for **all patients undergoing deep sedation** and those undergoing **moderate sedation with significant comorbidities** (significant CV disease or dysrhythmias) and/or procedures that can evoke autonomic reflexes or hemodynamic disturbances.

Availability of personnel—A designated individual, i.e., other than the practitioner performing the procedure, should be present to monitor the patient throughout procedures performed with sedation-analgesia. During deep sedation, this individual should have no other responsibilities; however during moderate sedation, he/she may assist with minor interruptible tasks once the patient's level of sedation-analgesia and VS has stabilized.

Training of personnel—The individual responsible for monitoring the patient should be trained in recognition of complications associated with analgesia-sedation. As noted above, since sedation is a continuum, practitioners must be able to rescue a patient from a deeper state of sedation than intended, as outlined above. He/she should understand the pharmacology of the agents used as well as the role and indication for antagonists for opioids and benzodiazepines. At least one individual capable of establishing a patent airway and positive pressure ventilation should be present when sedation-analgesia is administered. An individual with **advanced life support skills** should be **immediately available (within 5 min) for moderate and in the procedure room for deep sedation.**

Emergency equipment—Pharmacologic antagonists and other emergency medications (e.g., epinephrine, ephedrine, nitroglycerin, lidocaine), defibrillators, and equipment for establishing an intravenous line and airway (including pediatric endotracheal tubes where appropriate) should be immediately available for all cases of sedation-analgesia.

Supplemental O_2—Supplemental O_2 should be considered for moderate sedation and should be administered **during all cases of deep sedation** to reduce the possibility, frequency, and duration of hypoxemic episodes. Its use has been shown to decrease the magnitude of desaturation and decrease the incidence of ST changes in patient with ischemic heart disease. O_2 at 2–3 L/min or an inspired concentration of approximately 30 % O_2 can help maintain normal oxyhemoglobin saturations even in the presence of significantly reduced minute ventilation. Supplemental O_2 can delay recognition of apnea and hypoxemia is not identical to a state of pulmonary hypoventilation.

Use of Sedative-Analgesics

- **Combination**—Sedatives and analgesics used in combination can provide adequate moderate and deep sedation; however**, combinations may increase likelihood of adverse outcomes, i.e., ventilatory depression and hypoxemia**. Each component should be given to achieve the desired effect, e.g., additional analgesic for pain relief and additional sedative for anxiolysis or reduction in awareness. Respiratory function must be **continually monitored** when given in combination and there should be an appropriate reduction in the dose of each component based on the patient's status.
- **Titration**—Incremental administration improves patient comfort and decreases risks for both moderate and deep sedation, i.e., sedative/analgesic agents should be given in small, incremental doses that are titrated to the desired end point and not given as one-time bolus. When administered via non-intravenous routes, allowance should be made for the time to bioavailability and potential for unpredictable effect (IM). **Repeated doses of PO meds to supplement sedation are not recommended.**
- **Induction agents for sedation-analgesia**—Propofol, methohexital, and ketamine can be used to achieve moderate and deep sedation; however propofol and methohexital can produce a **rapid, profound decrease in LOC and cardiorespiratory function** culminating in a state of general anesthesia. Ketamine, while associated with less cardiorespiratory depression, can still cause laryngospasm, airway obstruction, and pulmonary aspiration. Moreover, because of its dissociative properties, signs of depth of sedation may be obfuscated. When these meds are used for analgesia-sedation, practitioner should care for the patient **as if it were a case of deep sedation** and should be qualified to rescue the patient from general anesthesia.

Intravenous access—When analgesics-sedatives are given intravenously, IV access should be maintained until patient is no longer at risk for CV or respiratory depression (until ready for discharge). In cases where oral sedation is given, the need for access can be determined based on the potential need for additional medication and/or resuscitative drugs. In all cases, an individual with the skills to establish IV access should be immediately available.

Reversal agents—Acute reversal for opioids (**Naloxone** 0.4–2 mg initial dose may be repeated every 2–3 min; 0.1 mg/kg in pediatric pts) and benzodiazepines (**flumazenil** 0.2 mg dose, may repeat ×3; 0.01 mg/kg in pediatric pts with max of 3 mg/h) may result in pain, hypertension, tachycardia, and pulmonary edema. The literature supports the use of these agents to reverse opioid-induced sedation and respiratory depression as well as BZD-induced sedation and ventilatory suppression when given alone or in combination with an opioid. Nonetheless, the task force recommended that **respiratory depression be treated initially with encouragement or stimulation to breathe deeply, supplemental O_2 and, if necessary, positive pressure ventilation by mask**. Reversal agents should be immediately available and may be especially helpful where airway control and positive pressure ventilation are difficult. After reversal, patients need to be monitored to ensure that sedation and cardiorespiratory effects do not recur as **flumazenil and naloxone have shorter half-lives than the opioid and BZD they are meant to antagonize**. Routine reversal of sedative or analgesic medication is discouraged; that is, their use was discouraged to routinely awaken patients from a state of sedation at the conclusion of a procedure.

Recovery/discharge—Patients may continue to be at significant risk of adverse effects following procedures as stimulation is reduced, delayed drug absorption can occur and slow drug elimination may contribute to residual sedation and cardiorespiratory depression. Patients **should not be discharged until** they are **near their baseline LOC and are no longer at increased risk for cardiorespiratory depression. VS should be stable and the patient should be well hydrated prior to discharge. Sufficient time should have elapsed after the last administration of reversal agents (if given) to ensure that the patient is not at risk for re-sedation after the reversal has worn off.** An outpatient should be discharged in the presence of a responsible adult who will accompany them home and stay with him/her until the pt can function independently; written instructions should be provided; if a designated adult is unable to assume responsibilities, arrangements should be made to admit the pt to a hospital or aftercare facility.

Special situations—Patients with severe underlying medical conditions (extremes of age, severe cardiac, renal, pulmonary, hepatic dysfunction, pregnancy, etc.) should be seen by appropriate consultants prior to undergoing moderate or deep sedation. For deep sedation, immediate availability of an individual with postgraduate training in anesthesia will decrease the likelihood of adverse events, and the task force was equivocal in this regard for moderate sedation. An anesthesiologist should be consulted if it is likely that sedation to the point of unresponsiveness is anticipated or in the context of a severely compromised or medically unstable patient (e.g., anticipated difficult airway, severe COPD, CAD, or CHF).

Medications

Basics: Opioid analgesics produce potent, dose-dependent analgesia, but little sedation and sedatives alone do not result in optimal sedation for painful procedures. A synergistic effect exists when using opioids and sedatives in combination that can result in dose-dependent and potentially profound respiratory depression and apnea, and may require a dose reduction in both BZD and opioid when given in combination (although either class of medication can result in hypoventilation when given alone). Moderate-to-severe pain cannot be effectively treated with moderate IV sedation/analgesia and these procedures require general anesthesia if local anesthesia cannot be used. Clinicians who embark upon moderate sedation with the notion that it can provide adequate conditions will inevitably end up with a level of sedation deeper than moderate sedation. Naloxone should be given before flumazenil if significant respiratory depression exists as respiratory depression is more likely due to the opioid's effect.

Opioids/narcotics: Group of naturally occurring, synthetic and semisynthetic medications that act on six opiate receptors (Mu, Kappa, and Sigma most important) in CNS, each having a unique activity profile based on affinity for given receptor and its lipid solubility; Narcotics enhance the effect of other sedatives and reduce the amount of local required.

- **Mu** receptor is responsible for **analgesia** and euphoria, Kappa receptor results in sedation and respiratory depression, and Sigma receptors cause dysphoria.
- **Naloxone**—Opioid antagonist at all six receptors with **plasma half-life that is less than that of morphine**, i.e., narcotic overdose may recur after having been reversed due to shorter length of action of antagonist. Reversal can lead to catecholamine release that may lead to CV compromise in pts with underlying cardiac disease. Similarly, it can precipitate withdrawal Sx in chronic narcotic users.
- Clinical findings associated with opioid use:
  – Nausea—due to increased tone at GI sphincters and decreased peristalsis
  – Hypotension—due to peripheral histamine release
  – Pinpoint pupil—characteristic of narcosis due to stimulation of Edinger–Westphal nucleus
- Can lower seizure threshold in pts with seizure disorders
- Can produce significant respiratory depression in a dose-dependent manner but usually only produce mild hemodynamic depression
- Should be used carefully in pts taking other CNS-depressing meds, i.e., phenothiazines (thorazine, compazine), antihistamines, sedatives, and in combination with other narcotics
- Full agonists (e.g., morphine, fentanyl, demerol) have no ceiling effect to analgesia and this effect continues in a linear fashion until effect or adverse effect is achieved
- **Morphine**: Prototypical narcotic
  – Long-lasting (half-life 2–3 h), slow onset of action (poorly lipid soluble), may cause respiratory depression
- **Demerol (meperidine)**:
  – Greater lipid solubility → hypotension and dysphoria that may be more profound than morphine
  – Respiratory depression equal with equivalent doses
  – **Can interact with MAOi's and SSRIs → serotonin syndrome: seizures, coma, hypertension, and pyrexia**
  – Intramuscular doses may be erratically absorbed
  – Tremors, myoclonus, and seizures can result from accumulation of normeperidine (active metabolite with longer half-life than parent compound that may prolong duration of action); normeperidine seizures are **not responsive to naloxone**
- **Fentanyl**—Most commonly administered opioid with nearly ideal characteristics when used for sedation
  – Highly lipid soluble with immediate onset (and peak effect in 5 min) and short duration when given in small analgesic doses
  – Quickly redistributed through fat and skeletal muscle leading to saturation with repeated doses over 4-h period; poor drug for long-term pain control; increased muscular activity can release medication in recovery room; more potent respiratory depression, less N/V and Hypotension
- **Remifentanil, alfentanil, sufentanil**—opioids related to fentanyl with similar or higher potency
  – Remifentanil is metabolized by a plasma enzyme and accounts for its ultra-short duration of action
  – Along with fentanyl, these compounds do not cause histamine release and may be preferred in pts with CV instability

- **Dilaudid (hydromorphone)**—congener of morphine that is 3–5 times more potent; onset 15–30 min; half-life 2–3 h

Benzodiazepines (BZDS): Class of sedative-hypnotic medications that act on thalamus, hypothalamus, and limbic system via potentiation of inhibitory GABA neuronal activity. This effect is mediated by BZD receptor (linked to GABA receptor) causing conformational change with a resultant increased affinity for GABA. This causes an increased influx of chloride ions and subsequent hyperpolarization of the neuron that leads to an inhibitory response preventing propagation of further action potentials. BZDs have **amnestic, anxiolytic, sedative-hypnotic, anticonvulsant, and muscle-relaxing effects**. In general BZDs have **little or no analgesic** properties. Three parenteral BZDs are available in the USA: midazolam (versed), diazepam (valium) (both valium and versed are more lipophilic than ativan), and lorazepam (ativan), which has a longer onset and overall effect.

- **Hepatic degradation** is the only route of excretion mandating dose reduction in patients with liver dysfunction for these medications; patients with hepatic encephalopathy are at increased risk of exacerbation of their Sx when BZDs are given.
  - Age and degree of liver dysfunction must be considered prior to administration of BZDs and may require reduction in dosage.
- Hypoventilation that may be seen is likely due to depressant effects of BZD on respiratory center in brain and BZDs usually do not cause CV compromise (except in states of deep sedation where peripheral vasodilation may occur, resulting in decreased cardiac output and peripheral resistance causing systemic hypotension).
- All BZDs are highly protein bound in plasma and patients with hypoalbuminemia may have more active form of medication in circulation.
- Diazepam and midazolam are also subject to high degree of first-pass metabolism.
- **Valium (diazepam)**
  - Long half-life (~30 h for parent compound, up to 80 h with metabolites)
  - Undergoes oxidative metabolism in liver via CYP450 and has active metabolites which may prolong medication effect
  - Respiratory depression is a major side effect
  - Generally considered safe during gestation, although its use should be tapered or stopped prior to delivery as neonatal toxicity and withdrawal can be seen in infants
  - Increased volume of distribution in elderly patients as compared to young, healthy adults
  - May cause **phlebitis** at injection site due to preservatives in solution
- **Versed (midazolam)**—sedative of choice for most clinicians in short, ambulatory procedures
  - Water soluble with pH-dependent structure. Relatively short-acting due to high lipophilicity with rapid onset; context-sensitive half-life predicts that 1–2 h is often required for recovery
  - ~5× more potent than valium
  - Potent respiratory effects—depresses airway function with significant increases in airway resistance
  - Produces anterograde amnesia more commonly than valium
  - Should be given in small incremental doses; bolus doses should only be given if intubation and ventilation are anticipated
  - Dose reduction by half should be considered in elderly patients; liver and kidney play roles in excretion with hepatic blood flow being a main determinant of metabolism and excretion
  - Patients receiving concomitant P450 inhibitors (e.g., azoles, phenytoin, diltiazem) and inducers (rifampin) may need dosing modifications
- **Ativan (lorazepam)**—not routinely used in procedures requiring sedation, as it is less lipophilic than versed and valium. This results in a longer onset of action (30–40 min) and

therapeutic concentrations that remain in the CNS for longer periods.
  - Overall duration of action can last for 6–8 h.

Propofol—alkylphenol that is used for induction and maintenance of anesthesia and sedation in minor procedures and sedation in ICU patients

- Possesses sedative, amnestic, and analgesic effects.
- Highly lipophilic with rapid distribution to tissues and CNS and rapid redistribution to blood resulting in a rapid metabolic clearance.
- Exerts its actions through GABA-mediated interactions, specifically at $GABA_A$ receptors:
  - Related but not identical to BZD mechanism of action
- May rapidly produce a state of general anesthesia. Short-acting with more rapid recovery than seen with midazolam and less amnesia at equal sedative doses. Leads to faster recovery times, and less post-op n/v.
- Decreases in cerebral blood flow and cerebral oxygen consumption can also be seen; can cause reduction in BP and decrease in cardiac output without an increase in HR.
  - Concomitant administration of fentanyl can increase hemodynamic effects of propofol and the combination of these two medications should be used with caution in patients with CAD.
- Respiratory depression can be significant and it is accompanied by depression of airway tone and reflexes. Apnea can occur, especially if given as bolus.
- Patient must be monitored as under deep sedation when using propofol; best titrated to effect by administration of continuous IV infusion based on weight-adjusted dose.
- Disadvantages: Cost, narrow-therapeutic window, cardiopulmonary complications, requires presence of specially trained personnel.

Barbiturates—classified by duration of action: ultra-short, short, intermediate, and long acting; primarily provide hypnosis and do not provide analgesia or muscle relaxation. Multiple sites of action in CNS including multiple voltage-regulated ion channels; most prevalent effect on GABA receptors; allosterically enhance binding of BZDs and GABA agonists and inhibit GABA receptor antagonists

- **Thiopental**: ultra-short duration; used in induction of anesthesia
- **Pentobarbital**: short-intermediate; used as sedative-hypnotic and antiepileptic

Ketamine—IV anesthetic, structurally related to phencyclidine and cyclohexamine; produces anesthesia with muscular rigidity and open eyes

- Patients may have purposeful movements unrelated to surgical or noxious stimuli.
- Produces prolonged analgesia, blocks pain signal transmission, and produces anesthesia by blocking sodium channels; causes dissociative state upon emergence that causes patients to hallucinate.
- Dose-related increase in HR and BP through direct stimulation of CNS and sympathetic nervous system (SNS).
- Can cause increases in intraocular pressure.
- **Contraindicated** in patients younger than 3 months of age and in those with histories of airway instability, tracheal abnormalities, active pulmonary disease, CV disease, head injury, central nervous system (CNS) masses, hydrocephalus, porphyria, and thyroid disease and in patients with h/o psychosis.
- Can be associated with high potential for laryngospasm when used during upper endoscopy.

Dexmedetomidine—alpha-2 agonist with similar mechanism to clonidine with much higher selectivity for its receptor.

- Centrally induces sedation, anxiolysis, analgesia, and hypnosis with some anesthetic effects; peripherally, it attenuates the hyperdynamic response and improves hemodynamic stability by attenuating SNS activity, thereby lowering BP and preventing pain-induced hemodynamic fluctuations.

- Spares respiratory drive and decreases need for supplemental O_2.
- Properties lead to less opioid/BZD use intraoperatively and less post-op nausea.
- Can be effective means of sedation-analgesia in facial surgery and may reduce the dosage of opioid and BZD required to achieve sedation and analgesia.
- Stabilizes CV parameters in response to pain; therefore, infiltration of local does not cause wide swings in BP and HR.
- Primary adverse effects are bradycardia and hypotension.

Clonidine—alpha-2 agonist, albeit with less selectivity for its receptor (compared to dexmedetomidine)

- Provides analgesia and sedation while stabilizing hemodynamic parameters.
- Due to its unfavorable pharmacokinetics, it is not routinely used during procedures requiring sedation:
  - Delayed onset of action (30–60 min) when given IV
  - Long-lasting, making intraoperative titration and fine-tuning of sedation difficult
  - Propensity to cause long-term orthostatic hypotension, making it further unsuitable in this setting
- Primary use is an adjunct in rhytidectomy for perioperative blood pressure control.

Total intravenous anesthesia (TIVA)—eliminates paralytics and use of volatile gases using IV agents exclusively for patient sedation. The usual regimen includes deep sedation with propofol and varying amounts of ketamine, midazolam, or fentanyl.

- Should be administered by a provider with postgraduate training in anesthesia due to the use of propofol.

Local Anesthesia

Acts by preventing depolarization of the ionic electrical gradient across the cell membrane of peripheral nervous system, via **reversible blockade of channels which prevents rapid influx of sodium ions which stops propagation of AP** (Fig. 1.4).

- **Amides** (2 "I"s in generic name): amide link more stable, resists changes in pH and temperature, metabolized by hepatic degradation; no plasma metabolism; e.g., lidocaine

	Topical		Infiltrative				
	Concentration	Dose	Concentration	Dose	Onset	Duration	Notes
Epinephrine			1:1000 -1:200,000 (1 mg/mL - 1 mg/200 mL or 1000 mcg/ml - 5 mcg/ml)	10 mcg/kg			
ESTERS							
Cocaine	4-10% (40-100 mg/mL)	3 mg/kg Topical	Not used		Immediate	30-60 mins	
Procaine (Novocaine)			1-2%	14 mg/kg Adults 5 mg/kg Children	2-5 mins	1 hr	
Tetracaine (Pontocaine)	0.5-2.0% (5-20 mg/mL))	1mg/kg Topical	0.10 - 0.25 %	1-1.5 mg/kg Infiltrative	20-30 mins	4-5 hrs	
Benzocaine (Americaine)	20%	200 mg max dose	Not used				
AMIDES							
Lidocaine (Xylocaine)	2-4 % (20-40 mg/mL)		0.5-2.0 %	4-5 mg/kg(without epi) 7 mg/kg (with epi)	7-15 mins	1.5-2 hrs	
Mepivicaine (Carbocaine	Not Effective		1-2%	7 mg/kg			
Prilocaine (Citanest)	Not Effective		1-2 %	7 mg/kg	10-15 mins	1.5-2 hrs	Methemoglobinemia with dose >600 mg
Bupivicaine (Marcaine)	Not Effective		0.25-0.75%	2 mg/kg (without epi) 3 mg/kg (with epi)	30 mins	3 hrs	High degree of cardiotoxicity

Fig. 1.4 Summary of concentration and dosages of common local anesthetic agents (table adapted from Essential Otolaryngology and references tables in Eval of Conscious Sedation in FPS)

(xylocaine), bupivicaine (marcaine), prilocaine (citanest)

- **Esters**: cocaine (broken down by plasma pseudocholinesterase), procaine, tetracaine; ester link is heat labile making esters less stable overall; hydrolyzed by cholinesterases in plasma and liver
- **Advantages**: control of airway, smoother recovery period with better pain control, less stress on CV system, less nausea → early discharge, less cost, less bleeding, awake patient can assist with positioning
- **Disadvantages**: apprehension, not all surgeons equally adept at administering local or regional anesthesia, systemic toxicities of local anesthetics, larger nerves more difficult to block, small risk of permanent nerve damage with intraneural injection, local anesthetics may have decreased potency in acidic (e.g., infected) environment due to configurational changes in anesthetic medication, resuscitation equipment, and personnel should be on hand to manage toxicity

Local anesthetic toxicity and management—Toxicity is dose dependent and is reduced by careful calculation and titration of dosage, co-administration of vasoconstrictant, avoidance of intravascular injection (leads to immediate high blood levels that can cause toxicity with small doses), and BZD premedication for its anticonvulsant effect by elevation of seizure threshold. Absorption varies by mucosal surface and application to the tracheobronchial tree can lead to rapid rises to toxic levels if excessive doses are given. Progression from mild toxicity to death is common to all of the aforementioned agents. Supplemental O_2 should be administered at first sign of toxicity and an IV line is mandatory in all but the most minor procedures and especially if the use of powerful sedative-analgesics such as midazolam and fentanyl is anticipated in addition to local.

- **CNS excitation**—Generally **first** sign of toxicity → agitation, muscle twitching, and hypertension; additional Sx in lower blood levels (1–5 μg/mL of blood lidocaine levels)—lightheadedness, euphoria, tingling of the lips, tinnitus, bitter/metallic taste.
- **Seizures:** When blood levels reach moderate range (8–12 μg/mL), a local anesthetic seizure can occur; this can be preceded by a prodrome of slowed speech, jerky tremors, and hallucinations; seizures should be controlled with BZDs (e.g., 0.1 mg/kg of valium or 1–2 mg of versed to raise seizure threshold); once seizure has developed maintenance of oxygenation is of critical importance and supplemental O_2 should be administered immediately with control of airway → patient may require intubation, ventilation, and vasopressors with persistent seizure.
- **CNS depression**—Occurs with very high blood levels (20–25 μg/mL) and toxic effects on cardiorespiratory system are seen. Somnolence, coma, and bradycardia accompany shallow respirations and respiratory acidosis ensues. This is followed by apnea, hypotension, and cardiovascular collapse and arrest.
  - Treatment should be directed toward maintenance of respiration and circulation with intubation, positive pressure ventilation, and cardiovascular support with vasopressors and fluids to restore circulation.
- **Bupivicaine** in concentrations of 0.75 % (and lower) can produce **prolonged cardiac depression if injected intravenously.**
- True allergies are rare, although esters more commonly act as allergens and cross-reactivity with amides is not described; that is, amides can be given with a hx of allergy to ester anesthetic; oftentimes allergic reaction is to preservative in solution (e.g., methylparaben, or metabisulfite).
- **Prilocaine** has **unique dose-related side effect of causing methemoglobinemia** in doses of 500 mg or more - > Tx: 1–2 mg/kg of IV methylene blue (both application of methylene blue and methemoglobinemia and can cause abnormal Sp02 reading).

Cocaine

- Naturally occurring ester that has both vasoconstrictive and topical anesthetic properties with a narrow therapeutic range.
- Mechanism—blocks norepinephrine reuptake at presynaptic terminal and blocks sodium channels for local anesthetic effect.
- Maximal dose: **3 mg/kg** and the use of more than 200–300 mg should not be necessary (e.g., 200 mg = 5 mL of 4 % solution).
- Metabolized by plasma pseudocholinesterase and should not be used in patients with **pseudocholinesterase deficiency** (dx suspected with prolonged apnea after administration of succinylcholine); patients on physostigmine or neostigmine may be prone to the toxic effects of cocaine as these agents inhibit pseudocholinesterase.
- Contraindicated in patients with h/o cardiac arrhythmias or ischemic myocardial disease, pts with h/o epilepsy or seizures, caution is urged in patients with HTN.
- **Toxicity**—primarily CNS in nature—excitability, followed by HA, N/V, tachycardia with rapid progression to delirium, Cheyne-Stokes respiration (cyclical periods of hyperpnea followed by apnea) and convulsions: Thought to be due to overwhelming sympathetic stimulation of CNS and cardiovascular and respiratory systems. If reaction is severe and therapeutic measures are not instituted rapidly, it can progress to respiratory arrest and death.
  - Hypertension and tachycardia can result prior to CNS excitation as well as sensitizing target organs to the effects of SNS stimulation-vasoconstriction, tachycardia, mydriasis, and elevated body temperature.
  - Cardiac arrhythmias (especially in pts on MAOis and TCAs)—ventricular ectopy (bigeminy is cardinal sign of myocardial hypoxia); antiarrhythmics may be necessary, e.g., lidocaine or propranolol.
- **Tx** = Provides adequate oxygenation, provides supportive measures, i.e., maintenance of patent airway, ventilation, IV administration of appropriate medications.
- Combination of ketamine and cocaine is best avoided as catecholamine release/effect by cocaine can be enhanced with this combination; halothane also sensitizes myocardium to the effects of catecholamines.
- In acute overdose, victim may report confusion, dry throat, and dizziness. Hyperreflexia may be present and tonic–clonic convulsions may occur.
  - Propranolol (Inderal) has been shown to be effective in acute setting of cocaine overdose.

Regional Anesthesia

Knowledge of cervicofacial neural anatomy guides infiltration of anesthetic medications to enhance patient comfort. Blockade of trigeminal and cervical branches achieves desired effect; volume necessary to produce anesthesia is directly proportional to the size of the nerve and larger nerves can take up to 30 min for full anesthetic effect to be seen.

V1—**Supra-orbital** and **supratrochlear** nerves can be blocked by injecting 2 cc at superior orbital rim **using superior orbital notch** as landmark and is done by lateral to medial insertion toward medial eyebrow and ending with ~1 cc over nasal bone (in some cases the lateral/deep branch of the supra-orbital nerve may need to be blocked 1 cm above the superior orbital rim at the ZF suture line in a sub-frontalis plane). **Nasociliary** nerve can be injected with 2 cc injected 2 cm deep to medial brow along medial orbital wall. The **external branch of the anterior ethmoid nerv**e can be blocked at the lower border of the nasal bone **6–10 mm** off the midline (this can reduce painful injections of the nasal tip).

V2—**Maxillary nerve** can be blocked at **foramen rotundum** by pre-auricular approach through sigmoid notch using spinal needle aiming slightly superiorly until the lateral pterygoid plate is reached and redirecting the needle anteriorly and superiorly for ~1.5 cm; 5–10 cc is usually required to block this nerve (paresthesias may be elicited to identify correct location and care must be used to avoid intravascular injection in the infratemporal fossa). **Sphenopalatine ganglion** can be blocked via greater palatine foramen. A 4 cm 27 gauge needle is used and the **midline and buccal edge of second maxillary molar** serve as landmarks with foramen lying half way between these two points; needle is used to locate foramen and is inserted approximately 1.5 cm and 5 cc injected after withdrawal to avoid intravascular injection. **Infraorbital nerve** can be blocked where it exits infraorbital foramen **5–8 mm below infraorbital rim** (at line dropped from medial limbus on primary gaze); foramen opens downward and medial; 1–1.5 cc is usually sufficient for this block. **Zygomatico-temporal** block can be performed along posterolateral orbital rim with foramen approximately 1 cm below the lateral canthal attachment (needle inserted 10–12 mm posterior to ZF suture line aiming toward posterior concave surface of lateral orbital rim). **Zygomatico-facial** nerve emerges through foramen on anterior surface of zygoma with multiple branches and exits on anterolateral surface of malar eminence—can be inserted by injecting dime-sized area lateral to junction of inferior and lateral orbital rims; lower mid-face can be a difficult area to block during laser procedures (unless block done at foramen rotundum) and often requires field block.

V3—**Mandibular division** can be blocked as it exits **foramen ovale** in a similar fashion as the maxillary division at the foramen rotundum; after needle contacts lateral pterygoid plate, reorient needle more posteriorly to a depth of 6 cm where paresthesias are elicited and 5 cc of local anesthetic is injected. **Inferior alveolar nerve** block can be performed by passing 5 cm needle into retromolar tissue using **lingula** as landmark for injection and injecting 5 cc. **Mental nerve** (foramen usually below **apex of second pre-molar**: can lie 6–10 mm in either anterior or posterior direction) block is done by injecting 2 cc through mandibular gingivo-buccal sulcus between first and second pre-molars (in some cases, e.g., chin augmentation, additional sensation of chin below mentolabial sulcus may need to be anesthetized by injecting additional local to block contribution from nerve to mylohyoid sensory branch or in some cases the lower branch of the mental nerve). Mental nerve is 2.6–2.8 cm from midline and ~1 cm above inferior mandibular border.

Cervical plexus: Superficial branches (lesser occipital, great auricular, supraclavicular, and transverse cervical nerves) can be blocked at Erb's point 1/3 of the way between mastoid tip and sternoclavicular joint; ~10 cc injected 3 cm deep to skin at this point will suffice; great auricular nerve (C2/3) can be blocked 6.5 cm down from lower EAC on line drawn delineating mid-SCM.

Special Situations

Sedation/Analgesia in Pediatric Patients

- If IV sedation is used in pediatric procedures, the provider(s) must be prepared for poor patient tolerance as children often become restless and combative during standard IV sedation regimens.
- Similar to adult procedures, hypoxemia, presumably due to oversedation, was identified as the most common complication.
- Deeper levels of sedation are associated with a child that may be unconscious, is unable to cooperate, and has its protective reflexes blunted; increased risks of sedation and prolonged recovery room stays are significantly correlated with deeper levels of sedation; can be difficult to distinguish between under- and oversedation in an agitated child. Similar to adult ASA criteria, it is generally felt that ASA class 1 and 2 patients may safely undergo moderate sedation, those in class 3 need further evaluation, and those in class 4–5 may be better served by general anesthesia.
- Standard IV sedation with fentanyl and midazolam is safe and efficacious; however there is reported incidence of 20 % of patients with at least one side effect of sedation including bradycardia, agitation, skin rxn, vomiting, and hypoxemia.
- Diazepam metabolism is slower in infants compared to school-aged children; fentanyl

is variably metabolized in the liver and may not be an ideal sedative for infants as it has been associated with significant apneas in infants <3 months.

- Current standard of care for monitoring patients undergoing pediatric procedures is continuous pulse oximetry and visual assessment of the patient; additionally, ventilatory monitoring should be done continuously by a nurse dedicated to monitoring the child.

Malignant Hyperthermia (MH)

- **Autosomal dominant** transmission most commonly due to abnormality of **ryanodine receptor** (although other mutations exist) resulting in **abnormal calcium metabolism** triggered by a sensitivity to volatile anesthetics (halothane [most potent], enflurane, isoflurane, sevoflurane, desflurane) and depolarizing paralytic agent, succinylcholine. When used in combination, they can result in explosive onset of MH. These agents cause a perturbation of the skeletal muscle membrane resulting in skeletal muscle hypermetabolism, with prolonged contraction and state of O_2 consumption, and release of lactic acid, CO_2, phosphate, and heat. Anaerobic metabolism follows and the plasma membrane begins leaking intracellular ions and myoglobin with a subsequent rise in serum potassium and myoglobinuria.
- Signs of MH include tachycardia and tachypnea, increased $ETCO_2$, hyperkalemia, muscle rigidity and eventual rhabdomyolysis, acidosis, elevated body temperature (**may NOT be immediate**), and masseter rigidity/spasm (may be more pronounced in children) which may serve as an initial warning sign.
- MH-susceptible individuals (those with a first-degree relative with a h/o MH) can be tested via genetic testing or in vitro muscle biopsy (**caffeine halothane contracture test**).
- Local anesthetics, opiates, and non-depolarizing paralytic agents **do not trigger** MH.
- If MH-susceptible individual proceeds with procedure, preoperative precautions must be performed including washing out anesthetic machine (with high-flow oxygen and/or use of charcoal filters) as large amounts of volatile gases can remain in reservoirs of such machines.
- Tx: **Dantrolene should be given immediately** (acts to stabilize ryanodine receptor and reduce efflux of Ca^{2+} from sarcoplasmic reticulum, 2.5 mg/kg as rapid bolus through large-bore IV line repeating at 5-min intervals until signs of acute episode are reversed; once patient has been stabilized [usually following transfer] infusion at 10 mg/kg/day should be given for at least 24 h after initial successful tx). Transfer to an ICU (if procedure is being performed at an outpatient facility) should be instituted immediately. Additional measures that should be implemented immediately are **cooling of body temperature, correction of electrolyte imbalances, and immediate cessation of all volatile gases.**

Operating Room Fires

- Cutaneous facial surgery is second most commonly affected site (tonsil #1) for occurrence of OR fires. Additional high-risk procedures include airway procedures and laser procedures of the head and neck.
- Majority of cases occurred while supplemental oxygen was being used, and buildup of oxygen beneath a drape was cited as a reason for the fire in cases of cutaneous surgery.
- Requires vigilance to prevent the fire triad of ignition: **ignition source** (electrocautery, lasers, fiber-optic light cables), **fuel** (ETT, drapes, towels, sponges, pt's hair or skin, alcohol-based solutions), and **oxidizer** (oxygen or nitrous oxide).
- Provision of O_2 via nasopharyngeal tube may reduce the local concentration of O_2 in the environment, thereby reducing the risk of fire; cautery should be performed at least 5 cm away from supplemental oxygen source.

- Selective use of supplemental O_2 can limit the risk, as can the use of the lowest possible inspired O_2, waiting a 60-s period prior to use of ignition source if O_2 is given.
- Presence of fire may be heralded by abnormal sound (cracking) or burning odor, flash, or flame.
- **Management of or fire**
  - The presence of a fire should be noted and all team members should be made aware as to the presence of a surgical fire.
  - The flow of all gases should be stopped and the fire should be extinguished as rapidly as possible—initially using water and saline, and smothering the fire.
  - The fuel, such as drapes, tubes, and gauze, should be removed from the patient as rapidly as possible.

    If the fire occurs in the **Airway**, the ET tube should be removed as quickly as possible, the gas should be stopped, remove all flammable and burning materials from the airway, and pour saline into patient's airway to cool tissues and extinguish residual embers.

    Additionally, the tube should be evaluated for possibility of any residual pieces/remnants in the patient's airway and rigid bronchoscopy should be performed to assess tissue damage and remove any residual foreign materials.
  - Following control of the fire, airway support should be provided as quickly as possible with bag-mask ventilation without the use of supplemental oxygen and/or nitrous oxide, if possible.

Questions

1. **What is the first sign of local anesthetic toxicity? How does the toxicity of local anesthetics progress with further increases in plasma levels of lidocaine? What is the treatment of local anesthetic toxicity?**

   The first sign of local anesthetic toxicity is CNS excitation. This can be manifested by psychomotor agitation with muscle twitching that may progress to seizures. Additional early signs/symptoms are lightheadedness, euphoria, tingling of the lips, tinnitus, bitter/metallic taste, and hypertension. As the toxic plasma concentration of local anesthetic rises to higher levels, CNS depression can ensue followed by cardiorespiratory collapse. With the first signs of CNS excitation/toxicity, supplemental oxygen should be given and a benzodiazepine should be administered for its anticonvulsant effects to increase the seizure threshold. Additional measures include supportive care, such as ensuring that an IV is in place, and securing the airway in the case of progression of local anesthetic toxicity.

2. **What is the mechanism of action of cocaine? How is cocaine toxicity managed?**

   Cocaine is an ester local anesthetic that is broken down by plasma pseudocholinesterase. Vasoconstriction results from blockade of norepinephrine reuptake at the presynaptic membrane. Its local anesthetic effect is produced by blockage of sodium channels similar to other local anesthetics.

   Management of cocaine toxicity is primarily supportive. This includes provision of supplemental oxygen, anticonvulsants, antihypertensives, and support of the airway if progression of toxicity ensues.

3. **What causes malignant hyperthermia? What medication should be immediately available if an MH crisis occurs? What other measures should be taken if MH becomes evident?**

   Most commonly, malignant hyperthermia is caused by a ryanodine receptor abnormality that is transmitted in an autosomal dominant fashion. Following exposure to a trigger, usually a volatile anesthetic gas, or depolarizing paralytic, such as succinylcholine, membrane instability in skeletal muscle results. This leads to a rapid release of calcium with muscular hyper-contraction with rapid consumption of available oxygen *leading to a catabolic state with release of CO_2, and lactic acid. As this cascade progresses, muscle fibers are broken down leading to uncontrolled elevation of central body temperature and significant abnormalities of serum electrolytes, most prominently hyperkalemia. Early signs of MH include tachycardia and tachypnea with an increase of expired end-tidal CO_2. Muscular rigidity and elevated body temperatures are generally seen later on in the course of disease progression.*

Dantrolene is the medication of choice if an MH crisis occurs. This medication acts at the ryanodine receptor and acts to stabilize the sarcoplasmic reticulum membrane, thereby limiting further calcium ion egress. Additional measures that should be undertaken if MH becomes evident are institution of cooling measures, correction of electrolyte abnormalities, immediate cessation of volatile gases, or other triggers. Transfer to a facility that has ICU capabilities for continued monitoring of the patient should also be considered.

4. **What are the four levels of sedation? What variables are used to identify the depth of sedation of a patient?**

   Four levels of sedation: minimal sedation/anxiolysis, moderate/conscious, deep, and a state of general anesthesia. The four variables used to define sedation are (1) a patient's responsiveness, (2) airway function, (3) spontaneous ventilation, and (4) cardiovascular status. See also Fig. 1.1.

5. **How are valium and versed different? Which is more potent? Which has a more rapid onset of duration? What other patient factors should be considered when administering these agents?**

   Versed is the more potent of the two benzodiazepines and has a more rapid onset of action. Additionally, valium is metabolized and some of its metabolites have a similar mechanistic effect, thereby prolonging the overall effect of valium as compared to versed, which does not have active metabolites. Age and hepatic status must also be considered when these medications are given as reduction in the dosage is usually advised in patients with advanced age and hepatic dysfunction.

6. **What is the primary cause of morbidity in procedures performed under sedation? How do you manage a patient who has entered a deeper state of sedation than anticipated, i.e., how do you treat a patient who has lost control of his/her airway or becomes cardiovascularly unstable?**

   The primary cause of morbidity in procedures under sedation is drug-induced respiratory depression, often with loss of airway support, usually with loss of muscular tone and protective airway reflexes. If this is unrecognized, this can lead to significant complications including anoxic/hypoxic brain injury.

   A patient who has lost control of his/her airway should receive immediate interventions that aim to reestablish airway support. This includes prompting the patient to breathe or stimulating the patient to do so, supplemental oxygen, chin thrust, bag-mask ventilation, and endotracheal intubation. Cardiovascular support may be administered via *intravenous administration of fluids and or pharmacologic means of blood pressure support,* i.e., *pressors, if necessary. Consideration of rescue medications in the form of pharmacologic antagonists should also be considered under these circumstances.*

7. **A patient presents for reconstruction of a 4 cm cheek defect and receives a combination of versed and fentanyl in addition to local anesthetic. She is no longer responding verbally and only reflexively withdraws from painful stimuli. What does this indicate with regard to the level of sedation and what should be done next for her?**

   Reflexive withdrawal from noxious stimuli indicates at least a level of deep sedation, if not a state of general anesthesia, and requires that the patient be "rescued" from *this level of sedation that may be deeper than anticipated or desired. As noted in the previous question's answer, this includes providing supportive care with administration of supplemental oxygen; chin thrust, bag-masking the patient if necessary, and making preparations to intubate the patient if the airway is deemed at risk. Similarly, if the patient is in a state of general anesthesia, he/she may be at risk for cardiovascular deterioration and appropriate management with medications and or IV fluids should be instituted where appropriate.*

8. **At the time of the preoperative evaluation, how do you determine if a patient is at risk for airway compromise during a procedure performed under conscious sedation?**

   Exam findings portending airway difficulty include short neck, obesity, neck masses, short hyo-mental distance (<3 cm in adult), large tongue (preoperative evaluation should include assessment of Mallampati classification), facial dysmorphia, limited neck extension, cervical spine disease, trismus/limited mouth opening, micro- or retrognathia, and dental problems including loose or capped teeth, and/or protrusive incisors.

   Historical elements that may indicate a patient with a difficult airway include any history of sleep apnea or prior difficult intubation, previous airway procedures/instrumentation, chromosomal or developmental delays, cervical spine disease, or advanced rheumatoid arthritis.

9. **Why is it necessary to give a combination of opioids and sedatives during a procedure? Are there certain risks associated with the use of a combination of these medications?**

   The two medications serve interrelated but different purposes during a procedure performed under sedation. Opioids primarily serve an analgesic role, and have a stronger inhibitory effect on a patient's respiratory drive. Sedatives induce hypnosis and amnesia without significantly blunting the pain response. As a result these medications are given in combination and titrated until a suitable level of sedation is reached. When given in combination however, there is a synergistic effect on the cardiorespiratory system and the risk of complication is increased when given together as compared to when they are given in isolation.

10. **During a procedure performed under sedation, a patient is reversed with naloxone and flumazenil for hypoventilation and hypoxemia. How do the pharmacokinetics of these agents affect the recovery and discharge of such a patient having received antagonist medications?**

    The patient should be watched for a longer period in recovery, as the effect/half-life of the antagonist medications is shorter than those of the opioids and benzodiazepines they are designed to counteract. As a result, a rebound effect with recurrence of sedation may be seen.

11. **A patient receives an injection of local anesthetic with prilocaine. He becomes cyanotic? How would you treat this patient? What is the appropriate dose?**

    Prilocaine can cause methemoglobinemia with doses that exceed 500 mg. This can be treated with 1–2 mg/kg of IV methylene blue.

12. **List the benefits of using dexmedetomidine in combination with other agents to produce sedation during aesthetic facial surgery.**

    Dexmedetomidine is a highly selective alpha-2 agonist. It thereby can induce sedation without reducing a patient's ventilatory drive and without having significant effects on the cardiovascular system. This also reduces the amount of sedative and analgesic that may be required during a case. This further reduces the morbidity of sedation with dexmedetomidine and decreases the likelihood of postoperative nausea/vomiting.

13. A mentoplasty is performed on a patient under sedation. A mental nerve block is performed at the second pre-molar in the gingivolabial sulcus. He continues to be very responsive and reacts to surgical maneuvers and manipulation. What can you do to improve the patient's comfort level? Why is this occurring?

This occurs due to inadequate local anesthesia along the inferior border of the mandible. While the mental nerve provides sensation to a large portion of the lower lip and chin, additional sensory branches may stem from sensory branches of the nerve to mylohyoid, nerves that leave the inferior alveolar nerve prior to entering the mandibular foramen, or inferior branches of the mental nerve. These additional sensory branches can be blocked by injecting additional local anesthetic along the inferior border of the mandible via *an intraoral or transcervical route.*

14. What does the pupil look like when patients have received narcotics? Why does this occur? What does it look like when cocaine is given? Why?

Narcotics—miotic pupil; due to effects at the Edinger-Westphal nucleus

Cocaine—mydriatic pupil due to sympathomimetic effects on iris sphincter muscles

Additional Resources

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Basic Techniques, Surgical Anatomy, and Histology

2

Scott Bevans

Basic Techniques

Wound Healing

Phases of Wound Healing (Pitzer & Patel 2011, Leach 2001) (see Table 2.1)

1. INFLAMMATORY (up to 7 days after injury)
   (a) Endothelial injury starts clotting cascade
   - Exposes: **Collagen**, laminin, and fibronectin
   - Clot: **Platelets** and **fibrin**
   - Releases: **Histamine**, proteases, prostaglandins, serotonin

   (b) **Vasoconstriction** priority (thromboxane A2—lasts 5–10 min)
   (c) **Vasodilation** from histamine, increased vessel permeability (edema) for 48–72 h
   (d) Key cellular response begins:
   - **Granulocytes** arrive within 6 h
   - **Macrophages** dominate by 2–4 days
     – Release TGF-B, FGF, remodeling factors

   (e) End result: **cells ready for proliferation** in wound bed
   (f) Wound strength: **5–10 %** of normal tissue
   (g) To promote optimal healing: use **aseptic technique**, **copiously irrigate** with saline (10–15 psi ideal for cleaning without causing damage/seeding), ±antibiotics (i.e., 50,000 U of bacitracin)
2. PROLIFERATIVE (1–21 days after injury)
   (a) **Re-epithelialization** (1–5 days)
   - Creates protective barrier
   - Begins at **hair follicles/adnexa/sebaceous glands**
   - **Rapid when primarily closed**
     – **Promoted by moist environment**
   - Prolonged (3–5 days) when healing secondarily or over poor vasculature

   (b) **Neovascularization** (3–4 days after injury)
   - **Granulation tissue** produced by activity of macrophages
     – **Scaffold** holding vessels, matrix of nutrients, cells, fibronectin/collagen
   - Present until epithelialization is complete

   (c) Collagen Synthesis
   - **Type III collagen** predominates early → **type I collagen** during maturation (see below)

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Table 2.1 Phases and characteristics of wound healing

Wound healing phases	Time after injury	Key cellular components	Strength
Inflammatory	<7 days	Platelets, granulocytes, macrophages	5–10 %
Proliferative	1 day–3 weeks	Fibroblasts	50 %
Maturation	3 weeks–1 year	Myofibroblasts	80 %

(d) Contracture (1–3 weeks after injury)
  - Mediated by **myofibroblasts**
  - Maximum at 12–15 days after injury, occurs at 0.7 mm/day
  - Worse if left open or inflamed
    – Contraction lessened by skin grafts (still contract by 20 % depending on type of skin graft)

(e) Key cellular components:
  - **Fibroblasts**—migrate to wound bed, direct collage, elastin, GAG formation, differentiate into myofibroblasts

(f) End result: **disorganized collagen, relatively hypertrophied, erythematous scar**

(g) Wound strength: **increases slowly for 2 weeks, linearly for 4 weeks, 50 % of final wound strength (40 % of normal skin) at 6 weeks**

(h) To promote optimal healing: **close primarily** if possible/applicable, optimize nutritional status (collagen cross-linking), **keep wound clean and moist**, use **occlusive/semi-occlusive or silicone dressings**. Mederma (onion extract) showed no visible benefit in humans in RCTs.

3. REMODELING/MATURATION (3 weeks–12 months after injury)

(a) **Collagen remodeling** (continue transition to type I collagen)—increases strength
  - Disarrayed fibers are remodeled, becoming **parallel, organized woven**

(b) Decreased vascularity—resolves erythema

(c) Key cellular components:
  - **Myofibroblasts**—mediate contraction, then die (except in keloids)

(d) End result: **fully contracted, avascular scar**

(e) Wound strength: **80 % of normal skin**

(f) To promote optimal healing**: pressure dressings, massage, sun avoidance**, reducing inflammation (steroid injections into scar only—not surrounding tissue)

Traumatic Wounds (see chapter 2.6 for more detail)

- Evaluation—depth of wound: layers, structures involved determine reconstructive approach
  – **Determine if there is functional or sensory deficit before application of local anesthetic**
  – Facial nerve exploration if the injury is lateral to lateral canthus
  – Parotid duct injury/exploration for lateral cheek
- Tetanus status
  – Booster (**tetanus toxoid**) every 10 years
  – **Contaminated wounds**, deep punctures—tetanus booster within **5 years**
  – Less than two prior doses of toxoid, needs tetanus immunoglobulin
- Post-injury use antibiotics:
  – Immunocompromised
  – Rheumatic heart disease or implants
  – Contaminated wounds (bites)
- Bites
  – Dogs and cats—cover *staphylococci*, *streptococci*, anaerobes, and ***Pasteurella multocida*** species for 5 days (see Table 2.2)
    - Augmentin BID or
    - Clindamycin with Cipro or
    - Bactrim
  – Monkeys—treat with antivirals also
  – Rabies (unprovoked attack, test the animal)

Surgical Techniques

- Infection prevention (aseptic technique) and control (wound cleanliness—see Table 2.3)
- WHO guidelines for antibiotic use:
  – Within 60 min but prior to incision for Ancef, Unasyn, clindamycin
  – Within 120 min but prior to incision for vancomycin and fluoroquinolones
  – Re-dose when surgery exceeds half-life of drug or if significant bleeding
- Place incisions in relaxed skin tension lines (see below)
- Debride necrotic tissue and remove foreign bodies (including unnecessary sutures)
- Atraumatic tissue handling (do not crush)
- Use sharp anatomic dissection of tissue and freshen wound edges
- Obliterate dead space (prevents seroma/hematoma formation)
- Avoid tension on epithelial wound edges
  – **Undermining up to 4 cm** from wound edge can relax tension (more doesn't help)
- Trichophytic incisions
  – Cut between follicles on a bias (so hair grows through the incision)
- Suture choices (see Tables 2.4 and 2.5)
  – Smallest needle and suture caliber that is strong enough to resist deformation
  – Least inflammatory
  – Remove permanent sutures in 5–7 days

Table 2.2 Antibiotic therapy in animal bites

Dog bites—"**Dog**"-mentin
Cats (or **PCN** allergic)—**C**linda & **C**ipro

- Tissue Glue
  – Three layers recommended by most manufacturers
  – Dermabond (Octylcyanocrylate) is strongest among currently available
  – Equally as effective to sutures in lacerations parallel to RSTLs
  – Superior to sutures in lacerations perpendicular to RSTLs
  – Not good for areas of high motion

Table 2.4 Absorbable suture types

Absorbable suture types and characteristics		
Monofilaments:	Absorption	50 % strength
Fast gut Plain gut	10–20 days 30–60 days	5–10 days 15 days
Chromic gut	70–90 days	30 days
Poliglecaprone (Monocryl)	3–4 months	1–2 weeks
Polydioxanone (PDS)	6–8 months	4+ weeks
Braided:		
Polyglactin 910 (Vicryl)	2 months	3 weeks

Table 2.5 Non-absorbable suture types

Non-absorbable suture types and uses
Monofilaments:
• Nylon—skin, vessels • Polypropylene (Prolene)—skin, removable running subcuticular • Stainless steel—cartilage or bone
Braided:
• Nylon or polyester—high tension for long duration (rhytidectomy, otoplasty) • Silk—used for ligating vessels, drains (knots won't slip)

Table 2.3 Surgical wound classification—ACS-NSQIP

Surgical wound classification used by ACS-NSQIP (Ortega 2012)				
Wound class	Class I—clean	Class II—clean contaminated	Class III—contaminated	Class IV—infected/ dirty
Example	Uninfected, incision in skin after surgical prep	Incision in the respiratory, alimentary, or urinary systems	Open or fresh wounds, surgical wound with gross spillage	Old wounds, evidence of infection in wound
Infection rate	1–5 %	3–11 %	8–17 %	12–27 %

- Secondary healing in <**2 cm concave areas** is acceptable (van der Eerden 2008)
- **Dermabrasion at 4–8 weeks after injury** improves scar appearance

Histology

- Normal Skin Histology
  - Layers of the skin (see Fig. 2.1)
  - Collagen—**80–90 % type I collagen**
  - Scalp—thicker stratum corneum
- Blood supply
  - **Choke vessels under the dermis–subdermal plexus**
  - Capillary network under epidermis
- Skin cancer histology
  - Sites of origination
  - BCC—basal cell layer
  - SCC—keratinocytes
  - Melanoma—melanocytes
- Keloid vs, hypertrophic scars
  - **Hypertrophic scars—more type III collagen**
  - Keloids—**increased TGF-B expression**, expand **beyond the boundary** of the original injury, failure of myofibroblast apoptosis

- Fitzpatrick skin types (see Table 2.6)
  - Classification of skin response to UV exposure

Surgical Anatomy

- Embryology (see Table 2.7)
- Facial proportions
  - **Vertically** divided in **1/3s** by:
    Trichion
    Glabella
    Subnasale
    Menton
  - **Horizontally** divided in **1/5s** by:
    Edge of helix
    Lateral canthus
    Medial canthus

Table 2.6 Fitzpatrick scale

I	Always burns	Pale, fair, freckles
II	Usually burns, sometimes tans	Fair
III	May burn, usually tans	Light brown
IV	Rarely burns, always tans	Olive
V	Moderate constitutional pigmentation	Brown
VI	Marked constitutional pigmentation	Black

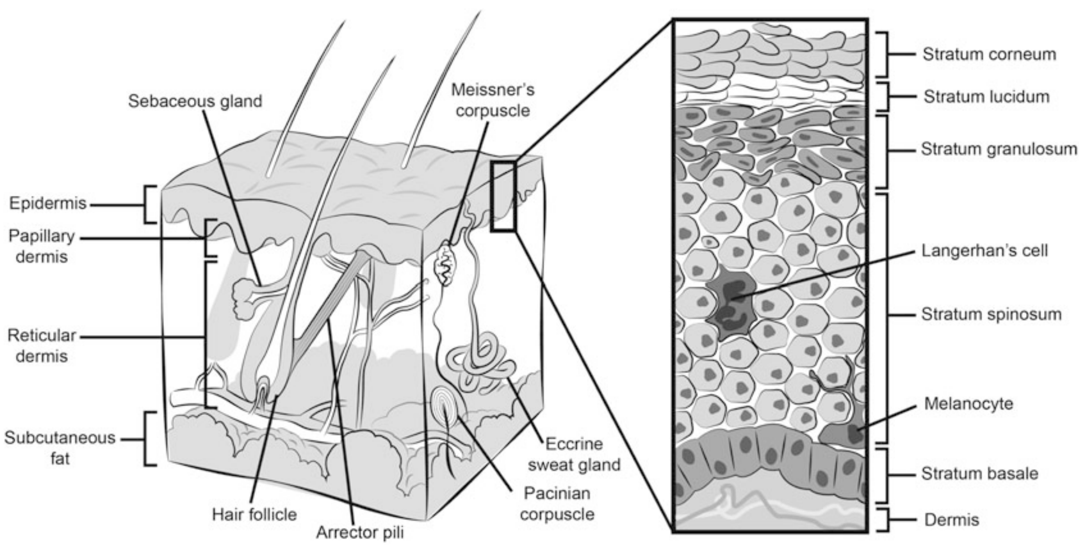


Fig. 2.1 Cross section of skin (*left*) with cellular component of epidermis (*right*)

Table 2.7 Embryologic arches and derivatives

Arch	Connective tissue	Artery	Muscles	Nerves
1st	Maxilla, mandible, zygoma, malleus, incus	Maxillary	Muscles of mastication, mylohyoid, ant digastric, tensor tympani, tensor veli palatini	V3
2nd	Stapes, styloid, hyoid (lesser horn)	Hyoid, stapedial	Facial expression, post digastric, stapedius, stylohyoid	VII
3rd	Hyoid (greater horn)	Common carotid	Stylopharyngeus	IX
4th	Thyroid cartilage	Aortic arch, right subclav	Constrictors, cricothyroid, levator veli palatini	X (superior branch)
6th	Cricoid cartilage	Pulmonary arteries, ductus arteriosus	Intrinsic laryngeal muscles	X (recurrent)

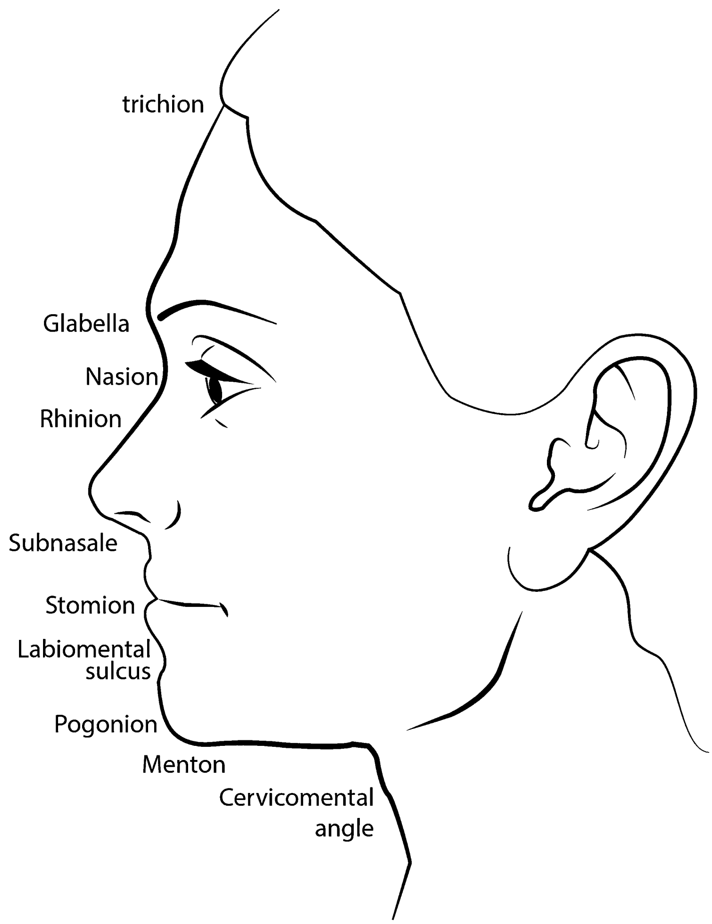


Fig. 2.2 Superficial landmarks (profile view)

- Divine proportions (Golden Rule)
  Φ (Greek letter phi) = 1.618...
  Facial height/facial width
  Facial height (trichion to midpupillary line to menton)
  Several others (controversial)

- Superficial landmarks (see Fig. 2.2)
  - **Skin-retaining ligaments of the face**:
    Mandibular
    Masseteric
    Zygomatic—McGregor's patch

Platysmal-auricular
Obicularis

- Facial skeleton
  - Beams (4)
    Frontal bar
    Infraorbital/Zygomatic process
    Maxillary alveolus
    Mandible
  - Buttresses (4)
    Nasomaxillary
    Zygomaticomaxillary—capable of greatest load bearing
    Pterygomaxillary
    Nasal septum
- Cutaneous innervation (see Fig. 2.3)
  - Anterior ½ from trigeminal nerves
  - Posterior ½ from cervical nerves

- Motor nerves
  - Facial nerve (see Fig. 2.4)
    Main trunk—five ways to identify it (see Table 2.8)
    Extracranial course—deep to posterior belly of digastric
    Pes anserinus—temporofacial and cervicofacial branches
    - Temporofacial—zygomatic and frontal
    - Cervicofacial—buccal, marginal, cervical
  - Motor nerve to masseter
    Subzygomatic triangle
    - Frontal branch, zygoma, TMJ
    - 3 cm anterior to tragus
    - 1 cm inferior to zygomatic arch
    - 1.5 cm deep to SMAS

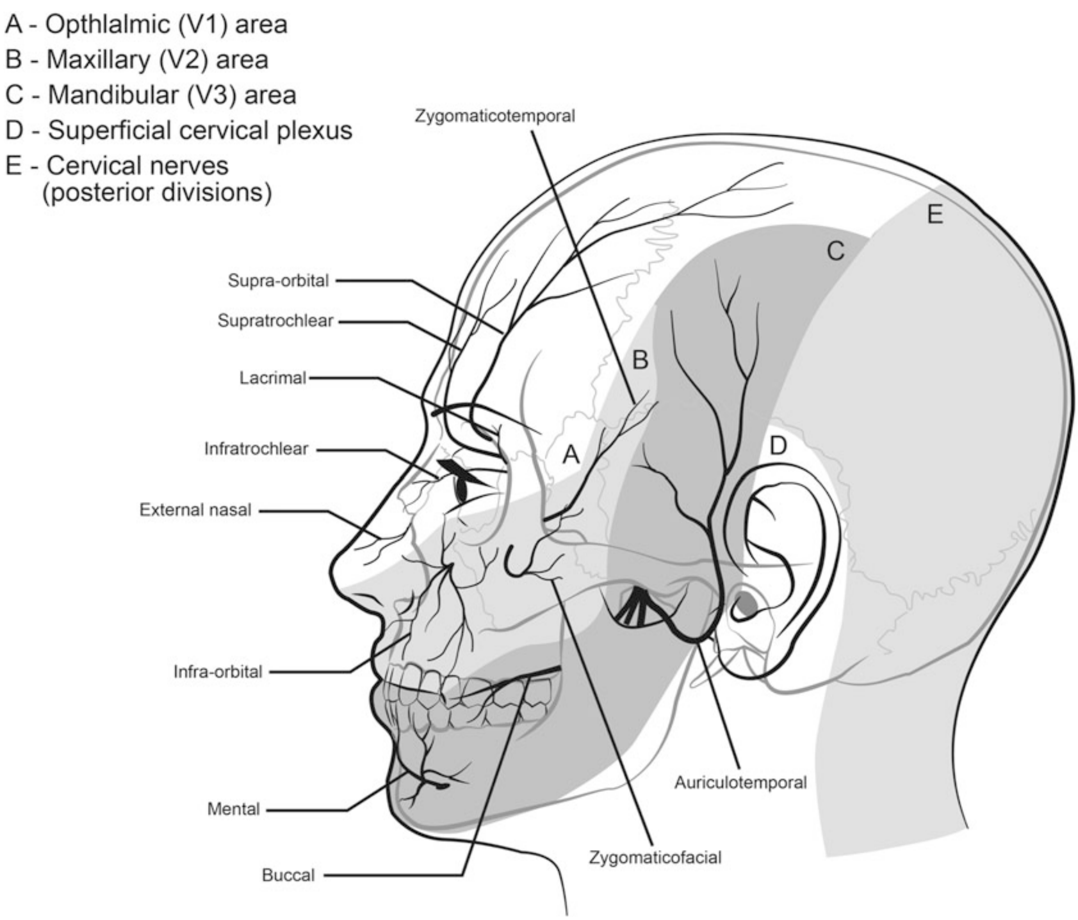


Fig. 2.3 Pattern of cutaneous facial innervation

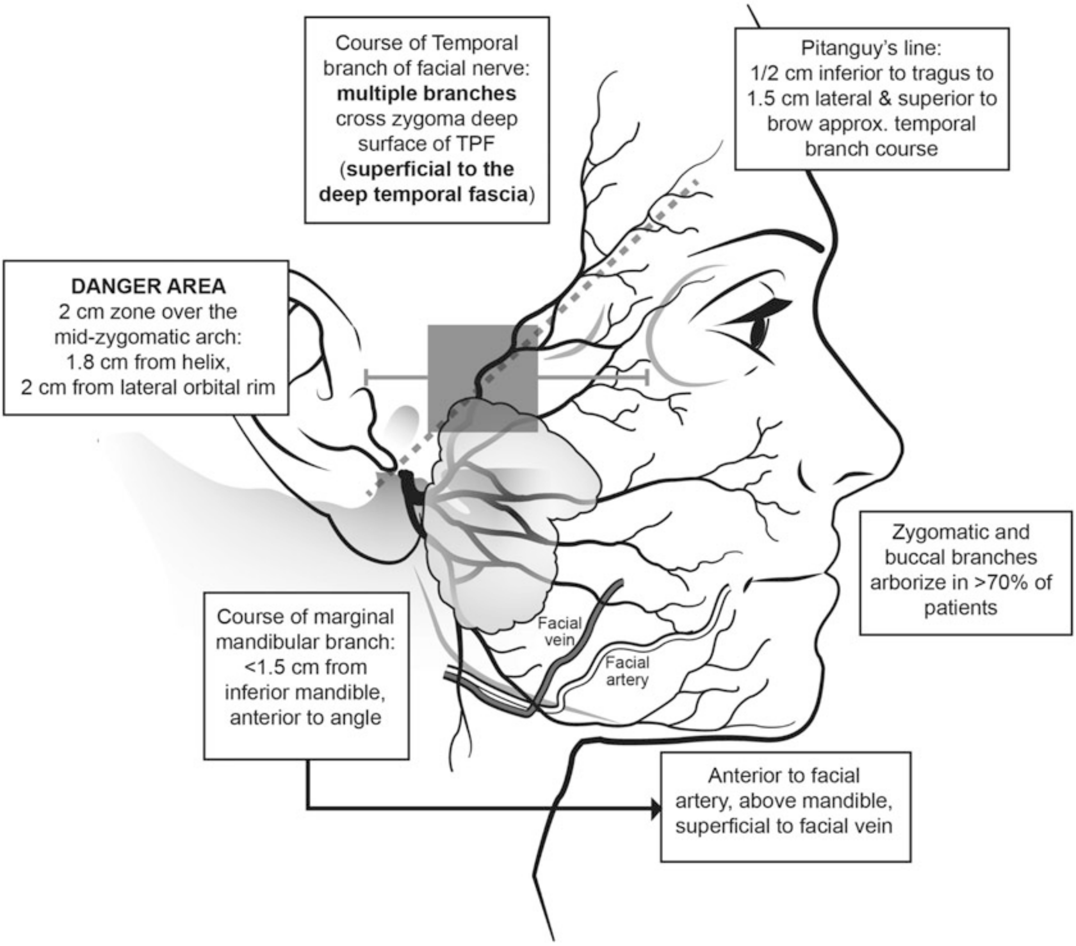


Fig. 2.4 Landmarks to finding the facial nerve

Table 2.8 Methods of finding the facial nerve

Identifying the facial nerve:	
1.	1 cm deep and 1 cm inferior to tragal pointer
2.	Drill vertical portion in the mastoid to the stylomastoid foramen
3.	Peripheral branch, retrograde dissection
4.	Follow the stylomastoid suture line
5.	Deep to posterior belly of digastric muscle attachment to digastric groove

- SMAS
  - Continuous with platysmal
  - Continuous with superficial temporal fascia
  - Invests in nasolabial, peri-ocular, peri-oral musculature
- Scalp
  - Layers—**s**kin, **c**onnective tissue, **a**poneurosis (galeal), **l**oose connective tissue, **p**ericranium

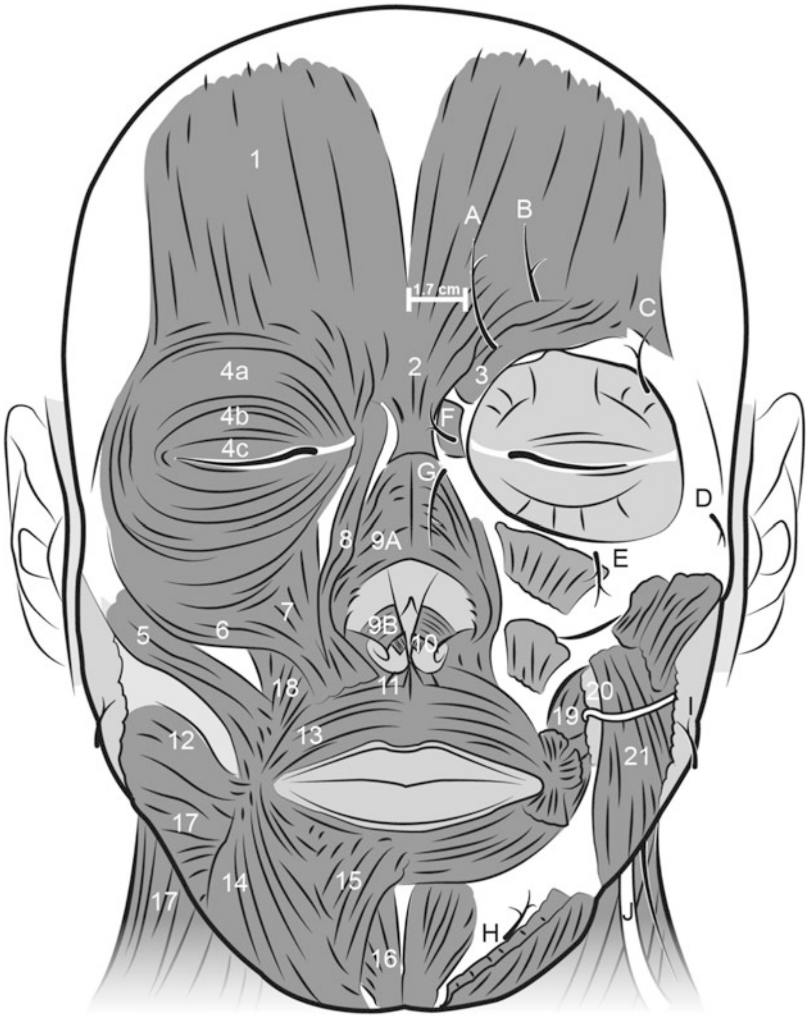
    Galeal aponeurosis invests the frontalis and occipitalis muscles
  - Temporalis fascia

    Superficial layer

    Deep layers—superficial and deep surround temporalis muscle

    Frontal branch of VII runs deep to the superficial layer of deep temporal fascia
- Muscles of facial expression (see diagram below) (see Fig. 2.5)

Fig. 2.5 Muscles of facial expression, facial innervation



- All **innervated from deep** surface **except** "MLB"
  Mentalis
  Levator anguli oris
  Buccinator
- Orbicularis oculi parts:
  Pretarsal } Palpebral
  Preseptal }
  Orbital
- Nasal musculature
  Nasalis dilator—flares lower lateral cartilages
  Nasalis transverse—compresses the nasal wall
  Depressor septi (depresses tip)
  Levator labii superioris alaeque nasi (flares—produces "**gummy smile**"—runs in the alar crease)
  Procerus (elevates tip)
- Ear wigglers:
  Posterior, superior, and anterior auricular muscles

- Rhytides
  - Glabella

Vertical rhytides—**c**orrugator (looks **c**oncerned)
Horizontal rhytides—**p**rocerus (looks **p**issed!)
- Crow's feet—orbicularis oculi
- Nasolabial and melolabial—investment of SMAS fibers to skin, orbicularis oris

- Orbital anatomy (see Table 2.9, Figs. 2.6, 2.7, 2.8, 2.9, and 2.10)
  - Medial wall structures (see Table 2.9)
  - Peak of eyebrow should be at the lateral limbus
  - Tarsal show (Caucasians): 7–8 mm

Table 2.9 Distance to critical structures along the medial orbital wall

Medial orbital wall structures
Anterior lacrimal crest to:
Anterior ethmoid art: 24 mm
Posterior ethmoid art: +12 mm
Optic nerve: +6 mm

  - Brow to supratarsal crease: 10–11 mm
  - Superior tarsal plate height: 8–9 mm
  - Inferior tarsal plate height: 4–5 mm
  - **Asian eyelid**: **lower (or absent) insertion of the levator aponeurosis** to the skin, allow ptosis of orbital fat down to lid margin

- Nose
  - **Nasal tip innervated by V1**
  - Vascular supply:
    External carotid
    (a) IMA → greater, lesser palatine
    (b) IMA → sphenopalatine → posterior septal and lateral nasal branches
    (c) Facial artery → superior labial, angular, lateral nasal
    Internal carotid
    (a) Anterior and posterior ethmoid, dorsal nasal

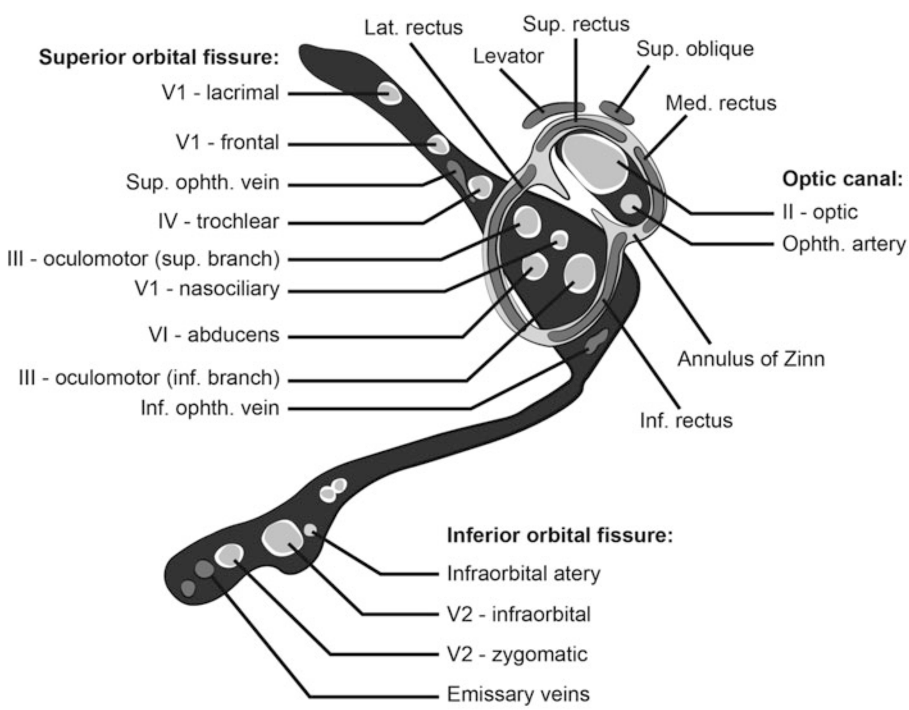


Fig. 2.6 Right orbital fissure contents

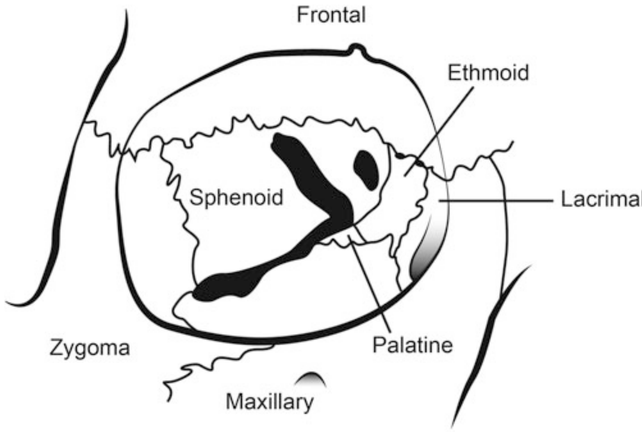


Fig. 2.7 Bone composition of the orbit (right side)

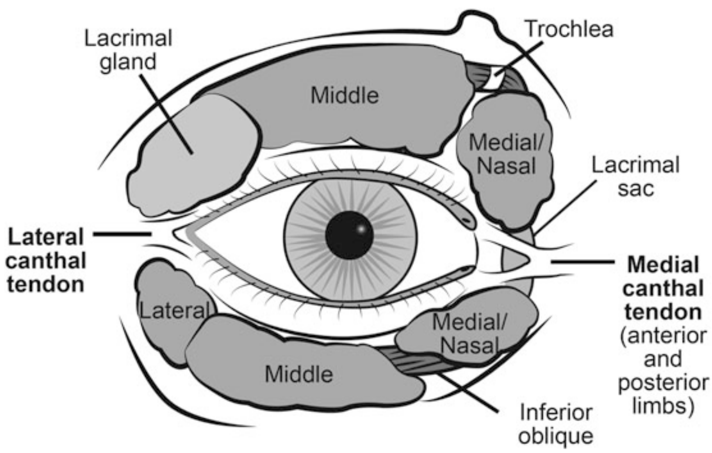


Fig. 2.8 Compartments of orbital fat

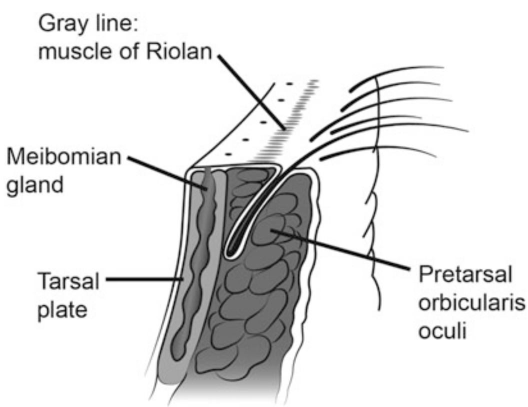


Fig. 2.9 Cross section of lower eyelid

- Mouth
  - External landmarks
    Philtrum
    Modiolus
    White roll
  - Musculature
    Several parts to orbicularis oris
    (a) Originate from buccinators, depressor septi, mentalis
    (b) Philtrum overlies area of decussation
  - **Labial artery runs between orbicularis and mucosa** at or inferior to the level of the vermillion border (see Fig. 2.11)

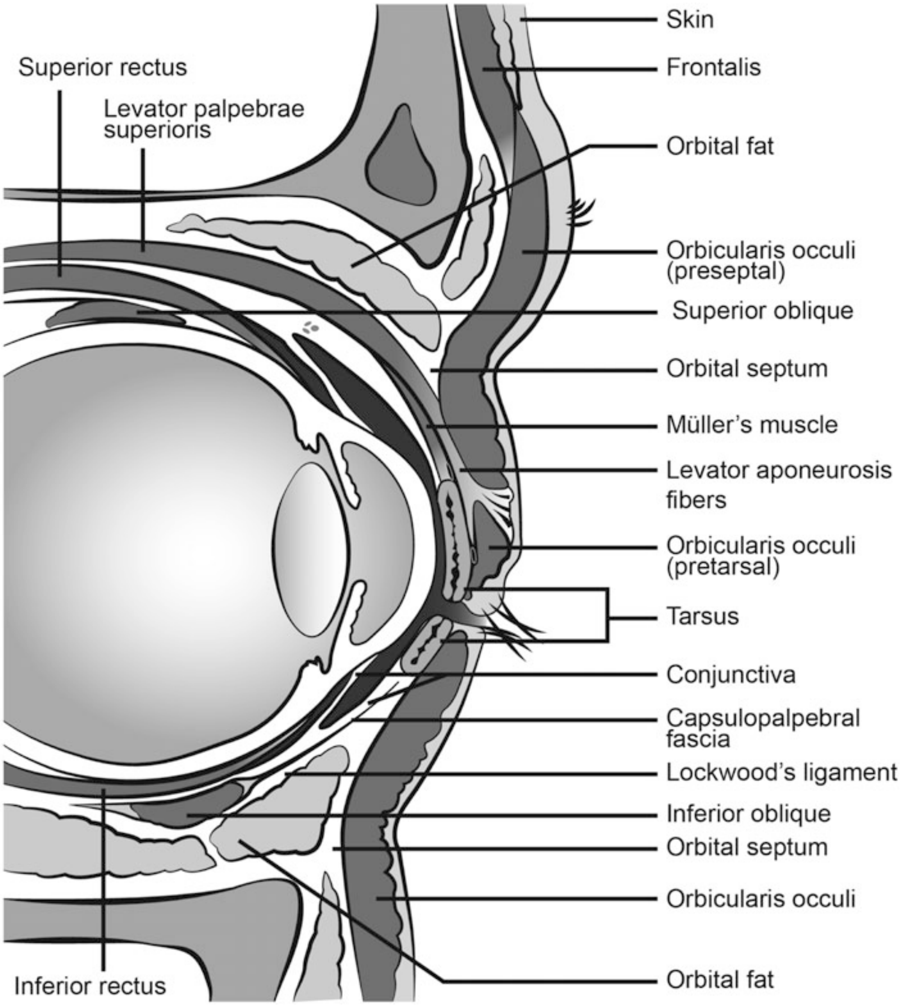


Fig. 2.10 Cross-sectional view of orbital anatomy

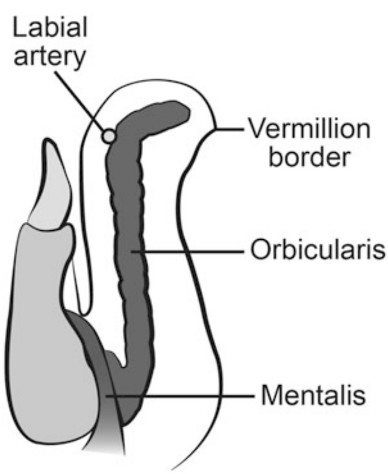


Fig. 2.11 Cross-sectional view of lower lip

- Mandible (see Fig. 2.12)
  - Muscles and motions
    Lateral pterygoid (condyle/coronoid) **opens the jaw**
    Temporalis (coronoid), Masseter (angle), medial pterygoid (behind the mylohoid groove, medial angle of mandible)—**close the jaw**

- Superficial neck
  - Great auricular nerve
  - External jugular (anterior to great auricular)

- Ear (see Figs. 2.13, 2.14, 2.15, and 2.16)
  - Vertical height ~6 cm; width: 3.5 cm

– Orientation: ~20° or **"parallel to nasal dorsum"** (usually less)
– **Projects 20–30°, 2–3 cm** from mastoid
– Blood supply from:
  Posterior auricular
  Superficial temporal
  Posterior occipital
  Deep auricular
– Cartilage framework
  Hillocks of His
  1–3 from first arch
  4–6 from second arch
– Cutaneous innervation (see below)

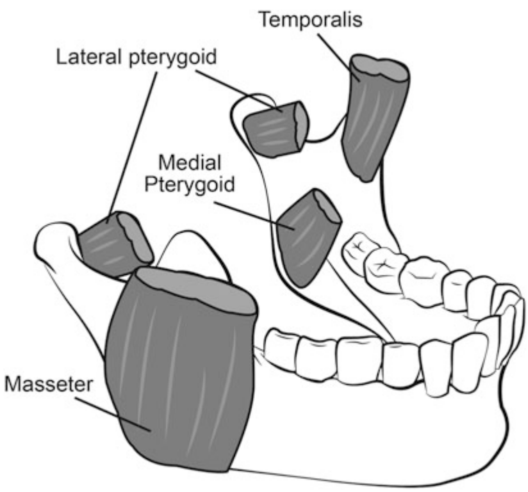


Fig. 2.12 Muscles influencing jaw opening and closing

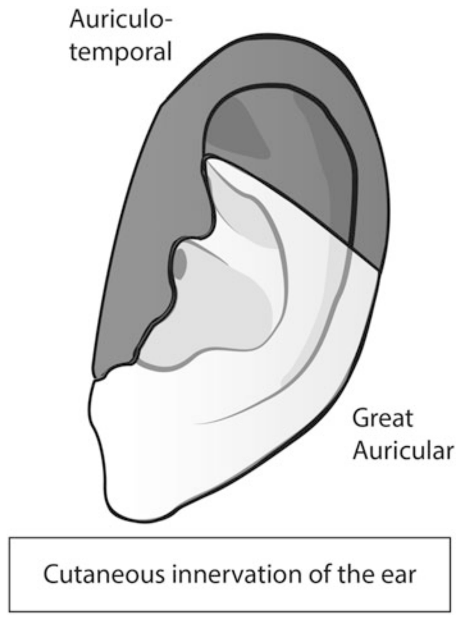
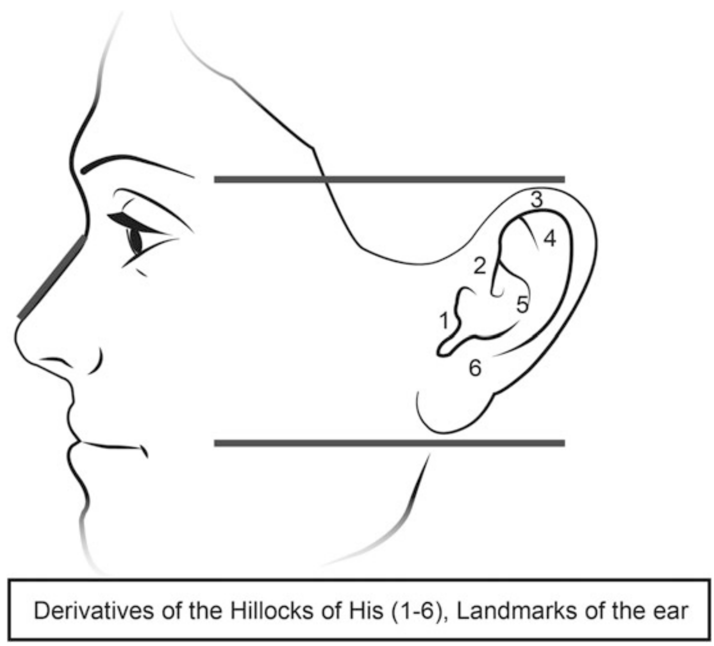


Fig. 2.14 Cutaneous innervation of the ear

Fig. 2.13 Facial landmarks of the ear and their derivatives (Hillocks of His numbering 1–6)



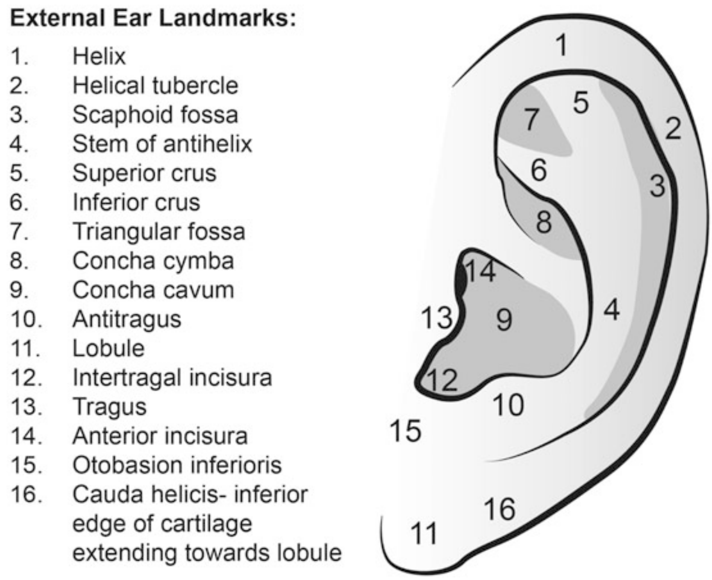


Fig. 2.15 External landmarks of the ear

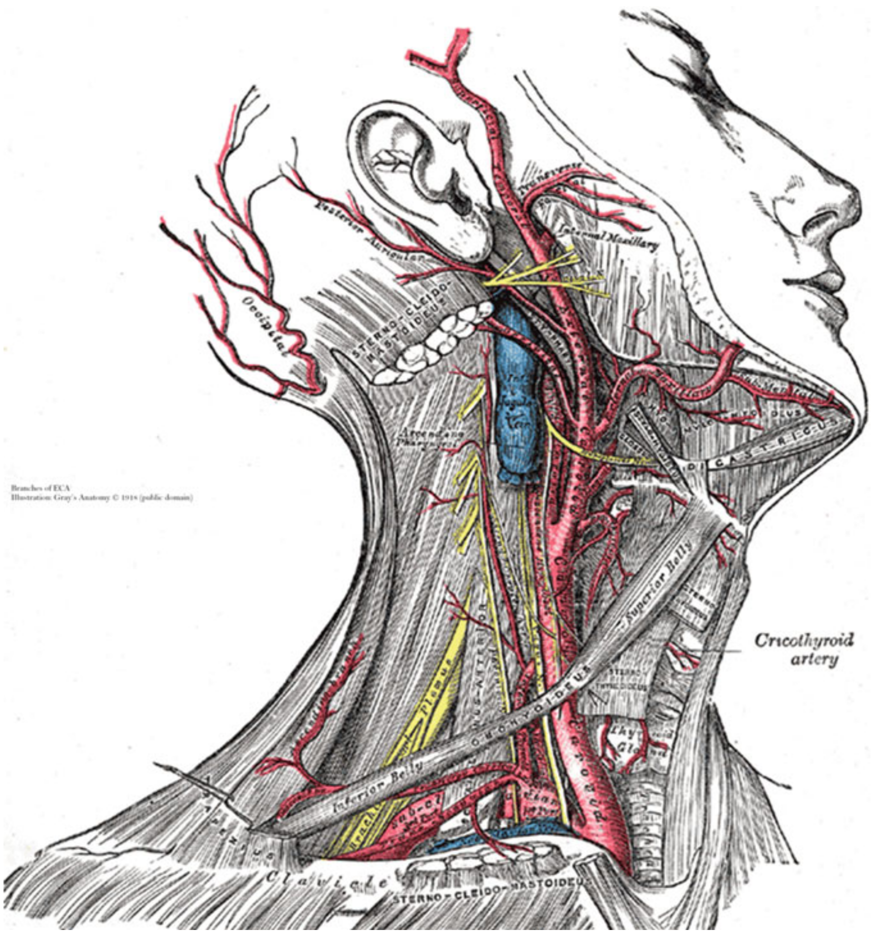


Fig. 2.16 Arterial supply to the head and neck. Illustration: Gray's Anatomy © 1918 (public domain)

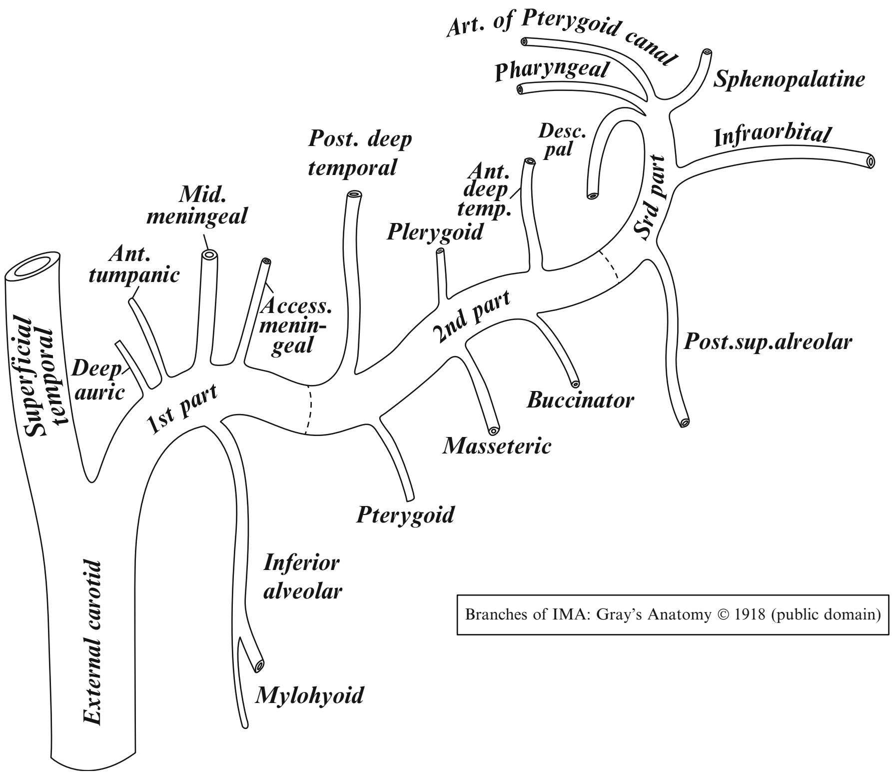


Fig. 2.17 Branches of internal maxillary artery: Gray's Anatomy © 1918 (public domain)

Table 2.10 Branches of the internal maxillary artery

(**DAM** **A**rtery! **I** **M**ade **Dolly** **P**arton's **M**ammoth **Br**a **P**op & **I** **D**idn't **St**op **P**leasing!)
Deep auricular
Anterior tympanic
Middle meningeal
Accessory meningeal
Inferior alveolar
Mylohoid
Deep temporal (post and ant)
Pterygoid
Masseteric
Buccinator
Posterior superior alveolar
Infraorbital
Descending palatine
Sphenopalatine
Pharyngeal

- Arterial anatomy of the face (see Figs. 2.16 and 2.17, Table 2.10)
  - External carotid branches (**S**ome **A**ngry **L**adies **F**ight **O**ff **PMS**)

Superior Thyroid
Ascending pharyngeal (posterior)
Lingual
Facial ("external maxillary" in old texts)
Occipital (posterior)
Posterior auricular (posterior)
Maxillary ("internal maxillary" in old texts)
Superficial temporal (terminal branch)

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Questions

1. What is the mechanism for wound contracture?
   (a) Neutrophils
   (b) Macrophages
   (c) Myofibroblasts
   (d) TGF-B
2. Why does edema impair wound healing?
   (a) Dilution of growth factors
   (b) Decreased pO_2
   (c) Increased protein deposition
   (d) All of the above
3. What is the difference between hypertrophic and keloid scars?
4. What surgical wound classification would you choose for closure of a forehead laceration caused by a beer bottle? Bear attack? Open septorhinoplasty?
5. What muscles of facial expression are innervated from their superficial surface?

6. What is the structural difference between Asian and Caucasian eyelids?
7. How many orbital fat compartments are there?
8. How many limbs of the medial canthal tendon? What do they surround?
9. What does the gray line represent?
10. How many parts of the orbicularis oculi?
11. What angle does the ear project off the mastoid? What distance?
12. What nerve innervates the nasal tip?
13. What are the measurements and/or superficial landmarks for locating the supratrochlear artery?

Answers

1. (c) Myofibroblasts are fibroblasts with increased levels of actin, making them able to contract. This occurs in the remodeling phase of healing.
2. (d) Oxygen and nutrients can only reach wounds by diffusing from adjacent capillaries (2 cell widths). Edema increases this distance, and allows protein deposition impairing healing.
3. Hypertrophic scars do not extend beyond the boundary of the initial wound (keloids do extend into adjacent tissue). Both are hyperinflammatory responses. Predisposition to keloid scars may be genetic (AD transmission).
4. Beer bottle: class III (contaminated), bear attack: class III (contaminated), open SRP: class II (surgical incision in the aerodigestive tract)
5. MLB—mentalis, levator anguli oris, buccinator
6. Lower or lack of skin insertions of the levator aponeurosis allowing descent of preseptal orbital fat toward the lash line
7. 5 (lacrimal gland replaces the lateral/superior compartment)
8. Pretarsal orbicularis that is behind the lash line (called the muscle of Riolan)
9. 2 (anterior and posterior) surround the lacrimal sac
10. 3—orbital, pretarsal, and preseptal (together called the palpebral)
11. 20–30°; 20 mm
12. V1
13. 1.7–2.2 cm from midline, medial head of the brow

3 Evidence-Based Medicine

Giriraj K. Sharma, Jacob O. Boeckmann,
and Brian J. -F. Wong

The practice of evidence-based medicine (EBM) involves the application of current, best-available clinical evidence from systematic research in health care decision-making for individual patients (Sackett et al. 1996). EBM entails a judicious search of the literature and the application of formal rules of literature appraisal in order to select the best-available evidence. In 1992, the five steps of EBM were defined for purposes of medical education (Evidence-Based Medicine Working Group 1992).

Five steps of evidence-based medicine:

1. Asking an answerable clinical question
2. Systematic retrieval of the best evidence available
3. Critical appraisal of evidence
4. Application of results in practice
5. Evaluation of performance

EBM Step 1: Asking an Answerable Clinical Question

A focused, structured clinical question should be directly relevant to a problem related to a patient or population and should direct the clinician's search to relevant and precise answers (Burns and Chung 2010). Formulation of a well-constructed clinical question typically involves using the **PICO model** to define four key elements (Richardson et al. 1995; Center for Evidence Based Medicine. http://www.cebm.net. Accessed 28 Jan 2015).

P = Patient/problem.
I = Intervention (a treatment, diagnostic test, or prognostic factor).
C = Comparison intervention (if necessary).
O = Outcomes from the intervention or test.

EBM Step 2: Systematic Retrieval of the Best Evidence Available

A well-formed question using the PICO model facilitates the organization of appropriate search terms needed to query a literature search engine (McCarthy et al. 2008). Generally, there are three categories of resources:

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1. **Background information**—These are usually in textbook form, but may be online. The year of cited journal articles will indicate how current the background resource is.
   Examples: Bailey's Head & Neck Surgery: Otolaryngology, UpToDate, Harrison's Principles of Internal Medicine.
2. **Secondary sources**—After posing a clinical question, filtered "secondary" resources synthesize evidence to state conclusions based on available research.
   Examples: Guidelines (US National Guideline Clearinghouse), Systematic reviews (Cochrane library), Evidence-based summaries (BMJ Clinical Evidence; www.clinicalevidence.com)
3. **Primary sources**—Unfiltered "primary" resources require the clinician to assess the quality, validity, and applicability of the literature to the clinical question.
   Examples: Medline/PubMed, Web of Science

EBM Step 3: Critical Appraisal of Evidence

Once the relevant literature has been obtained, systematic evaluation of the evidence is performed to establish if the studies address a focused clinical question (PICO model), validity of the methodology used to address the question, validity of the results, and the applicability (usefulness in clinical practice) of the results. Critical appraisal checklists may be used to evaluate systematic reviews, diagnostic studies, prognostic studies, therapeutic studies, or randomized controlled trials (RCT) (Center for Evidence Based Medicine 2015; American Society of Plastic Surgeons 2015). The evidence pyramid is often used to illustrate the relative strengths and weaknesses of different types of study designs (Fig. 3.1). With each ascending level in the pyramid, the study designs feature an increase in rigor, quality, and reliability of the evidence, with a minimization of statistical error and bias from confounding variables.

A hierarchical system of classifying evidence, known as the **levels of evidence**, ranks study design types according to the strength of the results and probability of bias (Center for Evidence Based Medicine 2015). Different organizations and journals have adopted variations of the classification system (American Society of Plastic Surgeons 2015). The hierarchy is also dependent on the type of research question being asked (e.g., treatment, prognosis, diagnosis, etc.). The Centre of Evidence-Based Medicine defines the levels of evidence for therapeutic studies as:

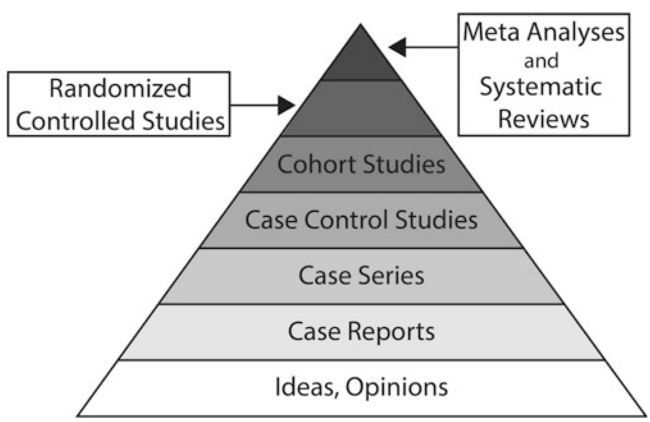

Fig. 3.1 Evidence pyramid. Each ascending level of the pyramid represents a different type of study design with corresponding increases in rigor of design, quality, and reliability of the evidence and decreases in bias from confounding variables

Level of evidence for therapeutic studies (Center for Evidence Based Medicine 2015)

Ia	Systematic review of RCTs (with homogeneity[a])
Ib	Individual RCT (well-designed, narrow confidence interval)
Ic	All-or-none study[b]
IIa	Systematic review of cohort studies (with homogeneity[a])
IIb	Individual cohort study Poorly designed RCT (e.g. <80 % follow-up)
IIc	"Outcomes" research, ecological studies.
IIIa	Systematic review of case-control studies
IIIb	Individual case-control study (well-designed)
IV	Individual case series Poorly designed cohort and case-control studies
V	Expert opinion, without critical appraisal (e.g., argument from physiology, bench research, or first principles)

[a]The homogeneity of a systematic review indicates the lack of variations in the directions and degrees of results between individual studies

[b]Category Ic is met when all patients died before the treatment became available, but now some survive because of it. Or, when some patients died before the treatment became available, but now none die who receive it

Clinical recommendations are developed based on the strength of supporting evidence (Center for Evidence Based Medicine 2015; American Society of Plastic Surgeons 2015).

Grades of recommendation (Center for Evidence-Based Medicine 2015):

A	Consistent level I studies
B	Consistent level II or III studies; extrapolations from level I studies
C	Level IV studies; extrapolations from level II or III studies
D	Level V studies; inconsistent or inconclusive studies of any level

EBM Step 4: Application of Results in Practice

Following critical appraisal of the literature for validity and importance, the evidence is integrated into clinical practice. At this point, in addition to incorporating the best-available clinical evidence, the clinician should draw upon past clinical training and experience to formulate a sound management plan for the patient.

EBM Step 5: Evaluation of Performance

In the final step, critical thinking is applied to evaluate the usefulness of the EBM process. Was the intended outcome achieved? Did the application of EBM principles to clinical management ultimately help the patient? How much time did the EBM process take? Outcome assessment and critical evaluation of each EBM step is essential to developing proficiency in EBM practice.

Study Design

A thorough understanding of different types of clinical studies facilitates proper EBM practice and appropriate study design to answer clinical questions. Systematic reviews and meta-analyses are generally considered the highest levels of evidence:

1. **Systematic review**: A systematic identification of all empirical evidence pertaining to a specific clinical question. Each study is selected based on clearly articulated, predefined eligibility criteria. After assessment of the validity of findings within each study (e.g., risk of bias), the evidence is synthesized and presented in an objective and transparent manner to maximize reproducibility and minimize bias. Systematic reviews often, but do not always, include statistical techniques to synthesize the results of eligible studies. Hence, a systematic review may include a meta-analysis.
2. **Meta-analysis**: Uses statistical techniques to combine and contrast the results from multiple clinical studies. Meta-analyses use a common statistical measure shared between the included studies to identify relationships, patterns, or sources of disagreement among study results. Often, greater statistical weight is given to results of studies with more events or studies of higher quality.

Individual clinical research studies can be divided into two categories: **experimental studies** and **observational studies** (Fig. 3.2).

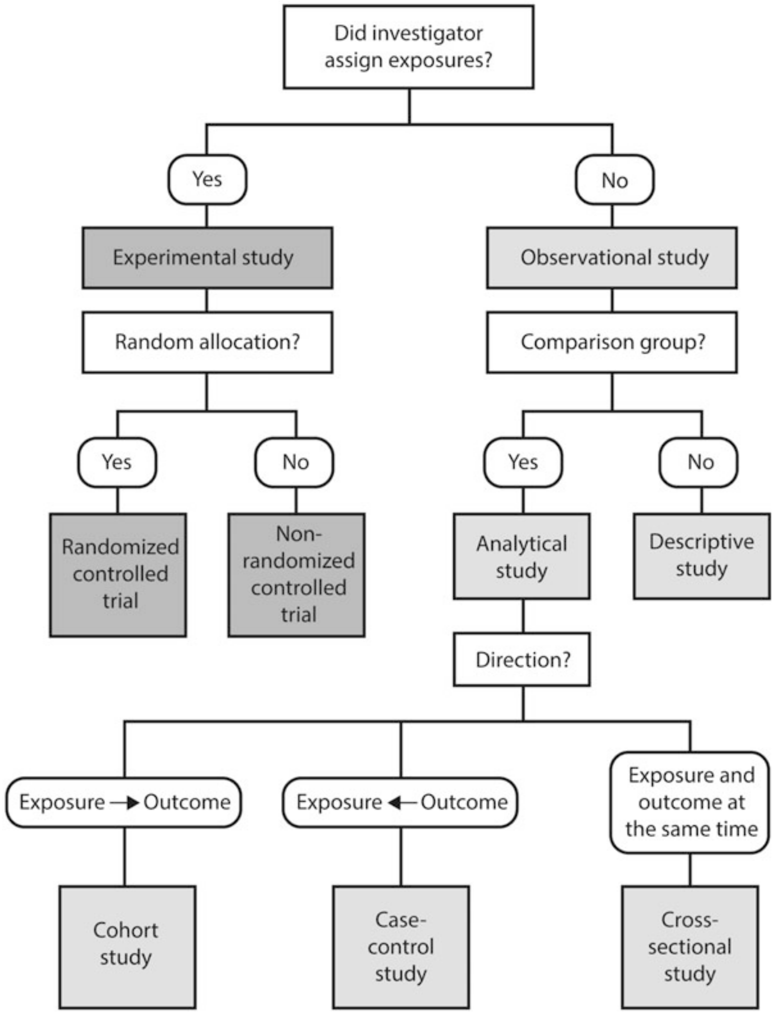

Fig. 3.2 Study design categorization

This differentiation is based on whether the investigators assigned the exposures (e.g., treatments) or whether they observed standard clinical practice (Hennekens 1987).

Experimental Study

In experimental studies, investigators assign treatments to a group(s) in a random (RCT) or systematic fashion and proceed to observe the effect of the treatment on the group(s).

1. **Randomized controlled trials** are considered the gold standard of scientific evidence. In RCTs, after determination of subject eligibility and enrollment, subjects are randomly allocated into two or more different groups (often a control group and experimental group) and prospectively followed in the same manner. Advantages of RCTs over observational studies include (1) unbiased distribution of confounders, (2) easier to blind/mask, (3) randomization facilitates statistical analysis, and (4) clearly defined subject populations. RCTs typically have greater time and cost requirements and are subject to volunteer bias.

Conventional RCTs typically randomize subjects to different intervention groups and individual clinicians provide interventions to subjects in both groups. **Expertise-based RCTs** randomizes subjects to clinicians with expertise in intervention A or clinicians with expertise in intervention B (Devereaux et al. 2005). In expertise-based RCTs, clinicians only perform the intervention in which they specialize in.

Blinding entails the prevention of patients, health care providers, or observers involved in the trial from knowing the assigned interventions to each subject (Boutron et al. 2006). RCTs may utilize different types of blinding (e.g., patients only, providers only, patients and providers only, observers only, etc.)

Observational Study

In observational studies, investigators observe subjects and measure variables of interest. Assignment of subjects into treated and untreated groups is beyond the control of the investigator. Analytical observational studies can be categorized based on when the observations are made (e.g., before, concurrent, or after the outcome).

1. **Cross-sectional study**: A descriptive study which entails the analysis of data from a population at one specific point in time.
2. **Cohort study**: An observational study where one or more samples (cohorts) who do not have a disease/outcome are followed prospectively. Correlation between initial exposure characteristics (risk factors) and disease/outcome is measured to determine an absolute risk of contraction.
3. **Case-control study**: A study that compares samples with and without a disease/outcome of interest. Retrospective analysis is performed to identify factors that may contribute to development of the disease/outcome.
4. **Case series**: A descriptive study that follows a group of subjects with a known exposure or who received a similar treatment.

A good **case series** should explicitly define its study population, inclusion/exclusion criteria, intervention/co-intervention, and the primary outcome. Only descriptive statistics should be used (no comparative tests). In reporting, a statement of external validity of the obtained data should be provided, including patient characteristics and completeness of follow-up. The presence and magnitude of bias should be acknowledged (Kooistra et al. 2009).

Designing a Study

The design of the study is often more critical than the analyses, as a poorly designed study cannot be retrieved. Study design also often dictates how the data will be analyzed. General steps for designing a study include:

1. Formulation of a well-built clinical question (PICO model).
2. Systematic retrieval of the best-available clinical evidence.
   A thorough literature search should reveal what is known and unknown pertaining to your question. Strengths and weaknesses of major studies which contribute to current knowledge related to the question should be noted.
3. Definition of a hypotheses and objective(s) of the study.
4. Selection of study design.
   Although RCTs carry the highest level of evidence (level I), they are not appropriate study designs for all clinical questions. For example, in certain clinical scenarios it is unethical to withhold treatment from a control group of patients. The simplest way to categorize studies is to decide the time sequence in which exposure and outcome are studied:

Prospective studies (most powerful)

(a) Parallel group design: Treatment and control are allocated to different subjects. If possible, the study should be double-blinded.

(b) Matched design: Randomization is between matched pairs.
(c) Crossover study: Two or more treatments are applied sequentially to the same subject.
(d) Quasi-experimental design: Treatment allocation is not random.
(e) Cohort study.

Retrospective studies
(a) Case-control study
(b) Cross-sectional study

5. Definition of study methods. Determination of study subject selection methodology, sample size, and measurement techniques.
6. Data analysis. Define the statistical techniques and strategy to adjust for potential confounders.

Sources of Bias

In research, **bias** refers to systematic error that contributes to the difference between the mean of a multiple test results and an accepted reference value, that is, multiple replications of the same study would reach the same incorrect result. Bias may occur at varying degrees. In contrast, **precision** refers to the closeness of agreement among the results of tests conducted under prescribed methodology. Imprecision refers to random error, that is, multiple replications of the same study will produce different estimates of the result because of sampling variation, even if they yield the correct result on average. Major sources of clinical bias are highlighted below, categorized by the phase of a clinical research study:

Study design
- **Design bias**: The researcher fails to account for the inherent biases liable in most types of experiments.
- **Selection bias**: Systematic differences between baseline characteristics of the groups being compared. Study subjects are not truly representative of the target population. Occurs when sampling is not random or if sample size is too small.
- **Channeling bias**: Patient assignment into a study cohort is dictated by prognostic factors or degree of illness. More likely to occur in nonrandomized controlled trials.

Study implementation (information bias)
- **Interviewer bias**: A systematic difference in how information is solicited, recorded, or interpreted between different.
- **Recall bias**: Systematic differences in the accuracy or completeness of reported information between subjects in cases and control groups.
- **Performance bias**: Systematic differences between groups in the care that is provided or in exposure to factors other than the intervention-of-interest.

Completion of the study
- **Citation or reporting bias**: Systematic differences between reported and unreported findings. Example: researchers or trial sponsors may be unwilling to publish unfavorable results.
- **Confounding**: An observed association is due to an independent variable (exposure), a dependent variable (outcome of interest) and a third, extraneous variable that correlates with both the dependent and independent variable. Pretrial study design is the preferred method to control for confounding.

Questions

1. A study was designed to assess the impact of sun exposure on skin damage in baseball players. During a game, one team wore sunscreen while the other team did not. After the game, skin from players on both teams was analyzed for texture and burns. What type of study is this?

(a) Case-control study
(b) **Cohort study**
(c) Randomized controlled trial
(d) Cross-sectional study

2. A study was designed to assess the effect of tamoxifen on the risk of breast cancer in women. In a blinded manner, women were allocated into two treatment groups: tamoxifen or placebo drug. All subjects were followed over a 10-year period of time and assessed for incidence of breast cancer. What type of study is this?
   (a) Case-control study
   (b) Cohort study
   (c) **Randomized controlled trial**
   (d) Cross-sectional study
3. A systematic review of cohort studies classifies as what level of evidence?
   (a) Ia
   (b) Ib
   (c) **IIa**
   (d) IIb
   (e) III
4. A single, well-designed case series classifies as what level of evidence?
   (a) IIa
   (b) IIb
   (c) III
   (d) **IV**
   (e) V
5. What grade of recommendation is assigned to information extrapolated from a level I therapeutic study?
   (a) A
   (b) **B**
   (c) C
   (d) D
6. A report that systematically combines data from selected studies and computes a weighted statistical parameter to estimate an overall, combined effect:
   (a) Randomized controlled trial
   (b) Systematic Review
   (c) Observational study
   (d) **Meta-analysis**
7. In a study of risk factors for breast cancer, women with breast cancer reported higher usage of oral contraceptives than women without breast cancer. Such a finding may be compromised by:
   (a) Reporting bias
   (b) Confounding
   (c) **Recall bias**
   (d) Selection bias
8. During systematic retrieval of the best-available evidenced, background sources are best used to:
   (a) Find systematic reviews
   (b) Find randomized controlled trials
   (c) **Find general information about a disease/treatment**
   (d) Find expert opinion
9. What is the correct order of evidence, from lowest to highest, according to the evidence pyramid?
   (a) Case series, cohort studies, case-control studies, RCT, meta-analyses
   (b) Case-control studies, case series, cohort studies, meta-analyses, RCT
   (c) Case series, case-control studies, cohort studies, meta-analyses, RCT
   (d) **Case series, case-control studies, cohort studies, RCT, meta-analyses**

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4 General Head and Neck

Taylor Robinson Pollei

Gross Anatomy

Arterial: Divided into three arterial plexuses: deep facial, subdermal, and subcutaneous plexus, all connected by small musculocutaneous perforating arteries.

Lateral face—(lateral to the nasolabial region): *External carotid* → perforators of the transverse facial, submental, and posterior auricular arteries.

Anterior face—Superiorly: *Internal carotid* → ophthalmic (eyes, upper 2/3 of nose, central forehead). Inferiorly: *External carotid* → facial → inferior/superior labial and angular.

Venous: Mostly coursing parallel and opposite to arterial flow. Connections to pterygoid plexus/cavernous sinus present with valveless, bidirectional flow distally (e.g., angular vein) = "danger triangle." Supratrochlear/supraorbital → angular (joins superior labial) → facial → common facial → *internal/external jugular veins* ← superficial temporal.

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Innervation

Facial Nerve

Extratemporal → posterior digastric and stylohyoid muscle branches → enters parotid gland.

Travels deep to SMAS, typically entering muscles from deep side.

- Temporal br. → frontalis and upper orbicularis oculi muscle (OOM). Runs underneath the superficial layer of the deep temporal fascia over the zygomatic arch and divides into 2–4 branches.
- Zygomatic br. → lateral aspect of lower OOM, enters the muscle from deep.
- Buccal br. → procerus, medial lower OOM, nasal muscles, cheek, upper orbicularis oris.
- Marginal mandibular br. → lower orbicularis oris, lip depressors. Relationship to mandible angle is dependent on degree of neck flexion/extension, and age.

Sensory and Autonomic

CN V1 (ophthalmic) → lacrimal, frontal (supraorbital, supratrochlear), nasociliary nerves

CN V2 (maxillary) → zygomaticotemporal, zygomaticofacial, infraorbital nerves

CN V3 (mandibular) → auriculotemporal, buccal, lingual, inferior alveolar/mental nerves

Sympathetic—postganglionic = from superior cervical ganglion → vasoconstriction

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Parasympathetic—parotid = inferior salivary nucleus, submandibular and sublingual = superior salivary nucleus.

Lymphatics

Divided into 3–5 lymph node (LN) "vessels" running laterally from midline

Above the brow → preauricular and deep parotid LNs

Lateral eyelids → parotid LNs

Medial canthus → buccinator, parotid and submandibular LNs (follows along with the angular vein)

External nose and cheeks → submandibular LNs

Lateral lower lip and upper lip → **ipsilateral** submandibular LNs (and some parotid drainage)

Central lower lip and chin → **bilateral** submental LNs

Tissue Layers/Fascial Compartments

Scalp Layers: Skin → SubQ → galea aponeurotica → loose areolar tissue → pericranium

Temporal Region Layers: Skin → SubQ → superficial temporal fascia (aka TP Fascia, includes superficial temporal a. & v. and joins with the galea superiorly) → loose areolar tissue → superficial layer of the deep temporal fascia → superficial fat pad → deep layer of the deep temporal fascia → deep fat pad → temporalis muscle → pericranium

Face and Neck

Superficial cervical fascia—contiguous superiorly with the **SMAS**; travels from the clavicle up to the zygoma and becomes superiorly the galea. Envelopes mimetic muscles.

Deep cervical fascia

1. Superficial layer (investing): envelopes salivary glands, masseter, and SCM
2. Middle layer (pretracheal): muscular division = straps, visceral division = pharynx, larynx, trachea, thyroid, buccopharyngeal fascia
3. Deep layer (prevertebral): cervical vertebrae, paraspinal musculature

Carotid sheath—consists of all three layers, jugular vein, carotid artery, CN X.

Structure

Buttresses—**Horizontal**: frontal, zygomatic, maxillary, mandibular

Vertical: nasomaxillary, zygomatico-maxillary, pterygomaxillary, mandible condyle/ramus

Orbit bones—(clockwise) frontal, ethmoid, lacrimal, palatine, maxillary, sphenoid, zygomatic

Musculature

CN 3—superior, medial and inferior rectus, inferior oblique, levator palpebrae superioris

CN 4—(trochlear) = superior oblique

CN 6—(abducens) = Lateral rectus

CN 5—**Masticatory muscles**: temporalis, masseter, medial and lateral pterygoid

CN 7—**Facial animation muscles**:

Face: Upper 1/3—frontalis, corrugator supercilii, orbicularis oculi, procerus, depressor supercilii

Face: Middle 1/3—orbicularis oris, buccinator, zygomaticus major/minor, levator labii (×2), levator anguli oris, risorius, nasalis, depressor septi

Face: Lower 1/3—depressor anguli oris, depressor labii inferioris, mentalis, platysma

Specialized Structures

Eye—Conjunctiva → cornea (sclera posteriorly) → Anterior chamber (aqueous humor) → iris → ciliary muscle, suspensory ligaments and lens → vitreous chamber (and body/fluid)

Ethnic Anatomic Considerations

Eyelid morphology—absence of an upper eyelid crease (e.g., Asian eyelid) is a result of:

1. Fusion of the orbital septum to the levator aponeurosis below the superior tarsal border

2. Protrusion of the preaponeurotic fat pad and a thick subQ fat layer at the tarsal border
3. Insertion of the levator into the orbicularis muscle and lid skin is closer to the lid margin

Nasal morphology-
Platyrrhine (broad and flat) = thick skin, low radix, short dorsum, bulbous tip, nostril flaring
Mesorrhine = low radix, variable dorsal projection, rounded and underprojected tip
Leptorrhine (tall and thin) = thin skin, long and high dorsum, projected tip, narrow ala

Micro Anatomy/Pathology of Head and Neck Structures

Skin: Epidermis—stratum corneum → lucidum → granulosum → spinosum → basale (basal layer) = location of melanocytes, Merkel cells

Dermis—90 % of skin thickness. Papillary layer (vascular network) → reticular layer (structure, elasticity) contains hair follicles, sweat (apocrine/eccrine) glands, sebaceous glands, nerve endings, collagen/elastin. Basement membrane = type IV collagen

Thyroid: Central follicle interstitial space (colloid) surrounded by simple cuboidal epithelium as the secretory cells. Intermixed with C-cells (parafollicular cells) that secrete calcitonin

Parathyroid: Embedded in the thyroid capsule, contains (1) chief (principle) cells which are small and oxyphilic and secrete PTH and (2) oxyphil cells—have no secretory function

Salivary: Based on the secretory acinus which is comprised of either mucous- or serous-secreting cells → intercalated ducts (simple cuboidal epithelium that is myoepithelial cell lined) → striated ducts (site of active water resportion and ion exchange) → interlobular ducts. Sublingual = ↑ mucin; parotid = ↑ serous; submandibular = mixed

Lymphoid: Tonsils are lined by squamous cells and contain lymphoid follicles below the surface containing germinal centers (similar to lymph nodes). Partially encapsulated with deep crypts present

Embryologic Development

Branchial Apparatus

1. Mandibular arch: Meckel's cartilage—malleus head and neck, incus body and short process, anterior malleal ligament, mandible
   Nerve: CN V3 → masticatory muscles, tensor tympani, tensor veli palatini, mylohyoid, anterior digastric muscle
   Artery: Maxillary artery
   Hillocks of His: 1 (tragus), 2 (helical crus), 3 (helix)
   Pouch: Eustachian tube, middle ear/mastoid, inner layer of tympanic membrane
2. Hyoid arch: Reichert's cartilage—manubrium of malleus, long and lenticular process of incus, stapes (not footplate) styloid process, stylohyoid ligament, lesser cornu and superior ½ of hyoid
   Nerve: CN VII → facial animation, stapedius, stylohyoid, posterior digastric
   Artery: Stapedial artery
   Hillocks of His: 4 (antihelix crus), 5 (scapha), 6 (lobule)
   Pouch: supratonsillar fossa, palatine tonsils, middle ear
   Groove: external auditory canal, outer layer of tympanic membrane
3. Cartilage—greater cornu and inferior ½ of hyoid bone
   Nerve: CN IX—stylopharyngeus muscle, superior and middle constrictors
   Artery: common and internal carotid arteries
   Pouch: thymus, inferior parathyroids
4. Aortic arch: Cartilage—thyroid and cuneiform
   Nerve: Superior laryngeal nerve (cricothyroid and inferior pharyngeal constrictors
   Artery: Aorta (left); subclavian artery (right)
   Pouch: Parafollicular cells of thyroid, superior parathyroids

5. and 6. Cartilage: Cricoid, arytenoid, and corniculate
   Nerve: Recurrent laryngeal nerve (remaining intrinsic laryngeal muscles)
   Artery: Ductus arteriosus and pulmonary artery

Physiology

Mastication/Deglutition: Oral Phase—Mastication prepares food to become bolus with salivary mixture. Next, tongue compresses bolus against the palate and posterior pharynx with tongue elevation. Hyoid elevates and bolus is propelled toward the vallecula.

Pharyngeal Phase—Reflexive (CN IX and X) activated elevation of the larynx/hyoid bone, elevation of the soft palate, contraction of the superior constrictor, and pushing of the bolus posteriorly by the tongue base. Next, the multiple levels of laryngeal closure occur: epiglottis, AE folds, and arytenoids, false cords, and true cords. Lastly, the pharyngeal constrictors contract and the cricopharyngeus opens, triggering the esophageal phase.

Speech (Articulation): Speech sounds produced by a coordination of lip, tongue, and mandibular musculature activity.

Phonation: The production of voice, dependent on vocal properties: position, vibratory capacity, length, and tension.

Lacrimation: Spontaneous, reflexive, or emotional based tear production.

Nerve Pathway: Superior salivary nucleus → parasympathetic fibers of the GSPN → IAC → middle cranial fossa → joins sympathetic greater petrosal nerve → pterygopalatine ganglion → lacrimal gland (and nasal mucosal glands)

Lacrimal System: Lacrimal gland (aqueous component) tear secretion is spread across the surface of the eye. Tarsal glands contribute the lipid component and conjunctival glands secrete mucous component. Lacrimal fluid is drawn into the punctum by capillary action → lacrimal canaliculi → lacrimal sac → nasolacrimal duct → inferior meatus

Testing

Imaging

CT scan: Ideal for osseous visualization. Temporal bone = 0.5–0.625 mm thick slices. Max-face = 1.25 mm slices; neck = 3 mm slices. Axial images with coronal and sagittal recons. Volume rendering with 3-D reconstruction models. Contrast for delineating soft-tissue abscesses and cellulitis.

MRI: Ideal for soft-tissue (skull base, neural tissue, cartilage) visualization with multiplanar images, even without contrast. Gadolinium contrast—risk of nephrogenic systemic fibrosis. Cons = motion artifact, pulsation artifact, metallic object interaction, greater cost, longer scan time. Most use a 1.5–3 T field strength.

Ultrasound: Good soft-tissue and fluid resolution, noninvasive, inexpensive, often requires "specialized training" for interpretation. Combined with Doppler for flow testing.

Cineradiography: Functional fluoroscopy, useful to delineate anatomic abnormalities in addition to functional (mastication, deglutition, esophageal) abnormalities.

Bone scan (bone scintigraphy): Nuclear scan utilizing T-99 m, for functional testing of bone lesions by highlighting areas of increased metabolic activity. Less expensive than FDG-PET.

DEXA: (Aka—bone density scan) low-dose X-ray for bone density testing, structural, inexpensive.

Angiography: The gold standard for evaluating vascular injury and vascular anatomy, but lengthy, expensive, and invasive.

CT angiography: Screening tool for penetrating neck trauma or blunt trauma. Quick and noninvasive, easily accessible. Requires iodinated contrast.

Radiogram

FDG-PET: Best technique for metabolic function testing. Poor spatial resolution which can be enhanced with hybrid scanning techniques (with MRI or CT).

Functional

Rhinomanometry: Measures transnasal airflow from the nares to nasopharynx, allowing for pressure changes and therefore resistance to be elucidated. Assesses turbulence vs. laminar flow. Clinically applicable in assessing degree of nasal obstruction. Use of decongestant spray attempts to separate structural/anatomic from functional/mucosal causes of obstruction.

Schirmer test: A small strip of filter paper is placed inside lower lid (± topical anesthetic) and checked at 5 min. >15 mm of moisture on filter paper strip after 5 min = normal. Mild lacrimal dysfunction = 9–14 mm, moderate = 4–8 mm, severe = <4 mm.

Assessment and Management

Differential Diagnosis Formation for Head and Neck Masses/Disorders

KITTENS Method . . .

K = Congenital, I = Infectious and Iatrogenic, T = Toxins and Trauma, E = Endocrine, N = Neoplastic, S = Systemic

Also, remember important info: Age, associated symptoms, symptom/sign characteristics

Management Algorithm

Management options can be arranged from most conservative and least invasive to most aggressive and high risk. Stepwise approach vs. combined approach may be useful.

1. Do nothing
2. Lifestyle: diet, exercise, sleep, habit changes
3. Therapy: physical/occupational therapy, stretching, massage, heat, ice
4. External applications: dressings, external splints
5. Medication: topical vs. systemic, taken orally, IM, IV, etc.
6. Surgery: prophylactic, diagnostic and/or therapeutic
7. Ancillary treatments: chemotherapy, radiation therapy, cryotherapy, etc.
8. Complementary and alternative treatments

Photography

Standardized pre-, intra-, and postoperative photography help achieve consistency, facilitate comparisons, and demonstrate anatomic detail. Keys include:

Photographic Consent—Use of photos for non-treatment purposes (presentations, lectures, print/Internet media, etc.) requires consent. Consent not required for treatment purposes.

Room setup—appropriate flashes, background, camera mount

Patient preparation—remove glasses, jewelry, place hair back, avoid excessive makeup

Positioning—Frankfort horizontal plane = top of tragus (superior EAC) to the infraorbital rim (estimated by junction of lower lid and cheek skin). In some cases to avoid submental laxity, the natural horizontal facial line may be preferred. Oblique facial views should align either (1) nasal tip with far cheek, (2) nasal dorsum overlying the far medial eye, or (3) medial canthus aligned with the lateral oral commissure. Lateral views should be void of over- or under-rotation. Avoid head tilting by keeping ear lobes symmetric. Include from the top of the hairline to the sternal notch.

Views/Series—Standard procedures have standard views. **Uniformity is key**. Utilize perspective/reference photos as needed. Typically with a 105 mm lens at 1 m distance

Camera Terminology—Aperture = the size of the iris of the lens, determines the amount of light hitting the camera film/sensor. Measured in an "*f-stop,*" which is a fraction, and therefore increases as the aperture decreases. Smaller aperture = greater field depth.

Shutter speed = How long the iris is open and therefore how long the sensor is exposed to light.

Depth of field = (aka—focal range) The distance between the closest and farthest in-focus areas of a photograph. The smaller the aperture (↑ *f-stop*) = the greater the depth of field.

Focal Length = the distance in millimeters from the optical center of the lens to the focal point, which is located on the sensor. Shorter focal length = larger field of view. Longer focal length = narrower field of view.

Lenses: Normal—When the focal length approaches the diagonal measurement (43.27 mm) of a rectangular 35 mm × 24 mm pane, the standard size that was previously film and is now a sensor. Wide angle—shorter focal length and shorter lens but a wider field of view. Telephoto—longer focal length and a longer lens, leaving a narrower field of view.

Resolution = A measurement of the pixel count of an image, given per inch or total. Increase resolution for print media (>300 ppi) and decreases for Internet use (72–150 ppi).

Zoom: Optical zoom—changes the amount of the scene hitting the sensor, thus allowing for more detail that can be enlarged without issue. Digital zoom—interpolates data in the scene to fit on the sensor, mimicking zoom without gaining detail. Can result in blurry, pixilated images.

Facial Analysis

Facial Subunits (Table 4.1)

Forehead: Extends from the hairline (or the superior extent of the frontalis in receding hairlines) down to the superior orbital rim. Contains a continuation of the scalp layers, with the frontalis contained between divided galeal layers.

Periorbital region: Includes the upper and lower lids, medial and lateral canthal regions, and the globe

Cheek: Extends from the preauricular crease anterior to the nasolabial fold; from the zygomatic arch/inferior orbital rim down to the inferior border of the mandible.

Nose

Perioral region and chin: From the subnasale and nasolabial folds to the menton, between lateral commissure bilaterally.

Neck: Key area of rejuvenation is the cervicomental angle, with superior neck skin behaving more like cheek skin, and lower neck skin more like chest skin (Table 4.2).

Table 4.1 Soft-tissue landmarks

Trichion (Tn)	Forehead/hairline junction at midline (~ upper edge of frontalis)
Glabella (G)	Prominent forehead/brow junction at midline
Radix (R)/Nasion (N)	Root of the nose, corresponding with soft-tissue nasion
Rhinion (Rh)	Junction of the nasal bone and upper lateral cartilage
Supratip (Su)	Gentle soft-tissue break between nasal dorsum and tip
Nasal tip (Tp)	Leading edge of nasal profile
Subnasale (Sn)	Soft-tissue point at the junction of the columella and upper lip
Vermillion (Vm)	Mucocutaneous junction of the upper lip and lower lip
Stomion (St)	Midpoint of the embrasure of lips when closed
Mentolabial sulcus (Ms)	Point of greatest depth above chin
Pogonion (Pg)	Most prominent soft-tissue point of chin
Menton (M)	Soft-tissue point at the inferior-most border of the chin at midline

Table 4.2 Hairline evaluation

Classification	Description
Type I	Minimal or no recession of the hairline
Type II	Areas of recession at the frontotemporal hair line
Type III	Deep symmetrical recession at the temples that are bare or only sparsely covered. Anterior hairline at midline is receding
Type IV	Hair loss is primarily from the vertex, limited recession of the frontotemporal hairline
Type V	Vertex hair loss region is separated from the frontotemporal region but is less distinct; the band of hair across the Crown is narrow
Type VI	Frontotemporal and vertex bald regions are joined together
Type VII	Most severe form, a narrow band of hair remaining in a horseshoe shape

Hamilton-Norwood Classification. Based on anterior and vertex degree of recession

Table 4.3 Skin analysis: Fitzpatrick's classification of skin types

Type	Skin color and features	Tanning ability
I	White skin, blue eyes, blond/red hair	Always burns, does not tan
II	White skin, blue eye	Easily burns, tans poorly
III	Darker white skin	Mild burn, average tan
IV	Brown skin	Occasionally burns, tans easily
V	Dark brown skin	Rarely burns, tans very easily
VI	Black skin	No burns, dark tan

Skin Tension Lines

Relaxed Skin Tension Lines: Direction of greatest elasticity, traveling **perpendicular to the facial musculature**. The exception is on the eyelids where the rigid tarsal plate overrides the orbicularis oculi pull. They tend to form in the direction in which rhytides form. The long axis of incisions and their scars need to line up with the RSTLs to close with minimal tension and avoid scar widening (Tables 4.3 and 4.4).

Lines of Maximal Extensibility: Tend to run in the direction of the mimetic musculature.

Langer Lines: Typically form in the direction of rhytides. Can be perpendicular to RSTLs and are based more on the direction of skin pull and the resulting rhytides.

Overall, scars are least conspicuous when placed in creases, and creases tend to occur perpendicular to muscle action.

Facial Divisions

Vertical 5ths: Based on the width of one eye, which should equal 1/5 of the facial width. Helical rim → lateral canthus → medial canthus/nasal ala → contralateral medial canthus/nasal ala → lateral canthus → helical rim.

Horizontal 3rds: Trichion → **glabella** → subnasale → menton.

Horizontal lower face: In the absence of a defined trichion/hairline, the lower face can be divided with 43 % from **nasion** → subnasale, and 57 % from subnasale → menton.

Blepharoptosis

Anatomy: Levator aponeurosis originates from the lesser wing of the sphenoid and inserts on the orbicularis oculi, dermis, and tarsal plate. CN 3 innervation providing 10–12 mm of lid elevation. Attaches to the orbital septum ~2.5 mm above the tarsal plate.

True lid ptosis = intrinsic drooping vs. pseudoptosis which is secondary to other issue giving the impression of ptosis.

Congenital Ptosis: Developmental dysgenesis of the levator muscle, presents shortly after birth and is not progressive. Absent eyelid crease.

Acquired Ptosis: **Myogenic** (typically **senile ptosis**) = the most common type. The levator attachments to the tarsus stretch and dehisce.

Traumatic = 2nd most common. Allow for ~6 months of recovery and healing before repair.

Table 4.4 Glogau photoaging classification

Type	Severity	Typical age range	Characteristics
I	Mild	Late 20s to 30s	Little wrinkling, no keratosis, requires little or no makeup
II	Moderate	30s to 40s	Early wrinkling with facial motion, early actinic keratosis
III	Advanced	50s or older	Persistent wrinkling, discoloration with telangiectasias, visible actinic keratosis
IV	Severe	60s to 70s	Generalized wrinkling, actinic keratosis with or without malignancy

Neurogenic = CN 3 palsy, Horner's syndrome, myasthenia gravis.

Mechanical = severe upper lid dermatochalasis and excessive weight, growths, etc.

Diagnosis and Testing: Degree of ptosis is measured by the amount of lid descent over the upper limbus; mild = 1–2 mm, moderate = 3 mm, severe = >4 mm. Levator function is measured by the amount of excursion with lid opening; good = >10 mm, fair = 5–10 mm, poor = 0.5 mm. Margin reflex distance one (MRD_1) measurement is required as well.

Treatment Options: Levator aponeurosis advancement done via external approach, external levator resection, frontalis suspension, or Mueller muscle/conjunctival resection.

Dental Anatomy

Pediatric dentition: 20 teeth; 4 incisors, 2 canines, 4 M per arch. Lettered A-J (R → L maxilla) and K-T (L → R mandible).

Adult dentition: 32 teeth; 4 incisors, 2 canines, 4 premolars, 6 molars per arch. Numbered 1–16 (R → L maxilla), 17–32 (L → R mandible).

Terminology: Mesial vs. distal, buccal vs. lingual. Overbite = amount of vertical incisor overlap. Overjet = amount of horizontal overlap of incisal edges. Crossbite = horizontal malalignment of teeth, either anterior or posterior. Open bite = occlusal surfaces not in contact when in centric occlusion (when condyle is in natural resting position).

Occlusion: Refers to tooth relationship to one another. Angle classification:

Class I—Mesiobuccal cusp of the maxillary first molar fits into the buccal groove of the mandibular first molar. *Class I occlusion does not = normal occlusion.*

Class II—Mandibular molar is distally positioned . . . "underbite."

Class III—Mandibular molar is mesially positioned . . . "overbite."

Cephalometric Evaluation

Allows for standardized measurements from lateral cephalograms to determine the relationship between the skull base, maxilla, and mandible. Evaluate dentofacial proportions and the diagnostic, anatomic basis for the deformity. Surgery planned based on aesthetic evaluation, not cephalometrics. Utilizes hard tissue/bone landmarks with the "hinge"point of the condyle and relationship to the sella.

Most common abnormalities:

1. Maxillary excess—vertical excess of middle third, convex profile typically a class II occlusion and lip incompetence. Treatment = LeFort I osteotomy with impaction.
2. Maxillary deficiency—deficiency of infraorbital/paranasal sinuses.
   Treatment = leFort I osteotomy with expansion ± bone grafting.
3. Mandibular excess—(prognathism) a prominent lower 1/3 with a class III occlusion.
   Treatment = maxillary advancement ± mandibular setback.
4. Mandibular deficiency—(retrognathism) deficient lower 1/3 with a class II occlusion.
   Treatment = mandibular advancement.

Basic Surgical Principles

General Principles

Alimentation/Nutrition

Malnutrition: Complete H&P may show >12 % weight loss, alcohol abuse, advanced-stage H&N cancer, fat/muscle wasting, vitamin deficiency stigmata. Labs = albumin <3.0 g/dL: 1–2 months window. Transferrin < 150 mg/dL—7 day half-life. Pre-albumin = t ½ of 3–5 days. Average adult requires 30–35 kcal/kg/day. Protein supplementation vital.

Nutrition delivery: Oral supplementation ideal if possible.

Enteral feeds: NG tube best option, temporary (2–4 weeks), but risk of obstruction, nasal/sinus inflammation, esophagitis. Gastrostomy tube better tolerated long term. May be placed either percutaneously vs. open.

Parenteral nutrition: Rapid, not GI tract dependent. TPN must be given via central line. Indications for TPN = severe protein malnutrition, defunct GI tract, refractory chyle leak.

Wound Healing

Three phases of wound healing:

1. Inflammatory Phase (days 1–6)
   Initial **vasoconstriction** for 5–10 min followed by **coagulation** via platelet aggregation and fibrin accumulation. Histamine, serotonin, and NO-mediated vasodilation and increased vascular permeability allow for immune cells signaled by platelet products, complement, etc. to enter tissues. Predominant cell types = neutrophils (24–48 h) for early phagocytosis and inflammatory product production. **Macrophages** (48–96 h) for growth factor secretion and continued cleanup. Predominant cell up to fibroblasts, **Most critical to wound healing**. Lymphocytes' (5–7 days) questionable role, possibly for remodeling.
2. Fibroproliferative Phase (day 4–week 3)
   Fibroblasts move into the wound on day 3, and are the dominant cell at day 7. Collagen synthesis peaks from day 5 to week 3. Initial HA, dermatan, and chondroitin production are followed by collagen. Tensile strength increases from day 5 and on. Angiogenesis occurs with early VEGF production. Epithelialization begins.
3. Maturation/Remodeling Phase (week 3–1 year)
   After 3–5 weeks, collagen breakdown and synthesis are balanced. Early type III collagen is replaced by type I collagen, eventually hitting a normal 4:1 ratio. Reaches peak tensile strength (80 %) at 60 days.
   After 3–5 weeks, collagen breakdown and synthesis are balanced. Early type III collagen is replaced by type I collagen, eventually hitting a normal 4:1 ratio. Reaches peak tensile strength (80 %) at 60 days.
   Other important processes/factors/cells:

   Epithelialization—requires mobilization of epithelial cells, migration, and mitosis followed by differentiation.
   Contraction—a result of myofibroblast contractile forces. Appears at day 3, max at days 10–21, disappear as contraction is complete.

Types of Wound Healing—Primary: closed within hours of creation by reapproximating edges of wound. Secondary: wound allowed to heal on its own by granulation, contraction, and epithelialization. Delayed primary: subacute/chronic converted to acute wound by debridement then closed.

Factors that decrease/affect wound healing.

Genetic: predisposition to keloid or hypertrophic scarring, collagen abnormalities, skin pigmentation, sebaceous quality, wound location, age.
Systemic: delayed healing with diabetes, atherosclerosis, renal failure, immunodeficiency, smoking, vitamin deficiency, hypothyroidism.

Vitamins required for wound healing = vitamin A (increases tensile strength and epithelialization), vitamin C (needed in collagen

synthesis), vitamin E (cell membrane-stabilizing antioxidant), and zinc (enzyme cofactor).
Local: infection (>10^5) decreases oxygen, lowers pH, slows angiogenesis, increases edema. Radiation, free radicals, denervation.

Hemostasis

Conceptual components of hemostasis

1. Blood vessel: Immediate vasoconstriction, damaged vessel wall presents factors that induce platelet aggregation.
2. Platelets: vWF and other factors assist the exposed collagen fibers in inducing platelet adhesion, aggregation, shape change, and secretion of additional coagulation factor stimulators.
3. Coagulation system: Cascade set in motion by activated lipoproteins/enzymes that results in thrombin-activating fibrin and plug formation.

Anticoagulants
Unfractionated Heparin—inactivates factors II, IX, X, XI, and XII. t½ = 60 min. Monitored by aPTT.
Low-Molecular-Weight Heparins—(Lovenox) decreased nonspecific tissue binding, inactivates factors II and X. Increased t½, no lab test monitoring. Reversed with protamine.
Warfarin—Inactivates Vit. K-dependent cofactors II, VII, IX, X, and proteins C and S. t½ = 20–60 h. Monitored by PT/INR. Reversible with vitamin K and/or FFP.
Factor Xa Inhibitors—(Fondaparinux) t½ = 14–20 h. No effect on PT, PTT, or clotting time.

Preoperative Medications

Preoperative antimicrobial coverage should be given 30–60 min before incision.
Skin incisions—cover for *S. aureus*: cefazolin, clindamycin, or vancomycin if PCN allergy
Mucosal incisions—cover for anaerobes: clindamycin or ampicillin/sulbactam
Major aerodigestive surgery—*S. aureus, Pseudomonas*, and anaerobe coverage: clindamycin + gentamicin, or cefazolin + metronidazole
CSF contamination—aggressive *S. aureus, Pseudomonas*, and anaerobe coverage: vancomycin + ceftazidime + metronidazole

Wound Dressings

Moist wound healing = ~30 % faster reepithelialization, plus ↑ local growth factors, ↑ fibroblast, and keratinocyte migration to wound. Oxygen at normal concentrations is required. Growth factor levels are based on oxygen tension. Ideal dressing properties: conform to wound, wick secretions, gentle compression (hemostasis), easy application/removal. Many pros and cons based on whether the dressing is natural (cellulose-based dressings) vs. synthetic, medicated vs. plain, occlusive vs. semipermeable. Skin-equivalent dressings typically contain a biocompatible structural scaffold/matrix with or without cultured keratinocytes or fibroblasts. Usually expensive, mostly for chronic wounds, burns.

Adjunctive Therapies

Hyperbaric Oxygen: Breathing 100 % O_2 while under elevated atmospheric pressure allows for complete hemoglobin saturation and additional O_2 to dissolve in the plasma. Boosts oxygen tension in compromised areas (chronic wounds, ulcers, tenuous flaps/grafts), thus increasing angiogenesis and fibroblast proliferation.

Leeches: Direct venous removal plus secretion of **hirudin**, collagenase, hyaluronidase, and factor X inhibitor, anticoagulant enzymes. Feed for 20 min–2 h, 10–15 ml of blood leeched, with additional oozing secondary to anticoagulants. Used for flap venous congestion. Prophylaxis with fluoroquinolone or third-gen cephalosporin due to *Aeromonas hydrophila* infection risk.

Intralesional Steroid Injection: Decreases local fibroblast proliferation and collagen synthesis, thus favoring net collagen degradation. Useful for postoperative swelling, keloid, or hypertrophic scarring. Therapeutic effect lasts for ~6 weeks, decreased dose needed for earlier injection. Concern for subcutaneous atrophy, up to 4 % in keloid/hypertrophic scar injections.

Complications

Tobacco Morbidity

Increased **tissue ischemia** due to (1) nicotine-induced vasoconstriction via ↑ thromboxane A_2 and platelet aggregation stimulation, (2) inhaled carbon monoxide binds to hemoglobin resulting in carboxyhemoglobin formation, thus decreasing oxygen delivery.

Additional intraoperative and postoperative pulmonary, cardiovascular, and cerebrovascular complications occur due to ciliary paralysis, thrombogenesis, leukocyte dysfunction, and microvascular injury. **Infection** rate is elevated. Wounds heal slower. Risk of skin flap necrosis increases. Suggest tobacco discontinuation for 4 weeks before and 4 weeks after elective surgery. Patient management should include identification of tobacco product use, provision of counseling and smoking cessation information, and selection of preoperative candidates based on tobacco use.

Complication Management

Arguably the most important step to preventing complications is patient selection, and the most important step to dealing with complications is patient education and management of expectations.

Complication management necessitates careful patient selection, estimation of operative risks, and patient-adapted selection of procedures. Preoperatively, the problem belongs to the patient. Postoperatively, the problem belongs to the surgeon.

Increasing frequency of obesity, aging population, and multimorbidity patients require more complication prevention discussions. Age alone is not an independent risk factor, but medical complications are more likely to be present in an advanced age population.

Informed Consent

Informed consent is not a signed piece of paper; it is a discussion of the risks and benefits involved, any alternative treatments, and the risks and benefits of doing nothing. For consent to be valid the patient must (1) be competent to take the particular decision, (2) have received sufficient information to make a decision, (3) not be acting under duress.

Universal Protocol

Intended to prevent wrong person, wrong procedure, wrong site surgery in hospitals and outpatient settings. Consists of three steps: (1) A preoperative/pre-procedure verification process. (2) Marking the operative/procedure site. (3) A "Time Out" (final verification) which is performed immediately before starting the operation/procedure.

Standard Precautions

A set of infection control practices used to prevent transmission of diseases that can be acquired by contact with blood, body fluids, non-intact skin, and mucous membranes. Treat each patient as if a potential infection source. Also, protects patients from the physician as a vector.

Questions

1. The buccal branch of the facial nerve innervates which muscles of facial animation: **Procerus, medial, and lower aspect of the orbicularis oculi, nasalis, partial innervation of the zygomaticus major/minor, upper orbicularis oris**

2. Which is the most correct regarding the lymphatic drainage of (1) the upper lip/lateral lower lip and (2) the central lower lip/chin:
   (a) No difference, they both drain to ipsilateral submandibular lymph nodes
   (b) **Upper lip/lateral lower lip drains ipsilaterally (submandibular nodes) and central lower lip/chin drains bilaterally (submental nodes)**
   (c) No submental lymph node drainage is present from these areas
3. What are the soft-tissue layers in the temporal region? What layer does the temporal branch of the facial nerve reside in:
   Skin → SubQ → superficial temporal fascia → loose areolar tissue → superficial layer of the deep temporal fascia → superficial fat pad → deep layer of the deep temporal fascia → deep fat pad → temporalis muscle → pericranium
   On the under surface of the superficial layer of the deep temporal fascia
4. Which fascial layer of the neck is contiguous with the SMAS in the face:
   (a) **Superficial cervical fascia**
   (b) Deep payer of the superficial cervical fascia
   (c) Muscular division of the deep cervical fascia
   (d) Investing layer of the deep cervical fascia
5. What are the four vertical buttresses and four horizontal buttresses of the face:
   Vertical: nasomaxillary, zygomaticomaxillary, pterygomaxillary, mandible condyle/ramus
   Horizontal: frontal, zygomatic, maxillary, mandibular
6. What additional muscles does the trigeminal nerve, branch V3 innervate besides the muscles of mastication:
   Tensor tympani, tensor veli palatini, mylohyoid, anterior digastric muscle
7. What additional muscles does the facial nerve innervate besides the muscles of facial animation:
   Stapedius, stylohyoid, posterior digastric muscle
8. In which ganglion are the cell bodies for the postganglionic parasympathetic fibers of the lacrimation nerve pathway found:
   (a) Lacrimal ganglion
   (b) Greater petrosal ganglion
   (c) Otic ganglion
   (d) **Pterygopalatine ganglion**
9. Name two major differences between the bone scan (bone scintigraphy) and DEXA scan (bone density scan):
   – Bone scan = functional test vs. DEXA = structural test only
   – Bone scan = nuclear based on radioactive particles vs. X-ray based
   – Bone scan = more expensive vs. less inexpensive
10. What is the definition of "depth of field" in photography:
   (a) Distance in millimeters from the optical center of the lens to the focal point, which is located on the sensor
   (b) **Distance between the closest and farthest in-focus areas of a photograph**
   (c) Distance between the optical center of the lens and the object to be photographed
11. Which type of zoom, optical zoom or digital zoom, changes the amount of the scene hitting the sensor, thus allowing for more detail that can be enlarged without distortion or pixilation:
   Optical zoom
12. Typically history alone can diagnose congenital blepharoptosis, but if history is equivocal, which of the following will you see with downward gaze:
   (a) No change in the position of the affected upper eyelid
   (b) **Lagophthalmos of the eyelid due to levator fibrosis**
   (c) Additional descent of the affected upper eyelid, matching the gaze
   (d) None of the above
13. Which of the following descriptions and treatment options best fit the cephalometric diagnosis of "mandibular deficiency":
   (a) **Retrognathism—deficient lower 1/3 with a class II occlusion. Treatment = mandibular advancement**.

(b) Prognathism—a prominent lower 1/3 with a class III occlusion. Treatment = maxillary advancement ± mandibular setback.
(c) Deficiency of infraorbital/paranasal sinuses. Treatment = LeFort I osteotomy with expansion ± bone grafting.
(d) Vertical excess of middle third, convex profile typically a class II occlusion, and lip incompetence. Treatment = LeFort I osteotomy with impaction.

14. List the three phases of wound healing, their duration, and the predominant cell type/processes found in each:

    Inflammatory = days 1–6, macrophages
    Fibroproliferative = day 4–week 3, fibroblasts
    Maturation/remodeling = week 3–1 year, fibroblast collagen synthesis

15. How does smoking affect wound healing on a cellular level by inciting tissue ischemia:
    (a) **Nicotine-induced vasoconstriction via ↑ thromboxane A_2 and platelet aggregation stimulation**
    (b) **Inhaled carbon monoxide binds to hemoglobin resulting in carboxyhemoglobin formation, thus decreasing oxygen delivery**

5 Information Technologies in FPRS

Benjamin C. Paul

Introduction

Understanding information technology is becoming increasingly important. From electronic health records to photographic three-dimensional modeling, information technology impacts many aspects of patient care. Understanding the terminology is fundamental to understanding information technology. As such, terminology is presented at the start of each subsection in this chapter, followed by a focused summary.

The important topics identified in this chapter include computer hardware, software, networking, the Internet, IT legal and security issues, IT and medical education, and miscellaneous topics.

Computer Hardware

Computer Hardware—Terminology:

- **Motherboard**: The motherboard is the main circuit board of a computer. It contains the central processing unit (CPU), the basic input/output system (BIOS), memory, mass storage interfaces, serial and parallel ports, expansion slots, and all the controllers for standard peripheral devices like the keyboard, disk drive, and display screen.
- **CPU (central processing unit)**: Traditionally, the term "CPU" refers to a processor and its control unit (CU), distinguishing these core elements of a computer from external components such as the main memory.
- **Microprocessor**: A major determinant of your computer's "speed." Sets the bandwidth (number of bits processed in a single instruction) and clock speed (how many instructions per second, measured in megahertz (mHZ)).
- **BIOS** (basic input/output system): This is the lowest-level software in the computer. Acts as an interface between the hardware (especially the chipset and processor) and the operating system.
- **ROM (read only memory)**: ROM chips contain permanently written data, called firmware (your BIOS lives here). ROM contains the programs that direct the computer to load the operating system and related files when the computer is powered on. ROM is nonvolatile. ROM chips are usually recorded when they are manufactured.
- **RAM (random access memory)**: This is the short-term memory. AKA primary storage, or internal storage. This is volatile storage: When the power goes, the data goes! RAM is a very important determinant in how fast your computer runs. RAM is especially

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important when editing big digital files such as photos or videos.

- **Hard drive**: Long-term memory storage of programs, documents, files, pictures, etc.
  - Measured in bytes: Small unit of data storage; 8 bytes usually holds one character. Today, hard drive storage is measured in gigabytes (1,000,000,000 bites (10^9)) or terabytes (1,000,000,000,000 bites(10^{12})). 1000 megabytes = 1 gigabyte. 1000 gigabytes = 1 terabyte.
  - Information may be stored in an internal hard drive, external hard drive, and remote "cloud" drive.

Summary of hardware: Computer hardware has become ubiquitous, but sometimes we take the basics for granted. The microprocessor sets the baseline speed of the computer. RAM is useful for short-term memory functions. A small amount of RAM will limit the speed of the computer, regardless of the processor. The hard drive is responsible for long-term memory.

Note: Information may be stored on a remote hard drive and accessed through the Internet via a "cloud" system. In this situation, the Internet connectivity may also be a rate-limiting component of computing speed.

Computer Software

Computer Software—Terminology:

- **Operating system**: An operating system (abbreviated as "OS") is the program that, after being initially loaded into the computer by a boot program, manages all the other programs in a computer. Operating systems provide a software platform on top of which other programs, called *application programs*, can run.
- **Driver**: Software program that controls a piece of hardware.
- **Database**: A large structured set of data; a file that contains numerous records that contain numerous fields.
- **Photography software**: Many different programs exist that allow for storage as well as manipulation of images.
- **Electronic medical records (EMR)**: An EMR is a digital version of a paper chart in a clinician's office. It contains the medical and treatment history of the patients in one practice.

Computer Software: Summary

MAC and PC are the two major operating systems.

Photographic manipulation of images to predict the outcome of proposed surgery is not a guarantee of results—rather is a powerful tool of communication to ensure that the vision of the surgeon and patient is shared. Photographs can be taken and manipulated in 2D or 3D. Surgeons have had medicolegal concern with photomanipulation, though Chavez et al. argue that a well-documented and honest projection using imaging may actually reduce malpractice by improving communication and expectation. Ultimately, malpractice results from communication failures.

Networking

Networking—Terminology

- **LAN** (local area network): Wired or wireless connection between computers in close proximity (often in the same building).
- **WAN** (wide area network): Wired or wireless connection between computers over great distance (up to 10 k kilometers).
- **Server**: A computer or computer program that manages access to a centralized resource or service in a network.
- **Network operations center** (NOC, pronounced like the word *knock*), also known as a "network management center": Is one or more locations from which network monitoring and management are exercised over a computer or telecommunication network.

Primary responsibilities of NOC personnel may include network monitoring, incident response, communications management, and reporting problems.

– **Router**: A networking device that forwards data packets between computer networks. Most familiar is a home router that connects a computer to the Internet.

Internet

Internet—Terminology

- **Internet protocol (IP)**: A computer's unique address or number on the Internet.
- **World wide web (WWW)**: An information system on the Internet that allows documents to be connected to other documents by hypertext links, enabling the user to search for information by moving from one document to another.
- **Internet**: The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to link several billion devices worldwide.
- **Intranet**: A local or restricted communications network (especially a private network) created using World Wide Web software.
- **Virtual private network (VPN)**: Is a network that uses a public telecommunication infrastructure, such as the Internet, to provide remote offices or individual users with secure access to their organization's network.
- **Application service provider (ASP)**: An enterprise that delivers application functionality and associated services across a network to multiple customers using a rental or usage-based transaction-pricing model.
- **E-Mail Variations**:
  – **POP3**: A protocol for receiving e-mail by downloading it to your computer from a mailbox on the server of an Internet service provider.
  – **Internet message access protocol (commonly known as IMAP)**: Is an application layer Internet protocol that allows an e-mail client to access e-mail on a remote mail server.
  – **Simple mail transfer protocol (SMTP)**: Most e-mail systems that send mail over the Internet use *SMTP* to send messages from one server to another; the messages can then be retrieved with an e-mail client using either POP or IMAP.
- **Portal**: An Internet site providing access or links to other sites.
- **Web design**: After purchasing a website, code is written by a web programmer following the owner's directive to construct a website.
- **Search engine optimization (SEO)**: The process of affecting the visibility of a website or a web page in a search engine's "natural" or unpaid ("organic") search results.
- **E-commerce**: Trading in products or services using computer networks, such as the Internet.
- **Social media**: Internet-based communities that allow for the exchange of user-generated content. Examples include Facebook, Twitter, and Realself.

Internet: Summary

The Internet serves as a valuable platform to advertise your practice and connect with patients. There are many potential pitfalls and important articles in the FPRS literature provide certain cautions:

Websites may increase patient consultation requests. When designing a website, many strategies to improve marketing may be employed. The following are 3 tiers of 11 marketing tactics based on ROI (return on investment):

- Tier 1:
  – **Lead tracking** (Any contact initiated by a potential patient through a surgeon's website, whether received from a contact form, quick contact form, consultation request form, or other means, is considered a lead. Lead tracking involves installing tools to store identifiable data about

inquiring patients, including detailed referral source data.)
  - **On-page optimization** (Once the cornerstone of search engine optimization, carefully crafting well-written, original, thoughtfully structured, informative, and engaging content remains a critical key to success on some search engines. Others rely primarily on measures of popularity to determine rankings; most other search engines look for clear signals inside a surgeon's Web pages to judge the value (and therefore ranking) of the site.)
  - **Off-page optimization** (There are two central themes of search engine optimization: (1) improving and continually updating content on the site itself and (2) networking the site with others as a way to demonstrate the site's importance and popularity.)
  - **Lead capture and conversion optimization** (Small adjustments and changes to a website can produce much higher lead capture rates and make it much more likely that a prospect will turn into an actual patient of the practice.)
- Tier 2:
  - **Word-of-Mouth Campaigns**
  - **Directory Advertising**
  - **E-Mail Marketing**
  - **Local Search Marketing**
- Tier 3:
  - **Video Optimization**
  - **Pay-for-Placement Advertisements**
  - **Social Media Marketing**

(Miller RJ, Internet Marketing 401Facial Plastic Surgery Clinics of North America Volume 18, Issue 4, November 2010, Pages 517–523)

Social Media is playing a larger and larger role in marketing and patient education. Roughly half of plastic surgeons routinely use social media. In a survey of the American Society of Plastic Surgeons, most respondents (64.6 %) stated that social media had no effect on their practice, whereas 33.8 % reported a positive impact and 1.5 % reported a negative impact.

Vardanian AJ, Kusnezov N, Im DD, Lee JC, Jarrahy R. Social media use and impact on plastic surgery practice. Plast Reconstr Surg. 2013 May;131(5):1184–93. doi: 10.1097/PRS.0b013e318287a072.

An older article in the compendium from 2009 reviewed the role of social media in medicine. The following is a summary of recommendations:

- Do not invite a patient to become an online friend.
- Avoid accepting friendship with patients on social media.
- Be thoughtful when using social media (Twitter, Facebook) for personal use.
- Use conservative privacy settings.
- Respect patient's privacy and comply with privacy laws (e.g., HIPAA).
- Consent patients specifically for use of photography in social media.

SOCIAL MEDIA (Guesh II—J Med Ethics 2009:35: 584–586).

When using your website for E-commerce, certain functional and ethical considerations must be made:

- E-commerce must function efficiently and securely.
- There are no direct restrictions on advertising by physicians. There are general laws though that all must follow to protect the public from deceptive practices.
- AMA issued the guidelines for truthful advertising—1992:
  - Advertisements should not contain material false claims or misrepresentations of material fact.
  - There should not be knowing omissions of material fact from advertisements.
  - Physicians should be able to substantiate material objective claims and representations made in an advertisement.
- Additional criteria for websites recommended:
  - The language on the Web should be easily understandable.

- The viewpoint should be from that of the patient.
- Claims should not be overly exaggerated.
- Claims should not be directed to the anxiety, fear, or hope of patients.
- Advertisements should be identifiable as advertisements.

E-COMMERCE: Facial Plastic Surgery Web Site Ethics (Meyers, Arch FPRS Vol 3 Jan–Mar 2001)

IT Legal and Security Issues

IT Legal and Security Issues—Terminology

- **HIPAA (Health Information Portability Accountability Act)**: Written in 1996, the primary goal of the law is to make it easier for people to keep health insurance, protect the confidentiality and security of healthcare information. and help the healthcare industry control administrative costs.
- **PHI (Protected Health Information)**: Information meets the definition of PHI if, even without the patient's name, if you look at certain information and you can tell who the person is then it is PHI.
- **HITECH Act (The Health Information Technology for Economic and Clinical Health)**: Enacted as part of the American Recovery and Reinvestment Act of 2009 to promote the adoption and meaningful use of health information technology.
- **Meaningful use**: Term to describe using electronic health records (EHR) to improve quality, safety, and efficiency, and reduce health disparities. There are a set of objectives that eligible professionals (EPs) and hospitals must achieve to qualify for Medicare and Medicaid Services Incentive Programs.
  - Meaningful Use is being implemented in three stages over 5 years: Stage 1—2011–2012: Data Capturing and Sharing, Stage 2—2014: Advanced clinical processes, Stage 3—2016: Improved Outcomes.
- **SSL (secure socket layer)**: SSL provides a secure connection between Internet browsers and websites, allowing you to transmit private data online. Sites secured with SSL display a padlock in the browsers' URL and possibly a green address bar.

http://www.healthit.gov, http://www.hhs.gov/ocr/privacy/

IT Legal and Security Issues: Summary

PHI includes names, dates relating to a patient (i.e., birthdates, dates of medical treatment, admission and discharge dates, and dates of death), telephone numbers, addresses (including city, county, or zip code), fax numbers and other contact information, social security numbers, medical records numbers, photographs, finger and voice prints, and any other unique identifying number.

The penalty for breaking HIPAA is tiered:

1. Individual did not know (and by exercising reasonable diligence would not have known) that he/she violated hipaa → \$100 per violation, with annual max of \$25 K for repeat violations.
2. Violation due to reasonable cause and not due to willful neglect → \$1000 per violation, \$100 K max, possible imprisonment of 1 year.
3. HIPAA violation to willful neglect, but violation is corrected within 30 days → \$10 K per violation, \$250 K max, possible imprisonment of 5 year.
4. HIPAA violation to willful neglect, but violation is NOT corrected within 30 days → \$50 K per violation, \$1.5 million max, possible imprisonment of 10 years.

http://www.ama-assn.org/ama/pub/physician-resources/solutions-managing-your-practice/coding-billing-insurance/hipaahealth-insurance-portability-accountability-act/hipaa-violations-enforcement.page?

IT and Medical Education

IT and Medical Education: Terminology IT and Medical Education

– **MEDLINE®**: Contains journal citations and abstracts for biomedical literature from around the world.
– **PubMed®**: Provides free access to MEDLINE and links to full-text articles when possible.
– **Web resource**: A resource on the Internet for physicians regarding the medical care. Examples include Medscape, Uptodate, and Epocrates.
– **Online CME** (Continuing Medical Education): The Internet provides rich opportunity to achieve CME credits for hospital and board credentialing.

Miscellaneous: Photography in Facial Plastic Surgery

Digital photography with a dSLR (digital single-lens reflex) is the gold standard, though most are familiar with a PAS (point-and-shoot). dSLR cameras involve interchangeable lenses, higher resolution, increased control of settings, and compatibility with external lenses.

PAS cameras, especially cellphone cameras, suffer from "parallax" where the middle third of the picture is stretched and the outer thirds are compressed, as if taking a picture of globe.

New dSLR cameras can cost anywhere from a few hundred to a few thousand dollars. Classically, a 35 mm "full-frame" sensor costs >2500 $. If your camera costs less than this, then you likely have an APC or "cropped lens" sensor. What this means is the sensor that captures the image is smaller and your image is magnified. Canon and Nikon are the most common brands that have "crop factors" of 1.5 or 1.6. So if you have a 60 mm lens with a crop factor of 1.5 → you are effectively shooting with a (60 × 1.5) 90 mm lens.

"Focal length" basically means the angle of view. A high focal lens distance (say 200 mm) has a very narrow angle of view. A low focal lens (say 8 mm) will be very wide. An 8 mm lens with curved glass is used in a fish eye.

The ideal portrait lens is 100 mm. So if you have a full-frame sensor, then buy the 100 mm lens. If you have a cropped sensor, then get a 60 mm.

"Macro" lenses have additional corrective groups that allow for improved close-up photography, focusing within inches of the subject. These lenses are worth the cost. Most macro lenses are prime lenses, meaning they have a fixed focal length. Thus, they do not zoom.

Most cameras have a flash integrated into the top of the body. External flashes allow for improved photography by minimizing shadows. Ideally, two external flashes positioned 45° from the midline of the patient will create a balance of light to reduce asymmetry from shadows. Alternatively, a ring flash may be attached to the end of the lens to create light from all directions. This is very good for intraoperative photography and for illuminating cavities (oral cavity). Be wary that too much light will flatten out the details of the face and skin.

Patient positioning is very integral to reliable photography, and it is probably the most common error during portrait photography. The patient should be seated in a way that posture is erect. Be wary of head tilt. The Frankfort horizontal ensures that the head is positioned correctly. This is defined as an imagined line parallel to the floor that passes through the superior border of the external auditory canal or tragus and the inferior orbital rim.

The following chart reviews the standard positions for facial photography (see Table 5.1).

Additional Resources

1. Conde C. Medbloggers beware: watch what you say on the web. Tex Med. 2009;105:29–32.

Table 5.1 The standard positions photographed in facial plastic surgery

Position	Notes
Frontal view	See both ears, position camera so that center is at eye level
Oblique—three-quarter view	Have nasal tip aligned with the edge of far cheek
Lateral view	Keep in Frankfort horizontal Be wary of head tilt Be wary of chin projection in neck evaluation
Base view	Nasal tip should be inline with medial brows/glabella—only view not in Frankfort horizontal

2. Guseh JS, Brendel RW, Brendel DH. Medical professionalism in the age of online social networking. J Medical Ethics. 2009;35:584–6.
3. Hawn C. Take two aspirin and tweet me in the morning: how twitter, Facebook, and other social media are reshaping health care. Health Affairs. 2009;28(3):361–8.

Questions

1. Which of the following LEAST influences the speed of your computer?
   (a) Microprocessor
   (b) RAM
   (c) ROM
   (d) Hard drive
   Answer: ROM
2. ____ ____ ____ is the process of affecting visibility of a website or web page.
   Answer: Search engine optimization
3. You know that you have a secure socket layer connection when you see what two identifiers?
   Answer: (1) a padlock in the browsers' URL and (2) green text in the address bar
4. When marketing, which of the following is most valuable?
   (a) Word-of-mouth campaigns
   (b) Lead tracking
   (c) Directory advertising
   (d) E-mail marketing
   (e) Social media marketing
   Answer: Lead tracking
5. True or false? When patients pay for their healthcare bills, "out of their own pocket," they can have information kept private from their health insurance plan?
   Answer: TRUE
6. True or false? If a patient requests copies of their PHI, the covered entity may impose a fee for labor, photocopying, supplies, and postage.
   Answer: TRUE
7. True or false: The non-compliance of HIPAA rules could lead to civil and criminal penalties.
   True
8. YES/No—An FPRS practice requires all patients to sign in when they arrive at the office. Is this a violation of HIPAA?
   Answer: NO
   Covered entities, such as physician's offices, may use patient sign-in sheets or call out patient names in waiting rooms, as long as the information disclosed is appropriately limited. The HIPAA Privacy Rule explicitly permits the incidental disclosures that may result from this practice, for example, when other patients in a waiting room hear the identity of the person whose name is called, or see other patient names on a sign-in sheet. However, these incidental disclosures are permitted only when the covered entity has implemented reasonable safeguards and the minimum necessary standard, where appropriate. For example, the sign-in sheet may not display medical information that is not necessary for the purpose of signing in (e.g., the medical problem for which the patient is seeing the physician). See 45 CFR 164.502 (a)(1)(iii).
9. Using a Nikon D90 dSLR (APC crop 1.5), you buy the same lens as your mentor, a prime 100 mm macro lens. You find your

experience frustrating as you are standing at the edge of the operating room to get patient's face fully in the frame. What went wrong?
Answer: Nikon D90 has a cropped sensor. You are shooting with 1.5 × 100 → or a 150 mm lens. This will have a very narrow viewing angle. You should have purchased a 60 mm macro lens.

10. How do you maintain consistency when shooting a base view of a patient?
Answer: Ask the patient to look up, and position the nasal tip between the medial eyebrows.
11. What are the important images taken in rhinoplasty?
Answer: Frontal, base, right and left oblique, right and left lateral.
Note: You can also ask the patient to smile in any view to appreciate dynamic change of the nose/nasal tip.

Legal, Ethical, and Socioeconomic Issues in Facial Plastic Surgery

6

Andrew Kroeker

Legal Issues

Informed Consent

- Term first used in 1957 malpractice case, now legally formalized
- Legal concept: implies three components
  - **"Disclosure"**
    Necessary information must be provided to the patient to make an autonomous decision; provider must ensure information is understood
    Written in layman language at a level appropriate for the general patient population (i.e., 8th grade reading level)
  - **"Competency"**: provider must assess the patient's ability to assess the information provided and ability to reasonably infer the consequences of undertaking the proposed
  - **"Voluntary consent"**: i.e., Autonomy—relates to the patient's right to make a decision, free from coercion, manipulation, or other outside force.
- Informed consent documentation and/or discussion must include:
  - **Diagnosis**
  - **Nature/purpose of proposed treatment and anticipated benefits**
  - **Risks, complications, and side effects of intervention**
  - **Probability of success and possible consequences if medical advice is not followed**
  - **"Alternatives to treatment"**
- Photography Consent
  - *Confidentiality*: treated with same safeguards as other portions of the medical record, encompassed within HIPAA guidelines
  - *Copyright*: images are "owned" by the physician, but must have explicit written permission from the patient and patient must understand that the photos are used to promote the physicians practice.
  - "*Misappropriation of likeness*"—legal term that applies specifically to the use of famous people's images without consent
  - Images can never be used for nonmedical reasons (i.e., personal enjoyment, practical jokes)
  - Images cannot be used if they are displayed in a manner not anticipated by a patient
  - Use of **"before and after"** images:
    Should be taken in similar lighting and background conditions

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Patients should understand that results may vary and these images may reflect the best outcomes

Regulations vary in the use of these images, based on individual state statutes

- Computer modeling: patients should sign an acknowledgment of the limitation of software (perceived misrepresentations by patients and “guarantees” have been the focus of malpractice lawsuits)

- Consent of a minor
  - **“Consent by proxy”** via parents until age 18, but recommendations are to procure adolescent children’s **assent** to procedure
  - *Exceptions*: legally emancipated children, specific issues related to sexually transmitted diseases and pregnancy testing/procedures
  - Physician responsibility to the patient preempts religious or other philosophical objections of family members, if physician deems necessary (beneficence principle, but must proceed through proper legal channels)

“Standard of care”: defined as the care that the average, careful, and prudent practitioner of one’s specialty would be expected to meet under the same circumstances.

“Affirmative duty”: legal concept under which the physician is required to volunteer information to the patient, rather than wait for a question.

Liability

- **Liability**: legal responsibilities for one’s actions or omissions.
- **“Prudent person”**: legal concept in which physician has **no liability** as long as a **reasonable and prudent person** in that patient’s position would have **accepted the treatment had he or she been adequately informed of all significant risks**
- **Vicarious liability**: legal concept of secondary liability, in which the employer is responsible for the actions or omissions of their employees, as long as they are working within the confines of their job. Related concept: see “Borrowed servant” component of medical negligence.

Record Keeping and Protected Health Information (PHI)

- Important to maintain accurate, timely, and secure medical records
- Never alter the medical record
- Correcting inaccuracies in the medical record:
  - Never change or erase what is already present
  - Should include a narrative entry into the medical record explaining the error and describing the correct information, time and date the correction
  - The original information should be viewable

Duty to finish care, regardless of ability to pay: once a physician has entered a formal doctor-patient relationship and care has been provided, care for that patient is the responsibility of the doctor regardless of whether the patient can meet financial obligations, until no further care is required.

Injectables and Fillers

- Drug vs device: based on whether effect is via chemical action
- Drug: Botulinum toxin
- Device: collagen and hyaluronic acid injectable fillers
  - FDA approval & **“off-label”** use
  - Drug must be approved for specific use, i.e., labeled and approved for marketing, allows for “off-label” use.
  - It is illegal to commercially advertise for any nonapproved or off-label use
- Local and state regulations vary with regard to who can administer fillers/injectables

  - Drugs and devices from outside the United States, not approved by FDA: only in clinical study protocols (or occasionally for life-threatening emergencies)

Medical Negligence/Malpractice

- Four general elements to prove in medical negligence/malpractice case
  - Physician **duty** to care for the patient—i.e., agree to treat the patient. Stems from basic ethics of doctor-patient relationship
  - **Breach of duty**: the physician did not perform to the level of the accepted **standard of care**
  - **Causal relationship**: violation of standard of care must have led directly to a bad outcome
  - **Damage**: a loss/injury must have occurred to the patient that can be compensated
- "Borrowed servant": negligence based on three legal elements
  - Employee was negligent
  - The physician possessed appropriate training, supervision, and control over employee
  - The negligent actions were within the scope of the employee's job description
- "*Res Ipsa Loquitur*" = "the act speaks for itself," legal concept referring to an act of negligence so egregious that the case does not require expert witness testimony.

Legal Issues Associated with Treating "The Unhappy Patient"

- Continue to treat the patient until they find care elsewhere
- Be courteous and kind to the patient, instruct office staff to do the same in all interactions
- Promptly make copies of all patient records upon request
- Notify your malpractice insurance carrier, even if only an "occurrence" and not yet a "claim"
- **Never alter** any aspect of the medical record
- Respond promptly to the state medical board, if inquiries are made

If a Case Goes to Trial...

- Promptly notify your malpractice insurance carrier as soon as a claim is received
- Hire a lawyer for the state medical board (interview multiple attorneys, talk to physicians they have represented). The insurance carrier will hire one for the court case, but investigate the lawyer and assure they have a good track record, work well with others, etc.
- Research the case extensively, insist the attorney perform a thorough "dress rehearsal"
- Assist in finding experts, texts, and journal articles to support your case
- Research the plantiff's expert witness
- Give testimony at your attorney's office, not your office
- Insist on reviewing the trial strategy with your attorney
- If insurance company decides to settle...
  - Settlements go into the National Physician Databank
  - You have a right to refuse, but understand the specifics of the policy as it relates to your own liability
  - If settlement is above policy limit, hire your own attorney to demand the insurance company settle within the limits of the policy.

Termination of Doctor-Patient Relationship

- May occur via mutual agreement, or by either party going through appropriate channels to end the relationship
- Lost to follow-up: a physician's duty is not relieved because a patient fails to return for care, reasonable effort must be made to ensure appropriate follow-up

- Termination must abide by the following criteria:
  - Determination that no further treatment necessary
  - Referral to another physical with patient consent
  - Sufficient notice to patient must be given to obtain care elsewhere, with the request made with registered letter
  - If these are not met, **regardless of patient ability to meet financial obligations**, can be considered **"abandonment"** (unilateral termination without effort to find competent and equivalent care)

Ethical Issues

Ethical Principles

- *Autonomy*: Ensures the patient have freedom of thought, intention, and action to make their own healthcare decisions
- *Beneficence*: Ensures a given action is carried out with the intention of benefiting the patient. Encompassed within this is that physicians develop and maintain skills and knowledge, continually update training, consider individual circumstances of all patients, and strive for net benefit to the patient. Dominated more traditional concepts of doctor-patient relationship, including original Hippocratic teachings.
- *Nonmaleficence*: Responsibility of physician to ensure all effort is taken to not harm the patient. Latin: *primum non nocere* = "first, do no harm"
- *Justice*
  - Requires that the burden and benefit of new or experimental treatments be distributed among all members of society.
  - Must consider four main areas when evaluating justice: fair distribution of scarce resources, competing needs, rights and obligations, and potential conflicts with established laws.

Doctor-Patients Relationship

- Historical precedence: Hippocrates and the Hippocratic Oath laid foundation of relationship
- **Physician duty**: "responsibility to treat patients with the reasonable diligence, skill, competence, and prudence as practiced by reasonably competent physicians in the same specialty"—establishes standard of care
- Privacy and trust: the fundamental component of the relationship that allows for full disclosure and honest communication necessary for patient care
  - **Exception**: patient threatening harm to self or others
- Understand and accept personal limitations: be honest about the limits of your ability

Discussion of medical errors: straightforward component of the underlying ethic of the doctor-patient relationship. More subtly in "errors" that do not cause a measurable effect.

Conflicts of Interest

- Personal
  - **Religious and political philosophies**: the physician must understand both personal and patient context and how this may affect care provided
- Professional
  - Financial
    Inherent conflict in fee-for-service healthcare economic model
    Decision to choose specific health insurance providers and not others
  - **Relationship to pharmaceutical industry**: Data shows that acceptance of gifts can influence medical decision making
  - Endorsements/Speaking arrangements: require full disclosure. Physician should be aware of clinical practice as it relates to corporate ties
- Physicians who are "aware" of outside interests are more likely to achieve ethical outcomes in medical care

Physician Duty to Adhere to Good Patient Selection Criteria

– Can help to avoid patient dissatisfaction
– Avoid unnecessary procedures

Online Ethics

- AMA guidelines for health information websites, area that require quality standards
  - *Content*: disclosure, authorship, and attribution should always be provided, independent expert review
  - *Advertising and sponsorship*: must be easily distinguishable from editorial content
  - *Privacy and confidentiality*: must state explicit policies, ensure patient privacy
  - *e-commerce*: must function efficiently and securely

    AMA Guidelines for Truthful Advertising of Physician Services, 1992

    (a) Advertisements should not contain material false claims or misrepresentation of material fact
    (b) Advertisements should not contain material implied false claims or implied misrepresentation of material fact
    (c) There should not be knowing omissions of material fact from advertisements
    (d) Physicians should be able to substantiate material objective claims and representations made in an advertisement

- Other areas, if listed on the website, that a surgeon must be able to substantiate: licensure, board certification, memberships, years of experience, subspecialization/unique skills
- Financial conflicts should be disclosed on the surgeons website
- Fees and cost listed shall not be misleading
- Success rates, if listed, must be explained
- Images: should accurately depict the results of services, should be only of the surgeons own patients, and should have full written consent for display in a public setting

Socioeconomic Issues

Trauma

- Patient population differs from standard Facial Plastic patients
  - Higher percentage of trauma patients will not pay bill and do not carry insurance
- Duty to treat: ethical considerations as above, and legal issues associated with Emergency Medical Treatment and Active Labor Act of 1986

Resource Allocation

- **Distributive justice** concept in reconstructive surgery (cosmetic surgery not considered in this context), in the climate of increasing fiscal constraints
- Elective non-life-threatening reconstructive surgery
  - Children vs adults: should the focus be on children?—society question
- Argument for intervention: moral judgments are related to how society perceives a "normal appearance" and negative consequences associated with abnormal appearances
- Society must determine relative value of procedures performed based on financial limitations and available finite resources

Non-reimbursed Care

- Emergency Medical Treatment and Active Labor Act of 1986
  - Prevents practice of "dumping," applies to all hospitals accepting Medicare
  - Requires the examination, treatment, and stabilization of all patients prior to transfer
  - Same legal requirements for insured and uninsured patients
- On call responsibilities: principle applies, as does requirement to assure appropriate follow-up even if patient not seen.

Questions

1. Name and describe the four fundamental ethical principles.
2. True or false. A calculation mistake made by a medical assistant in your clinic results in a patient receiving ten times the expected concentration of Botox. This results in significant bilateral brow ptosis. As the treating physician, you are medically liable for this mistake.
3. List the five components of "informed consent."

Psychosocial Aspects of FPRS

7

Anita Konka

The psychological aspects of plastic surgery as discussed below pertain to elective cosmetic surgery patients. Craniofacial, trauma, and reconstructive psychological factors are discussed later in this chapter.

Fundamental Principles of Psychological/Psychosocial Aspects of Elective Plastic Surgery Procedures

- Procedures exist beyond the realm of organic disease or physical trauma
- Improvement in physical appearance is only part of the motivation to undertake surgery
- Procedures are performed for the purpose of altering physical appearance in order to achieve psychosocial benefit.

Surgeon's Role

- In addition to the standard responsibilities of a physician, the plastic surgeon also takes on a psychosocial role
- Grossbart and Sawer outline the role of "biophysical surgeon" in three ways:
  - The cosmetic surgeon as a corrective surgeon who alters undesired physical characteristics without precipitation of physical trauma or genetic anomaly
  - The cosmetic surgeon as a social engineer who moderates the impact of ethnic or racial prejudice and ageism in employment or social contexts
  - The cosmetic surgeon as a "psychotherapist with a scalpel," who treats the adverse emotional impact of some aspect of plastic surgery.
- These identities are historically and socially based
  - Begins with credibility the field gains in treating the posttraumatic deformities of WWII
  - Progresses with the social, ethnic, economic, and technological changes that have developed since.
- DeVries outlines the incorporation of six key competencies for the modern plastic surgeon's successful fulfillment of his or her role
  - The influence of gender
    - Women predisposed to desire appearance of youth and health/active strategy to cope with transitions of life
    - Men may be more interested in combatting age or altering features to maintain or achieve a strong, powerful look

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  - Ruling out psychopathology
  - Including the patient's social world
  - Coping, stigma, and psychosocial history
  - Follow-up and a referral team
- Understanding the psychological motivation of plastic surgery patients is part of managing expectations between physician and patient.
- It is critical to optimizing surgical care and outcomes and is necessary to identify those patients who are at higher risk of being poor surgical candidates.

Profile of Cosmetic Surgery Patients

- Studies that ask "is there a common patient profile" aim to:
  - Delineate psychological/psychosocial motivations for surgery
  - Identify problem patients with psychological conditions who are risky surgical candidates or who may need psychological treatment instead.
- Motivating factors:
  - External motivators: fear of age discrimination, coercion by family, friends, coworkers, avoidance of ethnic prejudice
  - Internal motivators: diminish unpleasant feelings associated with depression, shame, social anxiety, reduce psychosocial distress
  - Desire to address a specific feature that a patient dislikes or finds distracting
- Identifying psychopathology:
  - 1950s–1960s: Interview-based studies reported majority of patients had significant psychopathology (personality disorders, neuroses, psychoses)
  - 1970s: Interview-based studies suggest that depression, anxiety, low self-esteem might be more enduring in cosmetic surgery patients
  - 1970s–1980s: Objective psychometric tests indicate patients undergoing rhinoplasty, rhytidectomy, and breast augmentation are ***no more emotionally disturbed than the general population***
  - Paradigm change: Contradictory evidence as above suggests that cosmetic surgery patients are both emotionally disturbed and psychologically normal
  - New hypothesis: Cosmetic surgery patients may suffer ***above average dissatisfaction with overall body image***, possess resources to seek change
  - Sarwer et al. 1997: First to debunk above hypothesis

    Case-control study of 100 cosmetic surgery patients

    Cosmetic surgery patients did not have greater dissatisfaction with body image

    However, cosmetic surgery patients had ***significantly greater dissatisfaction with specific bodily features***

    6–16 % met diagnostic criteria for body dysmorphic disorder (BDD)

    Further investigated type-changing vs. restorative procedures

    (a) Type changing: rhinoplasty, breast augmentation/reduction
    (b) Restorative: Facelift, blepharoplasty, liposuction
    (c) (Type changing often presumed to have more profound psychological impact than restorative procedures)

    No difference in body image perception between type-changing and restorative patients

    Type-changing patients showed significantly greater number of BDD symptoms

Body Image

- Considered the most important measure when estimating the effects of appearance changes.

- Defined as "the internal representation of the self's outer appearance".
- ***Tridimensional conception of one's own body involving interpersonal, environmental, and temporal factors***. The possession of certain characteristics is colored by feelings about their value.
- It is necessarily subjective and changing someone's appearance is a positive event only if that person considers it an improvement.
- ***Dissatisfaction with body image is considered a major motivation for patient's seeking cosmetic surgery***, though overall body image dissatisfaction is not significantly different between plastic surgery patients and the general population.
- Patients undergoing cosmetic surgery have been described as assigning high valence but low value to their own attractiveness
  - View beauty as an important quality (high valence), but find themselves unattractive (low value)

Body Image: 4 Stages of Development

- **Stage I**: The earliest months of life where children learn how to think about themselves and develop feelings of self based on the attention, love, and approval in their environment. This forms the foundation of a positive body image.
- **Stage II**: Begins when a child starts school (five or six), when he or she leaves the home environment, and encounters outside perception. Positive or negative feedback from the outside world influences personal confidence and patterns of thinking regarding body image.
- **Stage III:** Occurs during adolescence and puberty. Changes in height, facial features, and secondary sex characteristics can create vulnerability and sensitivity to opinions and impressions formed by peers. If feedback is negative during adolescence, one may develop a negative pattern of body image.
- **Stage IV**: Senescence. With aging occurs the loss of the youthful appearance. The older person may perceive this as weakening of the body and may avoid situations where he or she was previously comfortable with her body image.

- Plastic surgery offers the potential to change body image and is successful when this change is perceived as an enhancement by the patient
- Extreme body image dissatisfaction is a symptom of BDD

Body Dysmorphic Disorder (BDD)

- BDD involves a preoccupation or obsession with physical features that is far beyond what is considered normal.
- Associated with depression
- BDD is the only body image-related diagnostic category addressed in the DSM-V (Table 7.1).
- DSM V criteria also account for clinical impressions of whether the individual has good, poor, or absent (delusional) insight regarding their BDD beliefs.
- Patients with BDD can present with different levels of the disorder
- ***Patients will focus on an average of five different body parts over the course of the disorder*** (Table 7.2).
- This means that while preoccupation with one feature may resolve, preoccupation with another is very likely to develop.

Table 7.1 Body dysmorphic disorder (DSM V)

1.	Preoccupation with one or more perceived defects or flaws in physical appearance that are not observable by or appear slight to others
2.	During the course of the disorder, the individual has performed repetitive behaviors (e.g., mirror checking, excessive grooming, skin picking, or reassurance seeking) or mental acts (e.g., comparing his or her appearance with that of others) in response to the appearance concerns
3.	The preoccupation causes clinically significant distress or impairment in social, occupational, or other important areas of functioning
4.	The appearance preoccupation cannot be better explained by concerns with body fat or weight in an individual whose symptoms meet diagnostic criteria for an eating disorder

Table 7.2 Ten most perceived facial defects in patients with BDD

Body part	% of patients with concern
Skin	73
Hair	56
Nose	37
Eyes	20
Teeth	20
Ugly face	14
Lips	12
Chin	11
Eyebrows	11
Ears	9

- Exhibit behavior to "camouflage" defect (clothing, makeup)
- Often exhibit surgically addictive behaviors in an attempt to remedy perpetual dissatisfaction
- These are dangerous patients for the aesthetic surgeon as they usually cannot be satisfied unless BDD is treated successfully by mental health professional
- Patients rarely comprehend limitations of surgery (delusional fixation)
- Almost always desire multiple procedures (insatiable desire for surgery) "When can we schedule the next surgery?"
- While 30 % of surgeons believe that patients who have BDD are not surgical candidates, ***these patients should not be dismissed immediately***.
- Close cooperation with a psychiatrist who specializes in body image and who can offer counseling (cognitive behavioral therapy) and pharmacotherapy should be offered.
- ***Cooperation and communication between surgeon and psychologist/psychiatrist may allow for successful surgical outcome and management of patient expectations***.

Identifying Problem Patients

- Most patients seeking cosmetic surgery procedures appear psychologically healthy; however, some are not
- The ideal patient has legitimate concerns and realistic expectations; is secure and well-informed; and understands the limitations of surgery
- Patients with untreated psychopathology can have negative outcomes that create problems for both patient and surgeon
  - Problems encountered by the patient:
    Requests for repeated or revision procedures
    Depression, adjustment problems, social isolation, familial dysfunction, self-destructive behaviors
    Anger toward the surgeon and/or staff
  - Problems encountered by the surgeon:
    Distress to themselves and their colleagues
    Harassment by patients for further surgical procedures
    Complaints and legal action

- ***Tip-offs to "possible trouble"***
  - Obsessive–compulsive behavior
  - Excessive doctor shopping
  - Urgent demand for surgery without due consideration
  - Extreme flattery
  - History of litigation
  - Poor hygiene
  - Motivation based in interpersonal issues
  - Unreasonable or unrealistic expectations
  - SIMON (rhinoplasty)
    Single, immature, male, over-expectant, narcissistic

Patient Selection and Assessment Tools

- The patient's consultation interview should give ample time to include information about the patient's social network, family, and significant others.
- Obtain full medical, including psychiatric history (patient may willingly omit details)
- Complete medication history
- Social history
- Smoking history

- Basic labs
- Agendas to assess in the consultation
  - Psychological agendas (surgery as means to improve an emotional state brought on by major life changes such as familial death or to diminish depression, shame, social anxiety)
  - Interpersonal agendas (hoping to improve a relationship, compensating for a personal loss, hoping to facilitate future relationships)
  - Social agendas (employability, social status)
- ***Psychosocial assessment tools include validated instruments***
  - ***Multidimensional Body-Self Relations Questionnaire (MBSRQ) (Measures body image)***
  - ***Body Dysmorphic Disorder (BDD) Examination Self-Report (BDDE-SR). (Measures body image dissatisfaction and the symptoms of BDD)***
- Photo documentation
  - Digital imaging can be used to assess perceptual dimensions of body image

Outcomes

- It has been assumed that a positive change in physical appearance for the patient will lead to an improvement in their psychological well-being, including their self-confidence and self-esteem.
  - BUT patient satisfaction with procedures and changes in psychosocial status are two different, although related, issues.
- Patient Satisfaction
  - Has the surgery met the patient's expectations of cost (physical, emotional, financial)?
  - Has the surgery met the patient's expectations of benefit (physical and psychosocial)?
  - A "successful result" for patient and surgeon
- Most studies investigating the psychological impact of plastic surgery on appearance concerns are methodologically flawed
  - Moss and Harris 2009: prospective cohort study comparing pre- and postoperative psychological outcomes in aesthetic and non-appearance changing surgery patients.
  - Measured differences in anxiety and emotional/behavioral difficulties related to appearance between cohorts, using validated instruments
  - ***Preoperative anxiety was higher in aesthetic surgery patients than control***
  - ***Postoperative anxiety was lower in aesthetic surgery patients than control (two-way interaction was significant)***
  - For appearance concern, aesthetic surgery patients had significantly improved scores postoperatively vs. controls
- Other interview studies report a reduction in depression and anxiety in patients following cosmetic surgery
- Factors associated with poor psychosocial outcome:
  - Being young, being male, having unrealistic expectations of the procedure, previous unsatisfactory cosmetic surgery, minimal deformity, motivation based on relationship issues, and a history of depression, anxiety, or personality disorder.
  - Body dysmorphic disorder was also recognized by some studies as a predictor of poor outcome
- Anticipatory guidance has been shown to positively influence surgical outcomes immediately post-op
  - Patients who receive anticipatory guidance require less pain medication in the postoperative period, had smoother convalescence and earlier discharge from hospital

Anxiety Disorders in Plastic Surgery

- Surgery is a stressful event with the potential for significant disturbance to a patient's psychological and physical homeostasis.
- The plastic surgeon should be an expert in understanding "what is abnormal anxiety?"

- Cosmetic surgery is an especially intense psychological experience because in addition to the usual concerns of surgery, these patients bring added expectations that can contribute to the anxiety of disappointment.
- 55 % of all cosmetic patients experience a psychological reaction, mainly increased anxiety or depression during the postoperative period.
- Goin 1979: Prospective study of female facelift patients demonstrated that 54 % of patients had clinical evidence of psychological disturbances that was denied to the surgeon on written reports and only revealed to the psychiatrist.
- Surgery may induce a complex set of psychological symptoms, possibly reflecting additive effects of previous traumas or maladaptive coping patterns → increased levels of anxiety
- Severe anxiety related postoperative reactions include
  - Panic attack

    Discrete period of intense fear or discomfort, accompanied by at least four somatic or cognitive symptoms
  - PTSD

    Extreme anxiety following exposure to traumatic stressors involving direct personal experiences

    Lasts > 4 weeks
  - Acute Stress Disorder

    Immediate response to traumatic or stressful event that lasts at least 2 days, does not persist beyond 4 week after trauma or crisis.

    Sx: inability to concentrate, avoiding pleasurable activities, recurrent images/dreams/flashbacks of trauma. “Reliving the trauma of surgery”
- Close follow-up by plastic surgery team is essential, but these patients must also be promptly referred to a mental health professional.
- In general, patients who are less anxious during perioperative period report less emotional distress, fewer defensive behaviors, and are more likely to be satisfied with surgical outcomes

Special Circumstances: The Craniofacial, Reconstructive, and Adolescent Patient

- Facial attractiveness has a strong effect on interpersonal impressions.
- Facial deformities caused by trauma, congenital disabilities, and postsurgical sequela (reconstruction/scar revision) present with significant adverse functional consequences
- Rankin and Borah 2001: Compared “abnormal” congenital and posttraumatic deformity photos with digitally altered “normalizations” of same patients, reviewed by independent evaluators
- ***Patients with abnormal facial features were rated as significantly***
  - ***Less honest, less employable, less trustworthy, less optimistic, less effective, less capable, less intelligent, less popular, and less attractive***
- Sarwer 1998: Case-control study comparing 24 patients with craniofacial anomalies with age- and gender-matched controls
  - Measured body image dissatisfaction, self-esteem, quality of life, and experiences of discrimination
  - Craniofacial patients had greater dissatisfaction with facial appearance
  - Even after extensive surgical correction, 2/3 considered their facial attractiveness as neutral or unattractive
  - ***Craniofacial patients reported lower self-esteem, quality of life***
  - Subset of patients experience psychological problems that warrant formal treatment
  - Dissatisfaction with appearance is not universal; some report normal self-esteem and quality of life factors delineating this disparity are unknown.

Adolescent Patients

- Patients can present with congenital, aesthetic, or functional concerns
- Unique challenges:

  - Counseling includes patient when possible (awake, old enough, has comprehension, emotionally and intellectually mature)
  - Must account for parent/guardian as decision makers
  - Deformities with distinct physical and functional impairment (otoplasty, cleft deformity): proceed with parent/guardian approval
  - Traumatic deformities (rhinoplasty): should be delayed until child matures
- Koot et al. 2001: "Determine the effect of appearance related surgery on psychosocial functioning during adolescence"
  - Do adolescents benefit from plastic surgery?
  - Measured ratings of appearance, bodily satisfaction/attitudes, and appearance-related burdens between study group of aesthetic and corrective (congenital/acquired deformity) adolescent surgical patients and a general population sample
  - All surgery patients had significant decrease in burdens post-op
    - Implication: Much more prominent improvement in patient sample compared with regular development changes that occur in adolescence
    - Aesthetic group reported least appearance-related burdens post-op
    - Aesthetic "breast" corrections were most rewarding, least burden reported post-op
    - In both study and general population, body appraisal increased over time → maybe adolescents' self-assessments would improve over time, without surgery
    - Did not find expected changes for improved outcomes in cleft lip and craniofacial patients as reported by others.
      (a) May be an effect of adolescents having prior face/nose/lip interventions in childhood and therefore already well-adjusted/able to cope
    - Conclusion: adolescents may benefit from plastic surgery, particularly aesthetic breast surgery, in manner not accounted for by "natural" development.

Questions

1. How many stages are involved in the development of body image throughout life?
   (a) **4**
   (b) 3
   (c) 6
   (d) 10
   Body image develops during (1) infancy/childhood (2) school age (3) adolescence/puberty (4) senescence
2. Compared to the general population, cosmetic surgery patients report
   (a) Higher dissatisfaction with of body image
   (b) Lower prevalence of BDD
   (c) Higher prevalence of BDD, but lower dissatisfaction with body image
   (d) **Higher prevalence of BDD**
   Cosmetic surgery patients do not demonstrate a significantly different assessment of body image, but do have a higher prevalence of BDD (6–16 % by DSM criteria)
3. Postoperatively, the majority of cosmetic surgery patients meet diagnostic criteria for clinical anxiety
   (a) True
   (b) **False**
   The majority of cosmetic surgery patients have a positive outcome. While a minority may be unsatisfied with surgical outcomes, >50 % experience anxiety postoperatively. However, only a small proportion of this subgroup will meet diagnostic criteria for clinical anxiety disorder.
4. A patient with mild nasal deformity, who hates his nose and meets criteria for BDD, will stop obsessing if the deformity is corrected
   (a) True
   (b) **False**
   Patients with BDD have delusional fixations that inhibit acceptance of a good surgical result and may demand additional surgery or revisions. If the patient is satisfied with surgical outcome, he is nonetheless likely to move on to obsessing over another facial feature.

5. Compared with "normalized" patients, those with craniofacial deformities are evaluated as:
   (a) Less honest
   (b) Less employable
   (c) Less intelligent
   (d) **All of the above**

Part II

Reconstruction

8 Flaps and Grafts

Jennings R. Boyette and Philip K. Robb Jr.

The Reconstructive Ladder

- Secondary healing
- Primary closure
- Delayed primary closure
- Skin grafts (split vs. full thickness)
- Local tissue transfer (random flaps)
- Regional/axial tissue transfer
- Free tissue transfer

Grafts

Autogenous grafts are always preferred over synthetic or cadaveric grafts to minimize complications.

Graft Types

Skin Grafts

Skin grafts can be split thickness (STSG), full thickness (FTSG), or dermal grafts. Generally speaking, the thinner the graft, the more likely it will survive—as there is less biologic load to support. Graft survival is dependent upon the recipient bed for vascularization. The recipient bed should be free of necrotic debris, hemostatic, sterile, and immobile for optimal take. Grafts need direct contact for vascularization; therefore, do not place directly over bone, cartilage, or tendon. May survive if less than 1 cm^2.

- **Contracture of grafts: STSG > FTSG > composite grafts.**
- **Perioperative corticosteroids have been shown to increase graft survival**.

Stages of Graft Vascularization

Imbibition—first 48 h, wound nourishes the graft via diffusion

Inosculation—48–72 h, capillary anastomoses form

Neovascularization—greater than 1 week, new capillary budding into tissue

Split-Thickness Skin Graft (STSG): Contains entire epidermis and variable amount of dermis. Thin STSG: 0.008–0.010 in.; thick STSG: 0.016–0.018 in.

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Advantages: Large surface area coverage, reliable, can mesh to increase surface area, no donor-site closure

Disadvantage: Increased contracture, color/texture mismatch, fragile. Postop **dermabrasion** is also helpful to smooth transitions

Uses: Large scalp defects, high-risk recurrence sites, donor-site coverage (e.g., forearm/fibula)

Full-Thickness Skin Grafts (FTSG): Contain entire epidermis and dermis

Advantages: Better color/texture match, less contracture, multiple donor site options

Disadvantages: High graft failure rate, slow revascularization, more resistant to trauma

Uses: Nasal, ear, eyelid defect

Donor sites: Postauricular, preauricular, upper eyelid, supraclavicular skin

Dermal Grafts

Advantages: Reliable, resistant to infection, can be buried under skin, little resorption, capable of re-epithelialization

Disadvantages: Donor-site contour defect

Uses: Intraoral coverage, vessel coverage, tissue bulk/contour

Cartilage Grafts

Cartilage is classified into three types: elastic, hyaline, and fibrocartilage. Vascularized by diffusion

Advantages: Ease of harvest, malleable but maintains structural integrity, minimal resorption, and can be harvested as a composite graft

Disadvantages: Need for soft tissue coverage, potential donor-site morbidity

Uses: Nasal/orbital reconstruction, rhinoplasty, otoplasty

Donor sites: Nasal septum, auricle, rib

Bone Grafts

May be autogenous, allograft, or synthetic. Autogenous bone consists of cortical bone (outer layer, provides strength) and cancellous bone (inner layer, contains osteocytes and growth factors).

Biologic Principles of Bone Grafting:

Osteoconduction—bone grafting material creates a scaffold which facilitates new bone formation (characteristic of all bone grafts)

Osteoinduction—stimulation of osteoprogenitor cells to promote new bone growth (autogenous grafts and some allografts)

Osteogenesis—new bone growth secondary to osteoblast from bone graft material (autogenous grafts only)

Advantages: maintains structural support, minimal warping, abundant supply

Disadvantages: requires bone-to-bone contact and immobility to minimize resorption, needs soft tissue coverage, potential donor-site morbidity

Uses: mandible, midface, nasal, orbital reconstruction

Donor sites: iliac crest, calvarium, rib

Fat Grafts

Fat grafting has become increasingly important as an adjunctive and primary tool in reconstruction and cosmetic procedures. The key to successful fat grafting is attention to technique. Survival of transplanted adipocytes is dependent upon inosculation. Harvesting is typically performed using the Coleman technique which utilizes low-pressure liposuction harvesting, centrifuge refinement, and small aliquot placement in multiple tissue planes. This increases the surface area of contact between the newly grafted fat and host tissue to promote survival.

Advantages: abundant supply, natural contour, permanent

Disadvantages: potential for irregular contours, variable take rate (up to 60 % resorption)

Alloplasts

Biocompatibility is a major consideration when using alloplastic materials. Infection and extrusion are common. The degree of material inertness, the surface texture, the degree of tissue coverage, and fixation to the local tissues all affect an implant's long-term viability. Nasal implants are particularly prone to extrusion.

- EPTFE (Gore-Tex): sheets can be used for lip, cheek, nasal augmentation, solid shapes available for skeletal augmentation, easy to remove
- Acellular dermis: used for soft-tissue augmentation and as slings, prone to resorption over time
- Porous polyethylene: skeletal augmentation, orbital floor implants, microtia; pores allow for soft-tissue ingrowth; difficult to remove; carvable
- Silicone: solid implants used for augmentation of chin or malar region, lip and nasal augmentation; placed subperiosteal, fibrous capsule forms; may cause underlying bony resorption (2–5 mm at chin); carvable
- Methylmethacrylate: used for cranial defects, can be custom molded in situ; exothermic reaction during curing

Flaps

Classification of Flaps

Flaps may be classified by their blood supply (axial versus random), shape, location, or movement.

Local flaps can be classified by their blood supply: arterial (**axial**) flaps or **random**-patterned flaps based upon the interconnecting subdermal plexuses. Regional and free flaps are based upon an angiosome, which is an anatomic unit of tissue (consisting of skin, subcutaneous tissue, fascia, muscle, and bone) fed by a source artery and drained by specific veins.

Vascularization of the skin occurs through either **musculocutaneous** or **septocutaneous** arteries, which then terminate into the subdermal and dermal vascular plexuses.

Survival of a random pattern flap is dependent upon the capillary perfusion pressure. Increasing flap lengths result in less perfusion pressure to withstand the critical closing pressure exerted on the end arterioles. Venous congestion or lymphedema can also result in decreased perfusion pressure and resulting flap necrosis.

With any flap, impairment of arterial vascularization results in rapid flap loss (<24 h). More common complication and reason for flap loss (free, regional, and random) is venous congestion. Congestion leads to stasis and clotting. Thrombus propagation causing microcirculation failure results in sludging which ultimately causes irreversible cell death (the "no reflow" phenomenon). In free flaps reversing this process should occur in less than 6 h to reliably reverse ischemia.

Several therapies exist to attempt reversal of venous stasis including:

- Aspirin (antiplatelet)
- Nitropaste (vasodilator)
- Leeches (*Hirudo medicinalis*)—need coverage for Pseudomonas Aeromonas with ciprofloxacin 500 mg q day.

Local Flaps

Advancement Flaps

Flap moves in one, straight vector. Sliding flap in an area with increased skin laxity. Random blood supply. Dissected in the subcutaneous plane. May be **unipedicle** or **bipedicle. V-Y** (used in lengthening procedures) or Y → V. Immediately adjacent to the defect site. Burrow's triangles frequently excised on either side of the flap to prevent standing cone deformities.

Rotational Flaps

Rotational flaps rotate immediate adjacent tissue skin into defect site. Ideal for triangular defects. The arc of rotation is typically less than 90° to the axis of the defect. Standing cone deformities develop at the base of rotational flaps (consider excising Burrow's triangle).

- The length of the **arc should be ~4× the width** of the base of the defect.
- Conversion of the defect to a 2:1 triangular defect can reduce standing cone deformity.

More arc length → less tension. Inferiorly based flaps have better lymphatic drainage. Undermining around the base of the flap may facilitate more of an advancement movement which will decrease wound closure tension. Rotational flaps are commonly used to repair large defects (cervicofacial advancement-rotation flap, Fig. 8.1) and scalp defects.

Transposition Flaps

Transposition flaps are pivotal flaps in which only the base of the flap may be adjacent with defect. Thus the flap moves over normal tissue in order to inset into the defect.

- **Rhombic** and **bilobe** flaps are the most common.

Area of **greatest tension is at base of secondary donor site**. This is the most commonly used flap type in the face. The larger the angle of rotation, the more extensive the standing cutaneous deformity and the less length a flap can reach. Pivoting a flap at 45° reduces the length by 5 %, 90° reduces flap length by 15 %, and 180° by 40 %. Prone to trap-door deformities if rounded (ex: bilobe).

Rhombic Flap

The prototypical rhombic flap is transposed to reconstruct defects with internal angles of 60°

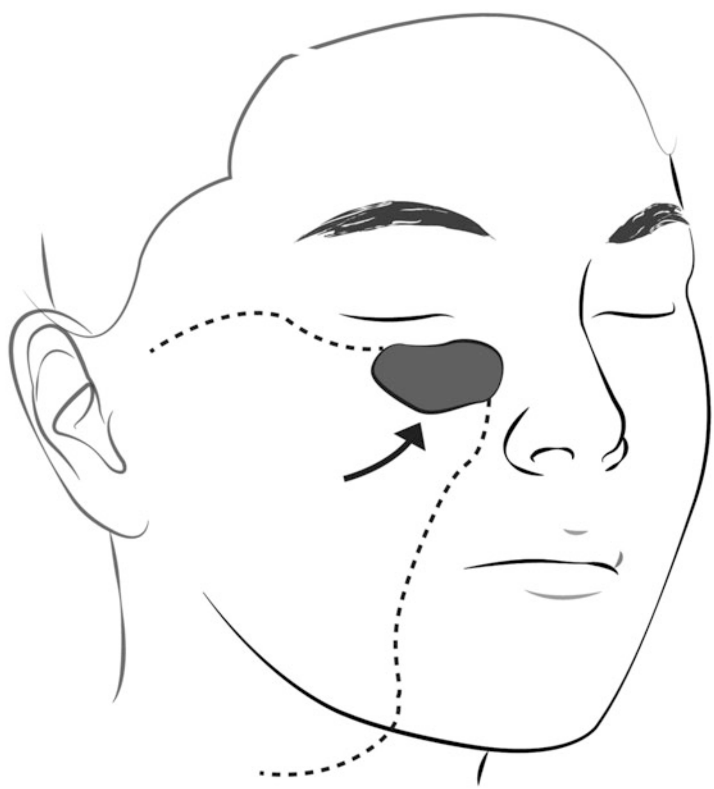

Fig. 8.1 Cervicofacial advancement-rotation flap designed to reconstruct a medial cheek defect

and 120°—this is referred to as a **Limberg flap**. Conversion of a defect to this rhombic configuration is necessary. Each defect has four possible flaps that can be created in order to take advantage of skin extensibility and placement in RSTLs. Standing cone deformities commonly occur at the medial base of the flap. Rhombic flaps can also be modified for circular defects ("note" flaps) or performed as bilateral opposing flaps to close larger defects.

- **Point of greatest tension** → at the point where the flap is designed extending from the defect and in the vector running parallel to this border of the defect (see Fig. 8.2).

Duformental modification: This allows for reconstruction of rhombus-shaped defects that don't have exactly 60° and 120° internal angles (**more square shaped**).

This design places the border of the flap between a line drawn in the standard Limberg fashion and a line drawn extending parallel from the defect border (see Fig. 8.3). It pivots less than a traditional Limberg flap.

Webster modification: Also known as a 30° rhombic flap, the Webster design calls for performing a W-plasty (**30° angle**) at the base of the defect instead of converting it to a 60° Limberg rhomboid. This limits the extent of the resection of normal tissue. The flap is then designed extending out from the defect at a similar bi-sected angle as the Duformental, but with a triangular flap created by a **30° angle** (see Fig. 8.4). This smaller angled flap requires more secondary movement from the adjacent tissue to close the defect and therefore may disturb surrounding structures.

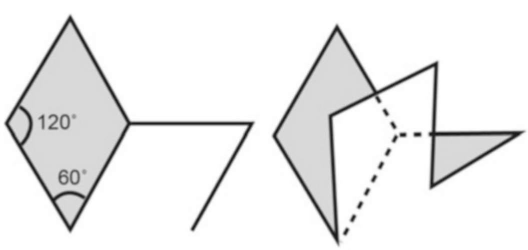

Fig. 8.2 Limberg rhombic flap. Note the angles of design, 120° and 60°

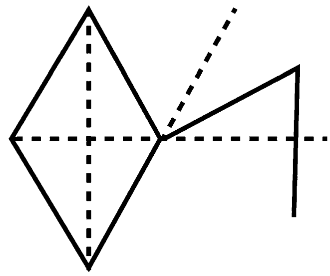

Fig. 8.3 Durformental modification of a rhombic flap. The design places the border of the flap between a line drawn in the standard Limberg flap and a line drawn extending parallel from the defect border

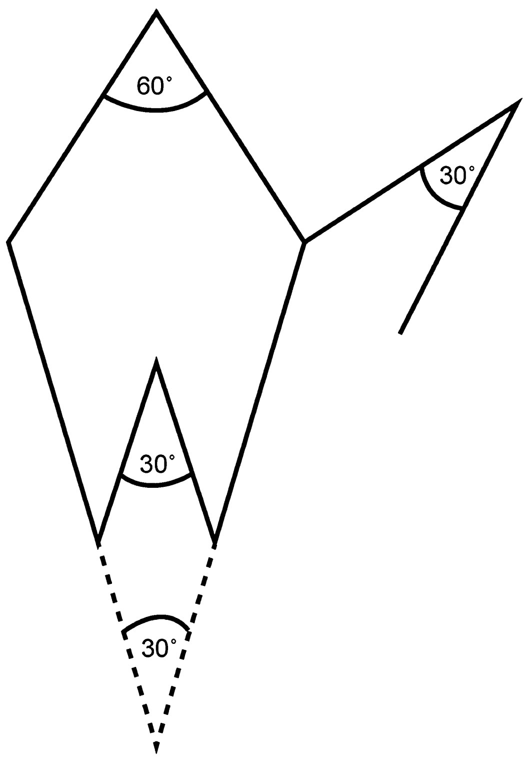

Fig. 8.4 Webster modification of a rhombic flap. A W-plasty is performed at the base of the defect, and a smaller angled flap is designed

Bilobe

The **bilobe flap** is a double-transposition flap with a single base. The bilobe is advantageous because it recruits skin that's not immediately adjacent to the defect. The vector of tension is also moved perpendicular, which can avoid distortion of adjacent structures (such as elevation of the nasal ala). Curvilinear incisions are **prone to trap door deformities**. Great for caudal 1/3 nasal defects as well as nasal tip.

- **Zitelli's modification**: Changed the total arc of rotation from 180° to 90°; thus each lobe moves 45°. This reduces tension and tendency for standing cone deformity.

Bilobe flap design: The classic small bilobe flap is used to repair a circular defect. A pivot point for the first flap is determined where the laxity and vectors of tension will be ideal. The second lobe is often designed to place the scar at the border of a subunit. The pivot point is placed from the defect edge at a distance of at least half of the defect diameter (see Fig. 8.5). The impending standing cone is removed as a triangle at the base of the circle.

At 90° to the pivot point, two semicircular arcs are created. A suture placed through the pivot point is particularly helpful during design.

First arc is based upon length: pivot point → far edge of defect
Second arch is based upon length: pivot point → center of defect

The first lobe flap extends to the top arc and the flap is as wide as the defect. The second lobe is twice as tall as the first, but half as wide and is more triangular in shape (see Fig. 8.5).

Interpolated Flaps

Interpolated flaps pass over intact skin to cover a defect. These are often axial blood supply flaps with the most notable of these the paramedian forehead flap and the nasolabial flap.

Paramedian Forehead Flap: Flap based off the supratrochlear vascular bundle. This is the workhorse for any nasal defect and is capable of reconstructing the entire external or internal lining. In general, paramedian forehead flaps are used for **nasal defects >2 cm**. Preoperatively

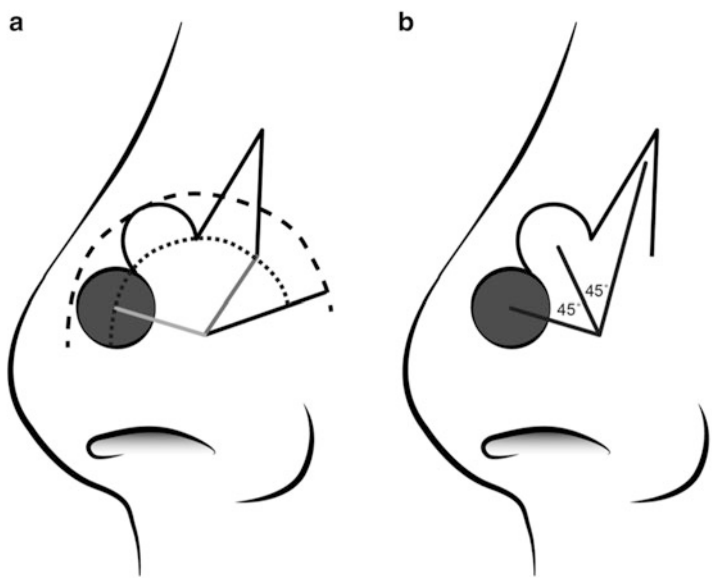

Fig. 8.5 Bilobed transposition flap for nasal reconstruction. Each lobe is placed at 45° creating a 90° total arc of tissue movement

assess forehead height → flap can be extended obliquely to avoid hair-bearing skin (however, lateral extensions wider than 3 cm may elevate brow), or hair follicles can be cauterized or removed.

- Supratrochlear pedicle is found 1.7–2.2 cm from midline.
- Three-dimensional templates will assist in flap design. Careful assessment of rotational forces on pedicle and ensuring sufficient pedicle length is key.
- Artery runs under the orbicularis oculi, pierces the corrugator, and passes through the frontalis muscle from deep to superficial
- Pedicle base widths around 1.2–1.5 cm allow for better flap mobility and geometry.
- Extending incisions below brow and division of the corrugator muscles will allow for further length if needed.
- The distal 2 cm of the flap can be thinned of muscle and subcutaneous fat for better contouring.
- Subperiosteal dissection is usually performed above the orbital rim in order to avoid pedicle injury.
- The donor site is closed primarily or left for secondary intention healing (usually if >4 cm).
- Pedicle division and inset typically performed after 3–4 weeks.

Melolabial (or nasolabial) flaps designed as interpolation flaps are commonly used for nasal alar reconstruction. The flap is based off supply from angular artery and can be designed with a cutaneous pedicle or a subcutaneous pedicle. The flap donor site places the scar in the melolabial crease.

- Reconstruct the entire ala by completing the subunit resection, but leave 1–2 mm of lateral alar tissue at the nasofacial junction.
- An exact template is made of the defect.
- Auricular cartilage graft often needed for external valve support and to contour the overlying flap.
- Flap pedicle takedown and inset at 3–4 weeks postoperatively.

Island Flaps

Island flaps relay on blood supply through the subcutaneous tissue as the cutaneous circumference of the flap is incised. These flaps are best suited to areas where there is abundant fat and subcutaneous tissue—allowing for creation of subcutaneous pedicle for flap mobility. The cheek and upper lip are common locations where these flaps are employed.

- Take care not to perform circumferential undermining around a defect if an island flap may be a possible reconstructive option.

Flap Delay

Process of exploiting the angiosome improves flap viability and vascularity prior to transfer; closure of A-V shunts results in increased perfusion of flap; performed 2 weeks prior.

Tissue Expansion

Major reconstruction modality developed over the past 30 years useful for a variety of reconstruction challenges. Tissue expansion has become a reliable method of reconstruction when soft tissue is of limited supply, such as in the scalp, pediatric patient, burn injury, and breast reconstruction.

Tissue expanders exploit the biomechanical properties of creep and stress relaxation.

Mechanical creep—rapid, intraoperative tissue expansion due to disruption of elastin and collagen fibers, and displacement of interstitial fluid and ground substance. No net increase in surface area occurs.

Biologic creep—long-term tissue expansion secondary to physiologic and histologic changes in the skin. Net increase in surface area occurs.

Stress relaxation refers to a decrease in tension on the tissue over time after applying constant strain.

Advantages: similar skin color, texture and thickness, minimal donor-site morbidity, improved survival versus random-pattern flaps.

Disadvantages: need for multiple procedures, temporary cosmetic deformity, prolonged period of expansion

Tissue Changes:
Epidermis → thickens
Dermis → thins
Skeletal muscle atrophy but no functional alteration
Fat atrophy
Vascular—increase in number and caliber of vessels

When choosing the size and shape of the tissue expander, the base of the expander should be **2.5–3×** the area of reconstruction and its shape should be based on the site of expansion. The expander is placed in the subgaleal plane in the scalp and in the subcutaneous plane in the face and neck to reduce potential neurovascular injury.

Complications of Tissue Expansion

Major: infection, extrusion, flap ischemia

Minor: pain with expansion, seroma, hematoma

Reconstructive Options Based upon Location

Optimal reconstruction of facial defects is dependent upon several factors including the size and depth of the defect, aesthetic subunits, disease process, and underlying patient morbidities. In general, the **aesthetic regions** and their individual subunits should guide reconstruction—using similar skin quality and placing scars in the aesthetic borders. Placing incisions parallel to **relaxed skin tissue lines** will minimize visibility of scars and reduce wound tension. **Secondary tissue movement** is the displacement of the surrounding tissue in response to the closure of the primary defect, and may distort adjacent structures such as eyelids, lips, and nostril position.

Nasal Reconstruction

Reconstruction of the nose presents several challenges as it has a very specific three-dimensional structure that extends off the surface of the face and is formed from multiple distinct layers. The principle of replacing "like with like" is particularly applicable to nasal reconstruction. The aesthetic subunits of the nose should be considered individually and defects should possibly be modified to conform to the subunits involved.

Mucosal Lining Flaps for Full-Thickness Reconstruction

Ala only, up to 1.5 cm → bipedicled mucosal advancement (bucket handle) flaps

Lower nasal vault → ipsilateral septal mucoperichondrial hinge flap
Flap can be as large as 3 × 4 cm. Leave 1 cm attached to the caudal septum at the hinge point.

Ala and sidewall defect → contralateral dorsal mucoperichondrial hinge flap
An ipsilateral mucosal flap hinged caudally is formed first and used for the alar portion. Septal cartilage is resected and the contralateral mucoperichondrial flap is hinged dorsally and used to reconstruct the sidewall mucosal defect. The septal cartilage can be used as a non-anatomic support graft for the lateral sidewall reconstruction.

Tip or dorsal mucosal defects → septal composite chondromucosal pivot flaps
Full-thickness mucosa, mucoperichondrium, and cartilage incisions are made to create a rectangular or trapezoidal shaped flap which is hinged caudally. The composite flap is pivoted forward and the cartilage is secured in place while the mucosa can be reflected laterally to line the nostrils. Often a wedge of cartilage only is removed at the posterior septal angle to facilitate in flap rotation.

The degree of rotation depends upon the necessary regions for reconstruction. For significant movements an initial delay procedure with mucosal cuts only is sometimes employed.

Other options:

- **Composite Chrondrocutaneous Grafts**—useful for small full-thickness nasal reconstruction, such as for the soft triangle or alar rim. Prone to graft loss. General recommendations are for grafts **no larger than 1 cm^2**. Postoperative cooling with ice water may improve flap survival. Consider placing "windows" in the cartilage to allow for neovascularization to the cutaneous portion
- **Inferior turbinate mucosal flaps, pedicled anteriorly**—requires second-stage takedown
- **Folded paramedian forehead flap for alar mucosal reconstruction**
- **Pre-laminated forehead flap formed with skin grafts prior to turning flap**.
- **Total internal lining defects → staged fasciocutaneous free flap, typically radial forearm free flap**

Reconstruction of Nasal Skin

Many small defects can be closed primarily after undermining, especially those that can be horizontally oriented near the nasion or supratip where a horizontal subunit transition is located. Vertical closure can be considered for centrally located defects.

Defect-based approaches: (Table 8.1)
Glabella and nasion

- **Vertical Advancement Flap (see figure)**—Burrow's triangles removed around eyebrows
- **Transposition (note flap)**
- **Bilobed flap**
- **Island pedicle flap from glabella**

Central dorsum

- **Vertical advancement flap**
- **Bilobed flap**—may be bilateral to split the tension
- **Subcutaneous island pedicle flap**
- **Cheek transposition flaps**—may be bilateral
- **Sliding dorsal nasal flap (Rieger flap)**—for larger defects, can reach to the supratip region (Fig. 8.6)

Nasal sidewall

- **Transposition flap**
- **Cheek advancement flap**—take care to suture the flap to the periosteum of the maxillary crest to avoid blunting of the nasofacial transition.
- **Sliding island pedicle flap**

Tip

- **Bilobed flap**—distributes the tension horizontally to avoid rotation of the tip

Table 8.1 General considerations to guide reconstruction of nasal defect based upon size

Defect size	Nasal tip	Nasal ala	Nasal dorsum
<1 cm	FTSG Bilobe	FTSG Bilobe	Bilobe Transposition flaps Advancement flap
1–1.5 cm	Bilobe	V-Y (at alar groove) Melolabial interpolation	Bilobe Transposition flaps Advancement flap
>1.5 cm	Paramedian forehead	Paramedian forehead	Dorsal nasal (up to 2.5 cm) Paramedian forehead

Many exceptions will apply

Fig. 8.6 Sliding dorsal nasal flap. This flap makes use of laxity in the glabellar region, and is best for dorsal defects supra-tip and upwards

- **Skin graft**—full-thickness or perichondrial composite graft from conchal bowl. Dermabrasion can improve final appearance
- **Paramedian forehead flap**

Ala

- **Skin graft**
- **V-to-Y island flap**
- **Melolabial interpolation flap**

Columella

- **Full-thickness helical rim composite graft**
- **Double-upper lip transposition flaps**
- **Melolabial interpolation flap**
- **Tunneled melolabial or nasofacial sulcus flaps**
- **Paramedian forehead flap**—flap reach to columella often exceeds distal blood supply

Total Nose

A multilayered reconstruction is required, to include intranasal lining, structural architecture, and overlying skin cover. Traditionally this has been accomplished with a **radial forearm fasciocutaneous free flap** to provide the intranasal lining. In successive stages the free flap is thinned and sculpted around a rib cartilage framework (which may incorporate calvarial bone grafts), followed by a paramedian forehead flap. Double-paramedian forehead flaps have also been utilized—one for the intranasal lining and another for the overlying skin. Pre-laminated constructs built on the forehead prior to turning the forehead flap down are another option.

Many elderly or cancer patients may instead opt for a **nasal prosthesis**.

Cheek Reconstruction

The cheek is the largest facial aesthetic subunit. Its convex curvature highlights even subtle imperfections and scars. It can be further subdivided into infraorbital, zygomatic, and mandibular aesthetic units.

Medial Cheek

Small defects (<2 cm) adjacent to the melolabial crease or along the nasofacial groove can either be closed with a **V-Y island advancement** flap along the borders of the subunit. If substantial laxity exists along the medial cheek, larger defects can also be repaired this way.

Small defects of the central cheek can be closed with small **transposition** flaps in order to disperse tension horizontally to avoid lower eyelid distortion.

Cervicofacial Advancement Rotation Flap

Curvilinear flap movement is utilized to move the remaining cheek to reconstruct larger defects, placing scars at borders of subunit. The flap may be based anteriorly or posteriorly along the preauricular region. Unaffected skin must be resected to remove standing cone deformities, either at the melolabial crease or the temple.

- Extend flap to subciliary line of lower eyelid and affix the flap to the infraorbital rim periosteum.
- Extend the lateral brow incision higher than the palpebral fissure to support the eyelid.
- Very large flaps may be elevated in the sub-SMAS plane for increased blood supply.

Lateral Cheek

Buccal region: many can be closed primarily after undermining.

- Recruitment from the neck via advancement or **pivotal flaps** is commonly used for larger defects.

Zygomatic region: careful elevation in the subcutaneous plane is necessary to avoid injury to the **frontal branch** of the facial nerve in this region.

- **Transposition flaps** are a good option for small to large defects and can be designed to reduce vertical tension upon the eyelid and canthus.

Eyelid Reconstruction

Eyelid reconstruction presents several challenges as all aspects and layers of the lid must be carefully and precisely reconstructed in order to protect the eye. One must also pay close attention to the dynamic movement of the eyelids and to the canalicular system. Reconstructive strategies are defined by the size of the defect, as well as by which lamellae of the eyelid are involved, and the location of these defects (canthal, lid margin, upper versus lower eyelid). Intraoperative recognition of excess tension causing eyelid malposition is imperative. The surgeon must be prepared to adjust tension at the lateral canthal tendon via a tarsal strip procedure (or apply Frost sutures) as needed during the operation.

Superficial Defects Not Involving the Lid Margin

Small defects (<1 cm) of the medial canthal region which do not involve the lid margin may be amenable to heal by secondary intention.

Direct closure may be possible in small defects; however, orientation of elliptical excisions on the eyelids should often be oriented vertically (perpendicular to the RSTLs) in order to prevent tension retracting the lid margin. Horizontally placed elliptical incisions can be employed in areas of excess skin redundancy (such as in the setting of upper lid dermatochalasis).

Small rhombic flaps are also particularly well suited to reorient the tension of closure horizontally in order to avoid lid retraction. Laterally based upper eyelid transposition flaps can be used to repair larger skin only defects of the lower lid. Horizontally oriented V-Y island pedicle flaps are also useful around the lateral canthal region.

Full-Thickness Defects

Small defects, usually **up to 1/3rd** of the lid margin, may be repaired with direct closure. Usually this entails making the defecting into a pentagonal shape in order to remove the eventual standing cone deformity. The tarsus must be sutured to an exact vertical alignment. Vertical mattress suture at the margin with slight eversion is recommended.

<25 %	Direct closure
25–50 %	Direct closure with lateral cantholysis
25–50 %	Tarsal rotation flap and skin-muscle flap or skin graft
25–75 %	Tarsoconjunctival graft and skin-muscle flap
33–66 %	Tenzel semicircular flap with periosteal flap
50–100 %	Cutler-Beard flap

Tenzel Semicircular Flap

Defects 1/3rd–2/3rd of the horizontal length of eyelid.

The Tenzel semicircular flap makes use of redundancy of lateral canthal skin laxity. Lateral canthotomy and cantholysis are performed. The flap is undermined in the submuscular plane and rotated to the lateral border of the defect and is sutured primarily. The lateral canthal angle must be recreated at the lateral orbital rim. For larger defects where there is minimal tarsal plate remaining, consider placing an ear cartilage graft for structural support.

Hughes Tarsoconjunctival

Defects 50–100 % of the *LOWER* eyelid

This two-stage flap reconstructs the posterior lamella with a superiorly pedicled tarsus and conjunctiva hinge flap (Fig. 8.7). The anterior lamellar skin is reconstructed either with full-thickness skin grafts or a local flap. The flap is divided and inset in approximately 4 weeks.

Cutler-Beard Bridge Flap

Large defects (>50 %) of the *UPPER* eyelid

With this procedure, a muscle and skin advancement flap from the lower eyelid is advanced underneath the "bridge" of intact

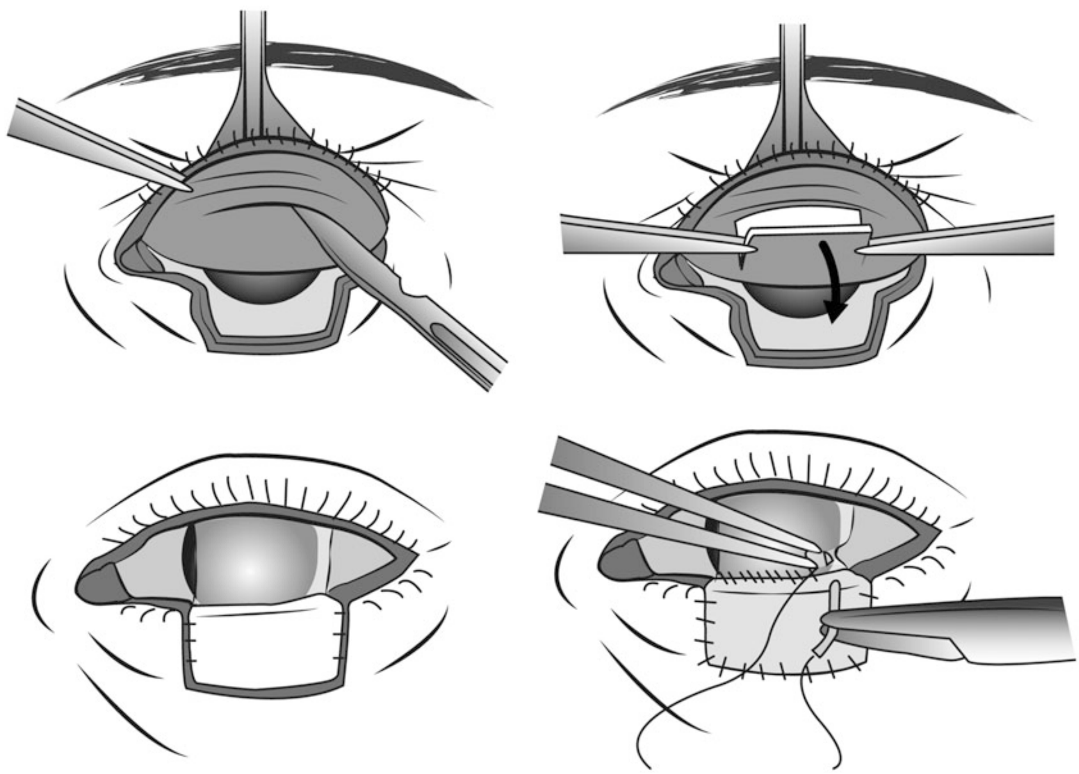

Fig. 8.7 A superiorly pedicled Hughes tarsoconjunctival flap is inset into the lower eyelid defect while its outer surface is skin grafted. The pedicle is divided at around 4 weeks

lower eyelid tarsal plate and lid margin. Therefore a graft for the upper eyelid posterior lamella is commonly employed (hard palate mucosa, free tarsoconjunctival graft from contralateral eyelid). The flap is divided and inset approximately 4 weeks later.

Lip Reconstruction

The upper and lower lips constitute a large portion of the lower face and each has its own aesthetic subunits. Both lips contain a vermillion and the upper lip has a central subunit defined by the philtral ridges. Care must be taken to restore the peaks and depth of the Cupid's bow. There is also a dynamic component to the upper and lower lips as several muscles act upon them in different ways. Maintaining good neuromuscular movement as well as sensation is important for oral competence.

- **Civelek B, et al. 2006, *Otolaryngol Head Neck Surg***: Postoperative EMG findings indicate that neurotization of non-innervated flaps (Gillies) occurs and that the lip ultimately may work as well as an innervated flap (Karapandzic or Nakajima).

Vermillion Only

Mucosal advancement flaps → Both small and large vermillion defects can be covered by utilizing red mucosa from the oral lip. The new lip may be more red in color than the native vermillion. The flap is raised deep to the salivary glands, but over the surface of the orbicularis muscle. This flap does not address volume deficiencies well.

Mucosal v-y flap → Small-volume deficiencies can be addressed with a V-shaped intraoral incision. An island flap is formed and moved in a vertical direction. Y-closure results in bulking of the tissue at the end of the incision.

Mucosal cross-lip → For wider defects with volume loss, a cross-lip vermillion flap can be placed and the pedicle divided in 3–4 weeks' time. The flap is raised over the surface of the orbicularis muscle. Unfortunately this procedure requires the lips to be tethered together during this period and can result in volume deficiency at the donor lip.

Non-vermillion (Cutaneous Lip Only) Defects

Transposition flaps—work well for defects near the vermillion of the upper lip as lax skin can be recruited from the melolabial region.

Rotational flaps—consider for larger defects of the upper lip under the alar base. The arc of the flap is designed to follow the normal melolabial crease.

V-Y island flap—works well for lateral defects located along the melolabial crease of the upper lip. The island is advanced superiorly and closed along the melolabial crease.

Full-Thickness Defects

Up to 33 % of the lip → wedge resection with primary closure

33–50 % → cross-lip (Abbe or Estlander) flap

>50 % → Karapandzic, Gillies, or Bernard Burrow

Wedge Resection

Care should be taken to reapproximate the vermillion exactly. Wedge resections typically create a volume discrepancy between the lateral thin lip and the fuller segments of the medial lip. Consider a **W-plasty** at the distal end of the excision to avoid crossing the mental crease.

Bilateral Advancement Flaps

A larger, more rectangular full-thickness defect can be closed by forming bilateral advancement flaps. For the lower lip the mental crease serves as the inferior border of the flap segments. For central defects of the upper lip bilateral advancement flaps can also be employed with removal of crescent-shaped perialar skin in order to prevent standing cone deformities around the alae.

Stair-Step Lower Lip Advancement Flap

For larger lower lip defects approaching the size recommended for a cross-lip flap, a stair-step flap

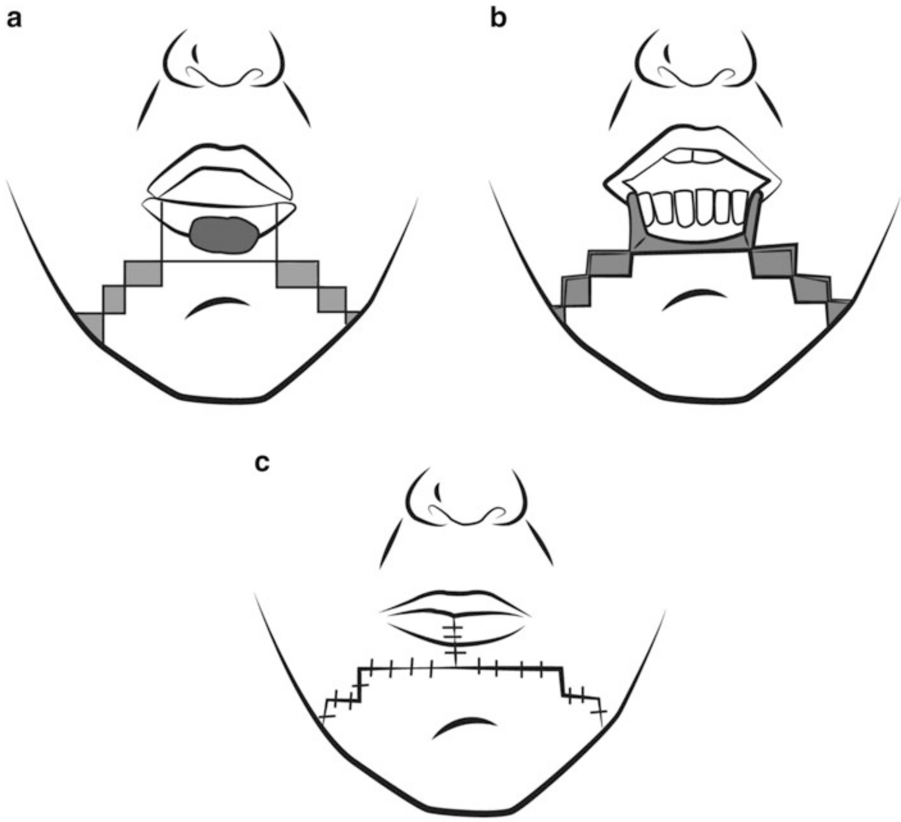

Fig. 8.8 Stair-step flap lower lip reconstruction. This preserves the central subunit

is a good option to close the defect in one stage (Fig. 8.8). It also has the advantage of preserving the central chin subunit as incisions are placed outside of the mental crease.

Cross-Lip Flaps (Abbe-Sabatini and Estlander)

- Vertical height of flap = vertical height of defect
- Width of flap = ½ of defect width
- Labial artery typically courses between the intraoral mucosa and the orbicularis muscle at approximately the level of the vermillion border

An Abbe cross-lip flap is a two-staged, full-thickness flap based upon the labial artery. The arterial supply to the flap can be pedicled medially or laterally, depending upon the ease of flap rotation. Also, consider basing the pedicle on the side which will result in less limitation to mouth opening during the time between stages. Larger central lower lip defects can also be reconstructed with double-Abbe flaps based on either side of the philtrum.

Estlander flaps are similar flaps used to reconstruct a lateral lip defect and are performed in one stage. However, Estlander flaps have a tendency to result in blunting of the commissure that typically requires a later commissuroplasty.

Fan Flap (Gilles)

For similarly large defects, a “fan” flap can be utilized to recruit from the laxity around the lips (Fig. 8.9). This is a full-thickness flap with its pedicle based around the commissure. The flap then pivots around the commissure to close the defect. This results in similar blunting of the

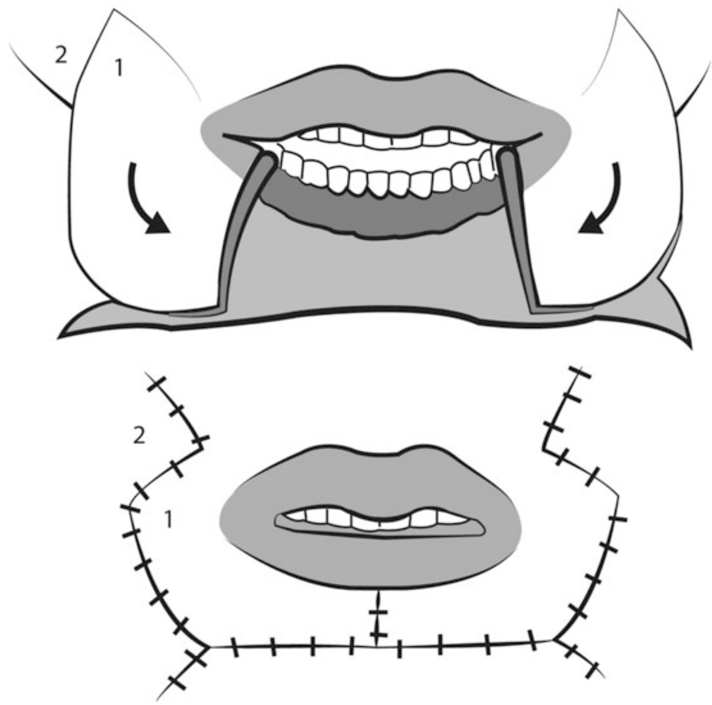

Fig. 8.9 Gillies fan flap design for a lower lip defect. This flap is best for larger defects

commissure as an Estlander flap. This flap can be used for either the upper or the lower lips and bilateral flaps can be employed for defects approaching 80 % of the lip. A Z-plasty at the lateral aspect of the flap is often utilized to aid in flap movement and inset. Nakajima modified this flap to dissect and preserve the neurovascular supply from below in order to innervate the flap.

Karapandzic

Larger lip defects over 50 % of the lip can be reconstructed with Karapandzic flaps, which have the benefit of preserving sensory and motor function. The incisions are designed to follow the curvatures of the melolabial creases and can be designed with asymmetric lengths for defects which are not centrally located. The skin and intraoral mucosa are incised while leaving the central muscular layer intact to allow for dynamic oral closure.

- **Microstomia** is a common result of Karapandzic reconstruction. Stretching appliances may be of benefit to counteract this result.

Bernard-Burrow (and Webster Modification)

For very large lip defects it becomes necessary to bring in tissue from adjacent regions. The Bernard-Burrow is a classic flap which employs bilateral cheek advancement flaps facilitated by excising “Burrow’s triangles” of skin (Fig. 8.10). **Webster** modified this design to remove skin-only triangles along the melolabial folds and paramental regions, which better preserves the subunits and preserves some motor function.

Total Lip Reconstruction with Free Flap

Microvascular reconstruction provides the advantage of dual-layer reconstruction (and possibly bony reconstruction) of large defects, but at the cost of a large adynamic segment that is often hypopigmented in comparison to the surrounding skin. Radial forearm flap folded over a **palmaris tendon sling** is a well-described technique for reconstructing the entire lower lip.

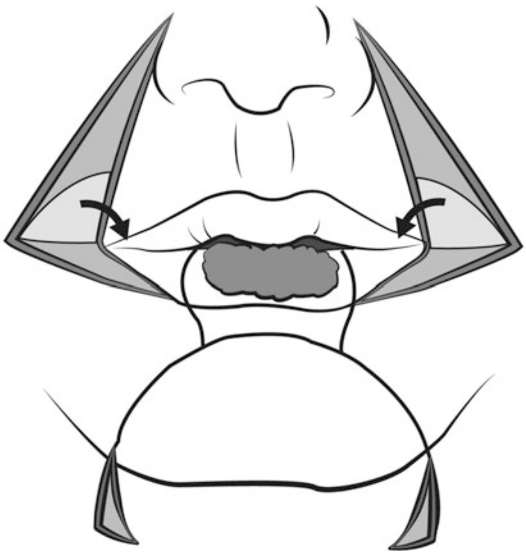

Fig. 8.10 Bernard-Burrow lip reconstruction. Triangles are removed at the melolabial and paramental regions to facilitate flap mobilization and inset

Forehead and Temple

Closure of forehead defects should maintain the hairline without distortion or paralysis of the brow.

Midline and paramedian: Recruit horizontal forehead laxity

Primary closure, vertically oriented, ± W-plasty
Rotational flaps along hairline
Bilateral advancement flaps closing vertically (tissue expansion may be helpful)

Lateral Forehead: Avoid brow elevation, utilize RSTLs

Small defects or horizontal defects: horizontally oriented closure with W-plasties at each end
Close to brow: Horizontally oriented unilateral advancement flap or H-plasty
A to T closure

Temple: Recruit vertical laxity from the cheek

Rotational flaps
Rhombic flaps

Scalp

Minimal laxity makes closure of even small defects challenging. Bone exposure frequently limits the application of skin grafts. However, healing by secondary intention can heal quite well if there is intact pericranium (such as a paramedian forehead flap donor site). **Galeal relaxing incisions** can provide a modest stretching of the tissue.

- Less than 3 cm defect → primary closure with wide undermining
- Greater than 3 cm defect → flap reconstruction or graft

Useful Flaps:

Rotational Flap (*Large*) → length of the flap border is 6× (instead of 4×) the defect width, back-cut often necessary. Secondary defect allowed to granulate or covered with skin graft
O to S → useful for large defects (up to 9–10 cm, but best for around 5 cm), ideal for vertex defects
Orticochea flaps → advantage is use of hair-bearing skin and the ability to restore the hairline for very large defects. Utilizes 2–4 individual transposition flaps, essentially elevating and mobilizing the entire scalp

Alternatives

Temporoparietal Fascia Flap: Can be raised with overlying skin to provide a hair-bearing reconstruction. Purely fascial flaps can be used to cover exposed bone with skin grafts applied to the vascularized fascia. TPFFs be made as large as 14 × 17 cm. The vascular pedicle can be variable; therefore use a **Doppler** to map it out in advance of elevation.

Allografts: For large areas (10 cm or greater) of exposed calvarial bone, dermal regeneration templates (Integra) can be applied directly to the bone to create a recipient wound bed for delayed skin grafting (3–4 weeks). Burr the outer table of the calvarium to expose diploic blood supply prior to placing dermal regeneration template.

Free Flaps: Latissimus dorsi free flap provides a thin sheet of muscle that approximates the thickness of all layers of the scalp. Skin grafts are used to cover the muscle.

Can cover defects up to 20 × 40 cm in size.

Regional Flaps

- **Pectoralis** (myocutaneous axial)
  - Based off the **thoracoacromial artery**, lateral thoracic artery (supplies in the inferolateral 1/5th)
  - Maximal flap size 10 × 20 cm
  - Innervation: lateral and medial pectoral nerves
  - Common usage: oral cavity and oropharynx defects, great vessel coverage
  - Advantages:
    Donor site out of radiation field
    Pedicle is large
    Easy dissection
    Good perforators/reliable blood supply
  - Disadvantages:
    Functional defect of pectoralis major
    Female—disfiguration
    Bulky, heavy body hair can be of concern for pharyngeal defects

- **Trapezius**
  - Based off the **transverse cervical arteries**, occipital, suprascapular, paraspinous perforators
  - Can be designed with three different skin paddle configurations:
    Superior flap—Intercostal perforators
    Lateral flap—Transverse cervical artery
    Lower flap—**Transverse cervical artery**, dorsal scapular artery
  - Maximal flap size: ~25 cm, but 8 × 12 cm is average size for skin paddle
  - Innervation: spinal accessory nerve
  - Common usage: inferior 2/3 facial defects, neck, temporal fossa defects
  - Advantages:
    Can provide thin tissue for pharyngeal defects
    Little donor-site morbidity
    Can be used for carotid coverage
  - Disadvantages:
    Variable vascular supply
    Limited rotational reach
    May need to sacrifice the spinal accessory nerve—shoulder dysfunction
    Longer OR time with positioning changes

- **Latissimus dorsi flap** (myocutaneous axial)
  - Based off the thoracodorsal artery (10–15 cm pedicle length)
  - Maximum size 20 × 35 cm (tennis racket flap)
  - Innervation: thoracodorsal nerve
  - Common usage: oral cavity, oropharyngeal, carotid coverage, face/neck defects
  - Advantages:
    Long vascular pedicle
    Reliable blood supply
    Can close donor site primarily most times
    No breast deformity, relatively hairless flap
  - Disadvantage:
    Lateral decubitus position required for harvesting
    Bulky flap
    Large dissection; results in shoulder weakness and dysfunction
    Large STSG if not able to close primarily

- **Deltopectoral** (fasciocutaneous flap random)
  - Based off the 1–4th perforators from IMA; random distal to deltopectoral groove
  - Maximum flap size 12 × 22 cm
  - Innervation: sensory: supraclavicular nerves C3, C4 and intercostals T2–T4
  - Common usage: cutaneous cervical defects, hypopharyngeal defects
  - Advantages:
    Donor site out of radiation field
    Ease of dissection, good arc of rotation possible (45–135°)
  - Disadvantage:
    Tenuous blood supply distally; contraindicated if s/p CABG, pacemaker, mastectomy

Unreliable for defects that cause tissue stretch
Possible requirement of split-thickness skin graft

- **Submental island** (fasciocutaneous axial)
  - Based off the submental artery
  - Maximum flap size: 4 × 4 cm
  - Innervation: mental nerve
  - Common usage: intraoral and facial cutaneous defects
  - Advantages:
    Ease of access—neck is exposed in ablative portion
  - Disadvantages:
    Cancerous nodes may involve pedicle, can be in radiation field

- **Supraclavicular artery island flap (SCAIF)** (fasciocutaneous axial)
  - Based off the supraclavicular artery
  - Maximum flap size: 16 × 30 cm
  - Innervation: cutaneous nerves from the cervical plexus
  - Common usage: parotid, pharyngeal oral cavity, tongue, cheek, and lateral skull base defects
  - Advantages:
    Excellent skin color match
    Can harvest STSG from discarded flap skin to cover donor defect
    Can be sensate if cutaneous nerves are preserved
  - Disadvantages:
    May require STSG to cover donor site
    Can constrict and create neck contracture scar band

Free Tissue Transfer (Table 8.2)

For larger defects, or composite defects, free microvascular tissue transfer is often needed.

- Disa JJ, et al. 1999: buried flaps had higher loss rate, usually later ~7 days due to infection or fistula. Conventional monitoring works

Table 8.2 Commonly referenced free flaps for head and neck reconstruction with their blood supply and sensory nerves

Flap	Artery	Vein	Nerve
Radial forearm	Radial a.	Venae comitantes or cephalic v.	Antebrachial cutaneous
Lateral arm	Post. radial collateral	Post. radial collateral	Post. cutaneous n.
Temporoparietal fascia	Superficial temporal a.	Superficial temporal v.	None
Anterolateral thigh	Descending branch from lateral circumflex femoral	Venae comitantes	Lateral femoral cutaneous
Rectus abdominis	Deep inferior epigastric	Deep inferior epigastric	Intercostal nerves
Latissimus	Subscapular a.	Subscapular v.	Thoracodorsal
Fibula	Peroneal a.	Peroneal v.	Lateral sural cutaneous
Scapula	Circumflex scapular a. Angular a. (tip)	Circumflex scapular v.	None
Iliac crest	Deep circumflex iliac	Deep circumflex iliac	None
Jejunum	Branch of sup. mesenteric a.	Branch of sup. mesenteric v.	None
Gracilis	Adductor a.	Venae comitantes	Obturator n. (motor)

great for non-buried flaps; but recommend implantable monitoring or monitor paddle for buried flaps.

Fasciocutaneous and Musculocutaneous Free Flaps

Radial Forearm Free Flap

Versatile flap for reconstruction of the head and neck. This is due to the thin, pliable, and mostly hairless fasciocutaneous paddle that can be harvested. The radial forearm free flap is ideally suited for smaller defects or those requiring a thin flap for a three-dimensional shape. A preoperative **Allen's testing** must be performed to ensure the integrity of the palmar arch. A segment of the radius (up to 6–12 cm) can be harvested with the flap; however, the thickness of the bone graft is limited to **40 %** of the cross-sectional area of the radius. The majority of surgeons recommend prophylactic internal fixation of the donor radius to minimize postoperative fracture, wrist immobility, and decreased grip strength.

The skin paddle can also be made sensate via the antebrachial cutaneous nerve.

Size: ~10–12 cm of skin paddle

Advantages: ease of harvest, thin, pliable flap that can be folded to fit the defect, potential for osseous component, long pedicle, potential sensate skin paddle

Disadvantages: requires skin graft to donor site, concerns for hand morbidity, donor site appearance, potential flexor carpi radialis exposure

Anterolateral Thigh Free Flap

The anterolateral thigh (ALT) free flap has become the workhorse for head and neck reconstruction as it has many ideal properties. Skin paddles as large as 20 × 15 cm can be created, which depending on the body habitus of the patient can be thin and pliable as well. Therefore it has many applications: oral cavity, glossectomy, oropharyngeal, and skull base defects. The flap perforators can be musculocutaneous or septocutaneous and can be identified along a line drawn from the anterior superior iliac spine to the lateral edge of the patella.

Advantages: thicker than an RFFF but can be better contoured than a rectus flap, long pedicle, pedicle usually not affected by peripheral vascular disease, donor site closes primarily, possibility for chimeric flaps based on individual perforators

Disadvantages: variable location of the pedicle and perforators, poor skin color match

Rectus Abdominus Free Flap

Reliable flap for head and neck reconstruction. Can be harvested as myocutaneous or muscle-only flap. The often ample subcutaneous fat in this region resists atrophy (unlike the rectus muscle) and may be advantageous for very-large-volume reconstruction. Uses for the rectus include total glossectomy, skull base defects

Advantages: reliable pedicle, large bulk

Disadvantages: large bulk, potential for ventral hernia, poor skin color match

Latissimus Dorsi Free Flap

The latissimus dorsi as a free flap instead of as a pedicled flap allows for more flexibility of placement and less strain on the vascular pedicle. It is often used as a muscle-only flap for total scalp reconstruction in conjunction with skin grafts

Advantages: large surface area, thin (~4 mm muscle), possibility for two skin paddles

Disadvantages: lateral decubitus positioning for harvest, small vessel caliber

Osteocutaneous and Osteomusculocutaneous Flaps

Fibular Free Flap

The fibular free flap offers a long segment of bone for reconstruction (up to 25 cm) and therefore is ideal for mandibular reconstruction. However, the height of the bone is small, which may limit placement of dental implants. This can be overcome by using a "double-barreled" flap. The distal and proximal ends of the fibular should be preserved both proximally and distally (**6–8 cm**) to prevent injury to the peroneal nerve proximally and to support the ankle joint distally. A preoperative **MRA** or angiography can assist in ensuring viability of peroneal vessels, ruling out atherosclerotic disease, and ruling out femoral profunda magnum (contraindication). Skin paddles are designed between the middle and distal portion of the fibula to optimize viability. A cuff of soleus muscle is harvested with the flap to protect perforating vessels.

Advantages: long segment of bone, ideal for total mandibular reconstruction, long high-caliber vascular pedicle, ability to support dental implants, ability to perform two-team approach

Disadvantages: limited vertical height of bone, small viable skin paddle, need for skin graft closure, potential leg morbidity, pedicle often affected by peripheral vascular disease

Iliac Crest Free Flap

Nearly 16 cm of bone can be harvested. The bone is a good caliber for osseointegrated dental implants. For internal and external oral cavity defects, only a small internal skin paddle can be obtained. The iliac crest can be used for hemimandibular defects with contouring cuts along the outer cortex. Extension to the anterior inferior iliac spine can be included if condylar reconstruction is needed. Inner, mucosal, reconstruction can be performed with this flap if the internal oblique is included and skin grafted for the mucosal side.

Advantages: good size bone for implants

Disadvantages: hernia formation at donor site is possible, short pedicle

Scapular Free Flap

Donor site of choice for complex 3-D defects of the head/neck. Ideal for defects requiring significant bulk of tissue for reconstruction, as well as through-through defects of the oral cavity. This flap can provide a moderate (up to 14 cm) amount of bone from the lateral segment of the scapula, with additional bone stock available from the scapular tip via the angular artery. The scapular tip bone is also a good match for palatal and maxillary reconstruction. The advantage of this flap is that **two skin paddles** can be designed off of the circumflex scapular artery, and the arterial anatomy allows for a significant amount of mobility for the inset of these two flaps (great for dual-layer oral cavity reconstruction with mandibular reconstruction).

Advantages: ability to reconstruction complex 3-D defects, primary closure of donor site, supports osseointegrated implants

Disadvantages: lateral decubitus positioning, potential donor-site morbidity

Jejunum Free Flap

The main application of a free jejunum transfer is reconstruction of the hypopharynx and cervical esophagus. The diameter is a good match for the esophagus. It is vascularized via branches from the superior mesenteric artery. The distal end of the jejunum should be oriented distally to the esophagus upon inset in order to ensure antegrade peristalsis. A segment of omentum can be included in the flap to be skin grafted for external coverage. An external monitoring flap is commonly used.

Advantages: already a tube, so only two anastomotic suture lines

Disadvantages: intra-abdominal complications from laparotomy and bowel resection, excess mucus production and wet voice with TEP, swallowing dysfunction from stenosis

Questions

1. Which free grafts typically exhibit the most postoperative contraction?
   (a) Thin split-thickness skin grafts
   (b) Perichondrial composite grafts
   (c) Full-thickness skin grafts
   (d) Thick split-thickness skin grafts
2. At 24 h postoperatively, a patient's nasal skin graft site appears to be necrotic. What medication could have been used perioperatively, which may have increased the chances of graft survival?
   (a) Nitroglycerin paste
   (b) Intravenous acetaminophen
   (c) Topical vitamin E
   (d) Dexamethasone
   (e) Bevacizumab
3. A rhombic flap is planned for reconstruction of a 3 cm cheek defect. According to the figure notations on the image below (Fig. 8.11), where would the vector of tension be greatest?
   (a) A → B
   (b) B → C
   (c) C → F
   (d) D → A
   (e) B → D
4. Duformental and Zitelli are both known for modifying well-known transposition flap designs. What do their modifications have in common?
   (a) Both design modifications employ an M-plasty to close the defect
   (b) Both design modifications lessen the arc of pivot for the flap
   (c) Both design modifications are intended for smaller defects
   (d) Both design modifications are intended to reduce "pin-cushioning"
5. A 33-year-old woman presents with a contour defect of the right cheek after removal of a hemangioma as a child. You decide to try a free dermal fat graft for her problem. How much volume loss should the counsel to the patient to expect postoperatively?

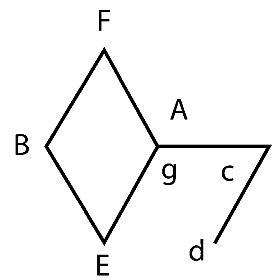

Fig. 8.11 Traditional rhombic flap prior to flap elevation and inset

   (a) 0–5 %
   (b) 10 %
   (c) 30 %
   (d) 75 %
   (e) 90 %
6. A patient presents with a 1.5 cm skin-only defect centered just medially to the medial canthus, involving the left nasal sidewall. Which flap would **NOT** be a reasonable option for reconstruction?
   (a) Glabellar transposition flap
   (b) Cheek rotation flap from below
   (c) Inferior and medially based bilobe flap
   (d) Melolabial island pedicle flap
   (e) Double-opposing transposition flaps
7. You are repairing a 40 % lower lip defect with a cross-lip flap. Which one of the following statements is correct?
   (a) The width of the flap should equal the width of the defect.
   (b) The labial artery is usually located between the orbicularis oris muscle and the labial mucosa.
   (c) Estlander flaps can be used to create a sharp, acutely angled oral commissure.
   (d) The vertical height of the flap is designed to be half the height of the defect.
8. A 70-year-old patient presents with a large squamous cell carcinoma of the scalp. Upon clearance of the tumor, a 20 cm scalp vertex defect remains with exposed cranial bone. Which reconstructive option would you recommend?

(a) Application of split-thickness skin graft from the lateral thigh.
(b) O to S rotational flap closure
(c) Temporoparietal fascia flap covered with split-thickness skin graft
(d) Split-thickness skin graft over a latissimus dorsi free flap
(e) Radial forearm fasciocutaneous free flap

9. Which technique can result in reduced morbidity of radial forearm free flaps?
   (a) Always use a monitor paddle.
   (b) Perform rigid internal fixation when harvesting radial bone.
   (c) Utilize ulnar arterial bypass grafts.
   (d) Remove splint on postoperative day 1 for early mobilization.
   (e) Always spare palmaris longus tendon.
10. Your head and neck surgery colleagues have just finished resection of a 5 cm buccal space and mandibular malignancy, and you are asked to assist in the reconstruction of the defect that encompasses the buccal mucosa, 3 cm of the angle of the mandible, and the overlying cheek skin. Which option would you recommend for this composite defect?
   (a) Osteocutaneous radial forearm free flap
   (b) Fibular free flap
   (c) Rib-pectoralis major osteomusculocutaneous regional flap
   (d) Split calvarial bone graft with a cervicofacial advancement-rotation flap
   (e) Scapular osteocutaneous free flap

ANSWERS

1. (a)
2. (d)
3. (d)
4. (b)
5. (c)
6. (d)
7. (b)
8. (d)
9. (b)
10. (e)

Additional Resources

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9 Facial Paralysis and Facial Reanimation

Jon-Paul Pepper

Extratemporal Anatomy of the Facial Nerve

Main Trunk Location (Rea et al. 2010)

- 5.5 ± 2.1 mm from posterior belly of digastric muscle
- 6.9 ± 1.8 mm from tragal pointer
- 10.9 ± 1.7 mm from external auditory canal
- **2.5 ± 0.4 mm from tympanomastoid suture (most reliable landmark)**

Temporal (Frontal) Branch Course

Pitanguy and Ramos (1966) described a line starting from a point 0.5 cm below the tragus that extended in the direction of the brow, passing 1.5 cm above the lateral extremity of the eyebrow. Note the frontal branch is on the deep surface of the temporoparietal fascia.

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Relationship of Frontal Branch to the Superficial Temporal Artery

The frontal branch of the superficial temporal artery at the level of the lateral border of the frontalis is a common point of entry of the temporal branch of the facial nerve into the muscle. The nerve rami are usually anterior to the vessel (~90 %) as it branches from the superficial temporal artery.

Buccal and Zygomatic Branches

The buccal and zygomatic branches of the facial nerve were found by Davis et al.(1956) to divide 2.0 cm beyond the anterior edge of the parotid gland before supplying the midface muscles.

Relationship of Marginal Mandibular Branch to Facial Artery and Vein

Dingman and Grabb (1962): Posterior to the facial artery, the mandibular branch was found to pass *superior to* the lower border of the mandible in 81 % of the specimens. In the other 19 %, one or more rami of the mandibular branch formed a downward arc, whose lowest point extended up to 1.0 cm *below* the inferior border of the mandible. Anterior to the facial artery, *all* of the rami of the mandibular branch were found to be above the lower border of the mandible.

B.J.-F. Wong et al. (eds.), *Facial Plastic and Reconstructive Surgery*,
DOI 10.1007/978-3-319-18035-9_9

Etiologies of Facial Paralysis, see Table 9.1 (Bleicher et al. 1996)

Sunderland Classification of Nerve Injury, Table 9.2 (Sunderland and Williams 1992)

Systems Used to Classify Severity of Injury in Patient with Facial Weakness or Paralysis

House-Brackmann Scale (Table 9.3): a global facial function grading system that is used for prognosis for recovery following Bell's palsy (House and Brackmann 1985). It is not descriptive of branch by branch dysfunction, which is most important for facial nerve reanimation surgery, given the importance of the buccal branch for normal smile.

Sunnybrook Facial Grading System, see Table 9.4 (Ross et al. 1996):

There are also three-dimensional image capture and analysis programs that provide quantitative measures, such as the FACIAL CLIMA system (Hontanilla and Aubá 2008).

Bell's Palsy: Acute Idiopathic Facial Paralysis (Bleicher et al. 1996; May et al. 1983; Sullivan et al. 2007)

1. The most common cause of facial paralysis
2. "Acute" means symptoms develop over 72 h time frame
3. A diagnosis of exclusion (i.e., no other causative factors or ominous signs)
4. Self-limited
5. Overall, has a good prognosis (see below)
6. Represents 50–70 % of all facial nerve paralysis per annum
7. Bell's palsy is acute idiopathic facial nerve paralysis thought to have a viral cause.
8. Other causes of facial paralysis excluded by clinical examination and history: tumor, stroke, Lyme disease, autoimmune disease, multiple sclerosis, HIV, trauma, otitis media, others

Bell's Palsy Epidemiology and Prognosis

- More common in ages 15–45, diabetics, immunocompromised, pregnancy, and with

Table 9.1 Etiologies of facial paralysis

Category	Includes	Annual incidence	Percentage
Idiopathic	Bell's palsy	75,396	49.6
Infectious	Lyme disease, otitis media	23,222	15.3
Neoplastic	Acoustic neuroma, parotid malignancy	20,508	13.5
Neurologic	Stroke, Guillan Barre	20,508	13.5
Traumatic	Temporal bone fracture, birth trauma	12,365	8.1
Total		*151,999*	

Table 9.2 Sunderland classification of nerve injury

Degree of injury	Pathophysiology	Prognosis	Time to recovery
1st degree	Conduction block without axonal degeneration	Excellent	3 weeks
2nd degree	Arteriole compression, causing ischemic axonal injury, or inflammation such as from a viral infection	Good	3 weeks–3 months
3rd degree	Endoneurial injury	Moderate	2–4 months
4th degree	Perineurial injury	Poor	Uncertain
5th degree	Epineurial injury	Poor	Uncertain

Note that recovery times are based on intratemporal facial nerve injury, with a presumed rate of axonal regeneration of approximately 1 mm per day (Sanders and Whitteridge 1946)

Table 9.3 House-Brackmann scale

Grade	Function	Description
I	Normal function	Normal facial function in all areas
II	Slight dysfunction	Gross: slight weakness noticeable on close inspection; may have very slight synkinesis At rest: normal symmetry and tone Motion: forehead—moderate to good function; eye—complete closure with minimum effort; mouth—slight asymmetry
III	Moderate dysfunction	Gross: obvious but not disfiguring difference between two sides; noticeable but not severe synkinesis, contracture, and/or hemi-facial spasm At rest: normal symmetry and tone Motion: forehead—slight to moderate movement; eye—complete closure with effort; mouth—slightly weak with maximum effort
IV	Moderate severe dysfunction	Gross: obvious weakness and/or disfiguring asymmetry At rest: normal symmetry and tone Motion: forehead—none; eye—incomplete closure; mouth—asymmetric with maximum effort
V	Severe dysfunction	Gross: only barely perceptible motion At rest: asymmetry Motion: forehead—none; eye—incomplete closure; mouth—slight movement
VI	Total paralysis	No movement

Table 9.4 Sunnybrook facial grading system

Resting symmetry	
Eye (choose one only)	
normal	0
narrow	1
wide	1
eyelid surgery	1
Cheek (naso-labial fold)	
normal	0
absent	2
less pronounced	1
more pronounced	1
Mouth	
normal	0
corner drooped	1
corner pulled up/out	1
Total	0
Resting Symmetry score Total X 5	0

Standard Expressions	Unable to initiate movement	Initiates slight movement	Initiates movement with mild excursion	Movement almost complete	Movement complete		NONE: no synkinesis or mass movement	MILD: slight synkinesis of one or more muscles	MODERATE: obvious synkinesis of one or more muscles	SEVERE: disfiguring synkinesis gross mass movement of several muscles	
Brow lift (FRO)	1	2	3	4	5	0	0	1	2	3	0
Geltle eye closure (OCS)	1	2	3	4	5	0	0	1	2	3	0
Open mouth Smile (SYG/RIS)	1	2	3	4	5	0	0	1	2	3	0
Snarl (LLA/LLS)	1	2	3	4	5	0	0	1	2	3	0
Lip Pucker (OOS/OOI)	1	2	3	4	5	0	0	1	2	3	0
	Gross Asymmetr	Severe Asymmetr	Moderate Asymmetr	Mild Asymmetr	Normal Asymmetr	Total 0					
				Voluntary movement score:	Total X 4	0		Synkinesis score:		Total	0

Patient's Name

Diagnosis

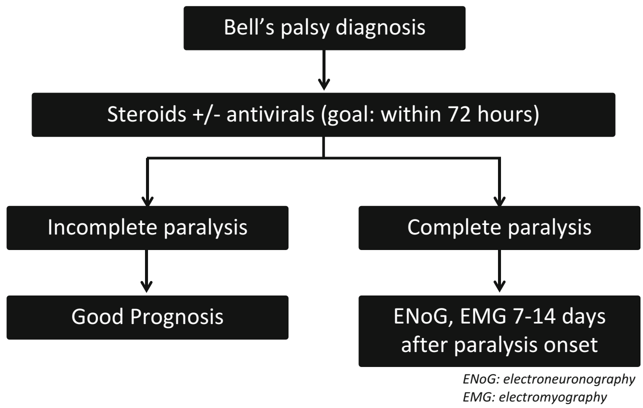
3/24/2011

Date

Vol mov't score 0 - Resting symm score 0 - Synk score 0 = Composite Score: 0

Note the inclusion of synkinesis in the grading scale

Table 9.5 Workup and treatment algorithm for Bell's palsy



concomitant viral upper respiratory tract infection

- In general, approximately one third of patients present with complete paralysis
- Nearly all patients with incomplete paralysis (paresis) will fully recover
- Up to 94 % with *paresis* will recover complete function
- Synkinesis occurs in ~20 % patients with Bell's
- Of those with complete paralysis, prognosis is worse
- In large series of *untreated* patients, approximately 70 % recover function with *watchful waiting alone* (Peitersen 2002).

Bell's palsy workup and treatment algorithm, note that use of antivirals is per practitioner preference, Table 9.5 (Baugh et al. 2013):

Electrodiagnostic Testing

ENoG: measures compound muscle action potentials after applying bipolar stimulation to the mastoid process region (main trunk of facial nerve)

1. Performed between day 3 and day 14 after symptom onset. Earlier evidence of conduction block (i.e., earlier Wallerian degeneration) likely indicative of higher grade of injury.
2. Fisch criteria: >90 % degeneration. The amplitude of the compound muscle action potential on the paralyzed side is 10 % (or less) of the amplitude of the compound muscle action potential on the contralateral (intact) side. Used as a criterion for possible middle cranial fossa decompression (Djalilian 2005).

EMG (volitional and resting): motor unit action potentials

1. Typically done on days 10–14 post injury. A confirmatory test for ENOG in the acute setting.
2. Resting: fibrillation potentials and positive sharp waves are indicative of denervation.
3. Volitional EMG: polyphasic action potentials are indicative of early re-innervation.
4. EMG can be used to follow patients for subclinical volitional responses in re-innervating muscle (El-Kashlan and Kileny 1998).
5. *EMG is a significant tool for determining the timing of reinnervation surgery, if any*.

When to Image (MRI with Contrast Preferred) a Patient with Presumed Bell's Palsy

- A second episode
- No improvement in symptoms after 3 months
- Associated second cranial neuropathy
- Isolated branches of facial nerve affected

Facial Paralysis (any Etiology), Management Concepts

1. Early corneal protection
2. Timely neurodiagnostics (see above)
3. Possible surgical intervention

Corneal protection

- Lubricating eye drops, tape, moisture chamber
- Platinum weight
- Palpebral spring
- Botulinum toxin of levator palpebrae superioris
- Blepharotomy
- Temporary tarsorrhaphy

Lower lid management: corneal coverage with upper lid weight *without* lower lid suspension is significantly less effective than upper lid loading in combination with a procedure to support the lower lid (Chepeha et al. 2001; Pepper and Kim 2012).

Options for treating the lower lid include:

- Lateral canthopexy
- Formal lateral canthoplasty
- Lower lid wedge excision
- Sub-orbicularis oculi fat pad (SOOF) lift for very ptotic midface

Synkinesis

- *Definition*: unintentional motion of one area of the face produced during intentional movement of another following facial nerve paresis or paralysis (Crumley 1979)
- Socially and functionally debilitating, sometimes painful
- Poor prognosis for spontaneous resolution of synkinesis
- Location of injury is thought to be a significant predictor of future synkinesis

Table 9.6 Relative incidence of synkinesis based on location and grade of injury

Population	Incidence of synkinesis (%)
Following surgical repair of intratemporal facial nerve, humans (Blomstedt et al. 1994)	100
Following surgical repair of extratemporal facial nerve, humans (Yamada et al. 2010)	69
Bell's palsy	18.3–55

Incidence of Synkinesis, see Table 9.6

Natural History of Synkinesis

- Synkinesis can follow any type of significant facial nerve paresis or paralysis (see below)
- Often begins 3–4 months following injury, but has been reported as early as 6 weeks post injury
- Prognosis for spontaneous improvement of facial synkinesis once it begins is poor (Husseman and Mehta 2008; Pepper et al. 2012)

Three proposed mechanisms:

1. Aberrant regeneration of axons (dominant theory)
2. Ephaptic transmission due to demyelination
3. Facial nucleus somatotopic changes and excitability threshold changes

Regenerating facial nerve axons may have a large number of collaterals after injury. A large number of these collaterals appear to stay intact over the long term, thereby disrupting the somatotopic organization of the facial nucleus for long periods of time (Choi and Raisman 2002).

Management of facial synkinesis:

1. Physical therapy/biofeedback
2. Neuromuscular facial retraining
3. Chemodenervation with botulinum toxin injections

Both physical therapy and neuromuscular retraining have been demonstrated to be effective based on large retrospective cohort studies (Beurskens and Heymans 2004, 2006). Chemodenervation has been validated by double-blind randomized controlled trial (Borodic et al. 2005).

Surgical Management of Chronic Facial Paralysis

In general, a combination of static and dynamic techniques may be employed. The surgical approach is tailored to patient desire, age, prognosis, prior radiation treatment, etc.

Static Resuspension

1. Direct brow lift
2. Endoscopic brow lift
3. Midface lift
4. Functional septorhinoplasty or suspension of external nasal valve
5. Deep plane rhytidectomy
6. Static sling with fascia lata or allograft
7. Contralateral neurectomy or myectomy

Note: the modiolus is the point of convergence of the zygomaticus muscles, buccinator muscle, orbicularis oris muscle, and the risorius muscle. It is usually 1 cm lateral to the oral commissure in most individuals (Pepper and Baker 2013).

Dynamic Reinnervation or Reanimation

1. Hypoglossal nerve transfer via interposition graft
2. Facial nerve transposition to hypoglossal nerve, end to side coaptation
3. Nerve to masseter transfer
4. Cross facial nerve graft
5. Innervated free muscle transfer
6. Temporalis tendon or muscle transposition

Hypoglossal nerve transfer:

- Excellent for tone, volitional movement may be limited or synkinetic
- End to side transfer is superior to use of interposition graft, due to need for axons to traverse two sites of coaptation in an interposition graft (Bertelli et al. 2004).

Nerve to masseter transfer:

- Usually coapted to buccal branch for zygomaticus complex reinnervation
- "Zuker's point," a convenient starting point for dissection of the nerve is masseter is located 3 cm anterior to the tragus and 1 cm caudal to the zygomatic arch.
- The nerve is found at a depth of 1.48 ± 0.19 cm deep to the submuscular aponeurotic system (SMAS). Relative to the zygomatic arch, the nerve emerged at an angle of $50° \pm 7.6$ as it coursed distally into the masseter muscle; the intramuscular course of the nerve pointed toward the oral commissure. The distance from the arch to the branching portion of the motor nerve to the masseter was 1.33 ± 0.20 cm (Borschel et al. 2012).
- The nerve to masseter may be used to drive the nerve to the gracilis in single stage gracilis free muscle transfer for facial reanimation
- High axonal input, *onset to function is most rapid of any re-innervation technique*.
- Patient must perform rehabilitation to smile. Spontaneous smile is not recovered in all patients (i.e., patients must "bite to smile").

Cross facial nerve graft:

- In general, axonal ingrowth through this long (~14 cm) avascular nerve graft can be uncertain. Although direct nerve coaptation to a paralyzed facial nerve branch has been performed with success, the failure rate of direct nerve coaptation is significant.
- Most useful as a source of axonal input to a gracilis free tissue transfer
- Gracilis is performed at second surgery, following ingrowth of axonal input to the contralateral (paralyzed) face. This is heralded by the "Tinel's sign," or tingling sensations produced by transcutaneous percussion of the nerve graft.

Gracilis-free tissue transfer:

- May be powered by a cross-facial nerve graft (two-stage procedure) or by a nerve to masseter transfer (single stage procedure).
- In general, commissure movement is greater with the use of the nerve to masseter.
- The cross facial nerve graft reestablishes spontaneous movement. Nerve to masseter is reported to provide spontaneous smile in roughly 50 % of patients in one case series (Manktelow et al. 2006).
- Facial reanimation using the free gracilis muscle transfer improves objective facial symmetry and patient quality of life (Lindsay et al. 2010, 2014; Bhama et al. 2014).

Orthodromic Temporalis Tendon Transposition:

- Excellent for patient with dense paralysis or significant atrophy
- Performed in single surgery, no need for multistage surgery (Byrne et al. 2007; Boahene et al. 2011; Boahene 2013)
- Dynamic excursion can be somewhat limited, in particular in a patient who has had buccal fat pad previously radiated (Griffin et al. 2012; Labbe et al. 2012).

Lengthening Temporalis Myoplasty

- Alternative technique that employs partial temporal fossa release of the temporalis muscle, and inset of the released temporalis tendon into the peri-oral region via melolabial crease incision (Labbe et al. 2012; Labbe and Huault 2000; Bénateau et al. 2004; Nduka et al. 2012).
- Preserves length–tension relationship of the muscle via release and translocation of the temporalis muscle toward target.
- Approach requires hemi-coronal incision and osteotomy of the zygomatic arch.

Questions

1. Which branch of the facial nerve is responsible for a normal, spontaneous blink?
   (a) Buccal
   (b) Temporal
   (c) Zygomatic
   (d) Marginal Mandibular
2. Which of the following is *not* an indication for imaging in a patient with acute onset facial paralysis:
   (a) A second episode
   (b) No improvement in symptoms after 3 months
   (c) Numbness of the conchal bowl
   (d) Associated second cranial neuropathy
   (e) Isolated branches of facial nerve affected
3. Which of the following muscles is *not* a contributor to the modiolus in most individuals?
   (a) Buccinator
   (b) Depressor anguli oris
   (c) Zygomaticus muscles
   (d) Risorius
   (e) Orbicularis oris
4. What time period is the upper limit that is considered “acute onset” for a clinical diagnosis of acute idiopathic facial nerve paralysis (Bell’s palsy)?
   (a) 5 days
   (b) 4 days
   (c) 3 days
   (d) 2 days
   (e) 1 day
5. What is the most reliable marker for the anatomic location of the main trunk of the facial nerve after it emerges from the stylomastoid foramen?
   (a) Posterior belly of digastric muscle
   (b) Tragal pointer
   (c) Tympanomastoid suture
   (d) External auditory canal

Answers

1. (a)
2. (c)
3. (b)
4. (c)
5. (c)

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10 Mohs Surgery

Sim Choroomi

Introduction

Mohs micrographic surgery (MMS) is a step-wise surgical technique of skin cancer extirpation named after Dr Frederik Mohs, from the University of Wisconsin, who conceptualized the technique in the 1930s. His technique was later modified by Stegman and Tomovich to today's current method.

MMS combines surgical excision with real-time histopathology analysis of margins. The components of the procedure include surgical excision, histopathological examination, precise tumor mapping, confirmation of tumor clearance, followed by reconstruction and wound management.

MMS is considered to have the most optimal cure rates for cutaneous BCC and SCC compared with other treatment modalities. From a practical perspective, MMS is best indicated for select cases of skin cancers, particularly in the head and neck region where recurrence rates are highest and aesthetic reconstruction is often complex.

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Overview of Skin Cancers

Skin cancer is the most common form of malignant neoplasm in the United States, with an estimate 1 in 5 people having a lifetime chance of developing the disease. With over three million cases diagnosed annually, there has been a dramatic increase in the number of cases being diagnosed in recent times. The lesions with the highest incidence include basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and malignant melanoma, with the following incidence:

- BCC: 80 %
- SCC: 15 %
- Melanoma: 5 %
- Other < 1 %

Etiology of Skin Cancers

- UV light (UVB wavelengths 280–320 nm most damaging, synergistic with UVA bulbs from tanning beds)—Causes mutation of tumor suppressor genes.
- H-zone of face (Fig 10.1)—high risk and recurrence rate in this region
- Fair complexion—melanin protects skin from UV radiation effects

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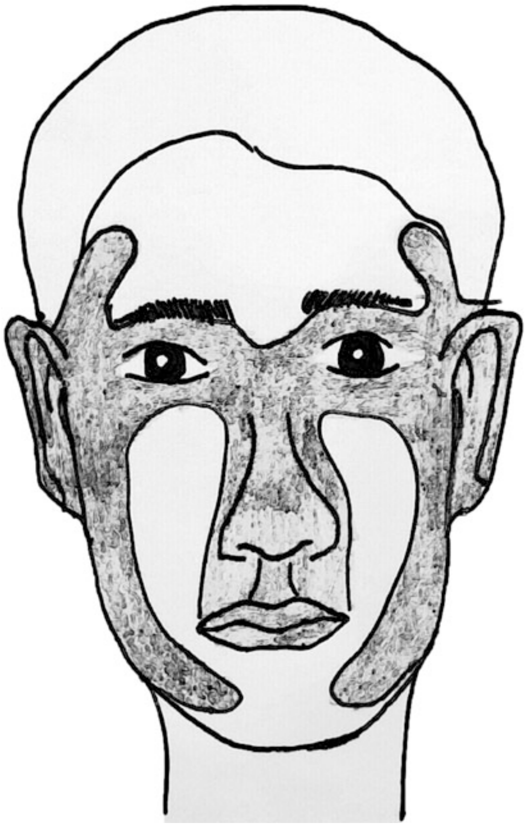

Fig. 10.1 H Zone of Face. The *grey shaded area* highlights the high risk "H-Zone" of the face

- Fitzpatrick type I or II skin
  Light hair
  Blue/green eyes
  Inability to tan
- History of multiple/severe sunburn
- Celtic ancestry

• Other risk factors
  - Radiation therapy
  - Burns
  - Ulcers and/or chronic inflammation
  - Occupational exposure to oils, tar, arsenic
  - Immunosuppression (particularly transplant patients)
  - Genetic Disorders
    Albinism—variable inheritance
    Xeroderma pigmentosa—autosomal recessive
    Gorlin's syndrome (nevoid BCC syndrome)—autosomal dominant

Basal Cell Carcinoma (BCC)

Occur mainly in head and neck and sun-exposed areas. Malignant, slow growing, rarely metastasizes (<0.5 % rate). Locally invasive and may have perineural involvement.

Pathology

Tumor cells originate in epidermis; the cells appear histologically similar to the basal layer of epidermis without intracellular bridges. The diagnostic histological features, common for all types of BCC, are basaloid cells with a thin pale cytoplasm surrounding round or oval nuclei with a rough granulated chromatin pattern. The peripheral borderline cell layers are characterized by palisade arrangement.

Subtypes of BCC:

- **Nodular**—Most common. Lesions are discrete, dome-shaped with a "pearly" surface and may have telangiectasia. The borders may be rolled and central necrosis may occur. Histology shows islands and sheets of tumor cells. Subtypes: Pigmented and cystic nodular BCC. Pigmented nodular lesions may resemble nevi and melanoma.
- **Superficial**—Multicentric epithelial pink–red patches with scaly appearance; more common on the trunk and extremities. Normal skin may exist between adjacent lesions.
- **Morpheaform/Sclerosing**—Most aggressive form. Occurs frequently in the head and neck with plaque-like appearance and ill-defined borders. Insidious and infiltrating growth pattern with extensions to deep dermis and therefore has higher recurrence rates.

Squamous Cell Carcinoma (SCC)

Occurs most frequently in the head and neck; also on sun-exposed extremities. More aggressive and likely to metastasize than BCC

(2–5 %); therefore, the draining lymph nodes must be assessed. May arise from preexisting lesions, namely, actinic keratosis, ulcers, chronic inflammation or in situ SCC. Clinical changes are noted to occur when malignant transformation occurs—typically increased size, bleeding, and ulceration. In situ SCC may progress to SCC with a 30 % risk over time.

Pathology

Macroscopically, the lesions appear as superficial crusting, erythematous with a granular friable base. Whether occurring de novo or from a preexisting lesions, histologically SCC demonstrates irregular masses of epidermal cells penetrating the basement membrane to reach the dermis. Keratinization may occur in well-defined low-grade lesions and less so in high-grade SCC.

Subtypes of SCC

- **Verrucous**—Uncommon on skin of head and neck (more common on mucosal surfaces). Cauliflower-like, white lesions, minimal atypia.
- **Spindle**—Anaplastic cells, little keratinization, spindle cells intermingled with collagen
- **Adenosquamous** cell carcinoma—Tubular and adenoid appearance
- **Basaloid squamous**—Aggressive, high-grade lesion

Keratoacanthoma (KA)—Though technically not a subtype of SCC, KA's are thought to be a low-grade SCC. They typically rapidly grow in sun exposed area, into a nodule with central ulceration and keratin plug. They may spontaneously involute. Surgical excision is needed to confirm histopathology and margins.

Melanoma

The most deadly skin tumor; although only 5 % of skin cancer it causes 75 % of deaths from skin cancer. Incidence is increasing, occurring in 20:100,000. Risks are mainly due to fair complexion and amount of sun exposure, with 10 % of melanoma occurring in familial melanoma syndromes.

Pathology

Melanoma most commonly occurs on the skin, although oral, anogenital mucosa, esophagus, meninges and the eye occur more rarely. Lesions arise at dermo-epidermal junction.

Two growth patterns occur: radial and vertical. **Radial** growth usually occurs first, spreading horizontally within epidermis/superficial dermis with low capacity to metastasize. **Vertical** growth represents spread deeper into dermal layers. Cellular maturation decreases, cells become smaller, and clinical nodule develops. Extent (and timing) of vertical growth determines metastatic potential.

Subtypes

- **Superficial spreading**—Flat, slightly elevated with variable pigment. Radial and superficial growth pattern.
- **Nodular**—Smooth, single-colored (brown or black) elevated nodule, minimal radial growth, may ulcerate. Thickest of all melanoma subtypes, correlation between thickness and prognosis.
- **Lentigo maligna (LM)**—Most common (>75 %) type of melanoma in situ. Slow, radial growth pattern. Typically arises from long-standing pigmented lesions on chronic skin damaged skin. May be hypopigmented.
- **Acral lentigo**—More common in darker skinned individuals on palms and soles of feet. Aggressive growth pattern.
- **Desmoplastic**—Uncommon, unremarkable plaque or nodule which can be easily misdiagnosed early on. **Neurotropic**, locally aggressive but lower incidence of nodal metastasis.

Diagnosis—Full thickness excisional biopsy with 1–2 mm margin for suspicious lesions or multiple punch biopsies of larger lesions. Shave biopsies should not be performed. Lymph nodes must be clinically examined as well as full skin exam as well as staging scans.

Nonsurgical Treatment of BCC and SCC Lesions

All therapies aim to remove or destroy primary tumor + some adjacent normal tissue

- Curettage—lesion and small margin removed by feel
  - For <1 cm low risk BCC
  - If the subcutaneous tissue is reached, then surgical excision should be performed
- Topical therapy
  - Imiquimod 5 % cream—induces cytokines related to cell-mediated immune response, such as interferon alpha. Used five to seven times per week for a period of 6 weeks on superficial BCCs. Local skin reactions are common but well tolerated. The initial clearance rate at 12 weeks post-treatment is about 95 %. Recurrence rate up to 20 %.
  - 5-fluorouracil (5-FU) cream is used for the treatment of superficial BCCs and actinic keratosis. Treat with 5 % 5-FU cream twice daily for up to 12 weeks. Treatment is stopped sooner if the lesion is clinically resolved.
- Cryosurgery
  - Treatment of choice for isolated, well-defined actinic keratoses
  - Need Temp $< -50\,^{\circ}$C to cause cell death, leaves an open wound
  - Useful when there is underlying cartilage as it is spared
  - Best for low-risk tumors with well-defined borders. Leaves scarring and hypopigmentation.
- Radiation therapy
  - For wide field tumors
  - For high-risk malignancies in poor operative candidates
  - High cure rate but lengthy treatment and radiation side effects
- Photodynamic Therapy
  - A selective non-invasive therapy for non-hyperkeratotic actinic keratoses, in situ squamous cell carcinoma, and superficial and thin nodular basal cell carcinomas.
  - Photosensitising drug (porphyrin, 5-ALA) applied either topically, IV, or oral
  - Activate drug by exposure to laser or LED light
  - May be used for palliation of advanced lesions

Surgical Excision of Lesions

Numerous factors are taken into account for each lesion, as seen in Table 10.1. Excision margins for SCC and BCC are generally based on the size and histology of the lesion, with higher grade lesions requiring a wider margin (Table 10.2). Location of the lesion may have some influence on margins taken, given potential functional outcomes post excision; however, priority should be on tumor clearance.

Table 10.1 Surgical treatment—determining factors for surgical treatment of cutaneous malignancy

Patient factors
Age General health Wound care post-op
Disease factors
Type of skin tumor Size and location of lesion Histopathological subtype and grade of lesion Primary tumor vs recurrent Presence of perineural involvement Prior treatment of lesion Presence of lymph nodes
Institutional factors
Physicians skills and competence with modalities of treatment Access and cost of resources Cosmetic and functional outcomes Cure rates for different modalities Access to adjunctive treatments

Table 10.2 Surgical margins for standard excision

	Margin (mm)
BCC	
Lesion <1 cm	4–5
Lesion >1 cm	5–10
Lesion >2 cm	15–20
SCC	
Low risk lesions	4–5
High risk lesions	6–10

Mohs

The concept of Mohs micrographic surgery (MMS) is a step-wise microscopic control of peripheral and deep margins during the procedure, to allow for maximal cure rates with minimal removal of normal skin.

To implement these two factors—tumor removal and normal skin preservation—every step of the MMS process needs to be meticulous, from the doctor's assessment to the technician's preparation of histopathology slides.

Given the variety of pathologies, particularly in cases of recurrent disease and aggressive tumors, MMS allows the surgeon to search deceiving lesions which initially may present as only the "tip of the iceberg." Some cases will have lesions with clinically easy-to-identify borders while others may require peripheral and deep margins to be "chased" until clear.

A tailored approach is taken in MMS, with there being a relative importance of normal tissue preservation, depending on the patient's age, skin laxity, location of the tumor, and other factors (Table 10.3). A cheek lesion on an elderly male with lax skin will certainly be treated differently to a peri-orbital lesion in a young female for example.

Tumors Treated by MMS

1. BCC
2. SCC
3. Melanoma in situ (MIS)—with reported 5-year recurrence rates of 0–7 %, being superior to traditional surgical excision
4. Other rare malignant skin lesions (such as dermatofibrosarcoma protuberans). Long-term follow-up necessary as recurrences have occurred after 5 years.

Table 10.3 Indications for MMS in non-melanoma skin cancer

Tumor characteristics
Facial tumors, particularly the H-zone, peri-orbital lesions, ears Recurrent lesions Size >1 cm on the neck or face Large lesions (>2 cm) on the body Aggressive histopathology subtypes • Morpheaform, micronodular, and infiltrating BCC • High grade, poorly differentiated, or infiltrating SCC • Spindle-cell SCC Poorly defined borders clinically Lesions with perineural invasion Mucosal lesions—oral cavity, paranasal sinuses
Background skin characteristics
Radiation induced tumors Tumors developed in an old scar or ulcer (Marjolins) Previous positive margins/reconstruction
Patient factors
Tumors in patients with familial tendency—xeroderma pigmentosa, BCC syndromes Immunocompromised patients

Importance of H-zone of the Face and Embryonic Fusion Planes

Of particular importance for a subgroup of difficult and recurrent BCC is understanding that some lesions have silent, subclinical contiguous extension, which tends to follow the "path of least resistance." Extensions of these lesions have an affinity for fascial planes, periosteum, perichondrium, dermis, nerve sheaths, blood vessels, the tarsal plates, and embryonic fusion plane sites.

An example is a BCC which spreads from the skin of the pinna to the perichondrium and then deeper to periosteum and can travel down the external auditory canal.

The mode of spread at sites of embryonic fusion planes is perpendicular to the skin surface and has three important sites in the head and neck:

1. Pre-auricular at tragus
2. Along the collumella
3. Junction of the nasal ala and naso-labial folds.

BCCs located in fusion lines tend to infiltrate deeper and have a higher recurrence rate.

The high-risk H-zone (Fig 10.1) incorporates these sites and the Mohs surgeon must be aware of subtle spread in these sites. The ala-nasolabial fold region may spread down a plane of the nasal septum and lesions of the inner canthus may have deep extension to the ethmoid sinuses. To maximize cure and minimize normal skin loss, Mohs is indicated in this region, as reconstruction for function and cosmesis are imperative in these sites.

Pre-op Assessment Prior to MMS

- Full medical and surgical history
- Photo-documentation of lesion
- Consultations with other specialties as needed—Head and Neck, oculoplastics, reconstructive
- Smoking/alcohol history
- Allergies—medicines, dressings, tape
- Presence of implants/defibrillators (use of cautery)
- Social history—important for post-op wound care
- Psych input for larger lesions and potential defects

MMS Procedure

MMS is step-wise, where the surgeon serves as his or her own histopathologist (Fig 10.2). This requires specialized training, staff, and resources. The procedure is typically carried out in an outpatient setting over the course of a day, under local anaesthesia, though sedation or general anaesthesia may be used in some cases.

- The area is prepped with betadine or other antiseptic agent
- Tumor boundary is marked with a pen
- Local anesthesia, typically 1 % lidocaine with epinephrine is infiltrated
- Obvious clinical tumor is removed, centrally debulked, and analyzed. The boundary however is the key for surgical excision.
- The initial boundary is incised with a scalpel at 45° to the skin with a 1–2 mm margin. This allows for orientation. A single, smooth peripheral cut is made circumferentially around the lesion.
- The area is marked with ink or is nicked with a blade, usually at 3, 6, 9, and 12 o'clock to orientate the lesion.
- A blade or scissors is then used on the deep layer, as it is then lifted and dissected carefully parallel to the base of the plane of the tumor.
- A Mohs "map" is drawn by the surgeon (such as quadrants in Fig 10.2) based on the orientation of the specimen
- The specimen is transferred to the histology lab
- The open wound is dressed

Processing/Interpretation

- The surgeon is the histopathologist, being unique to the Mohs process. Critical information is not lost in time between two physicians; rather, the surgeon has a clear intimate understanding of the lesion.
- Also unique to Mohs is the specimen is not cut vertically (e.g., it is not "bread-loafed" as in typical histology slides), rather is processed horizontally. It is estimated that only 1 % of a lesion is evaluated in standard vertical sectioning histopathology.
- The histo-technician has key steps to orientate, embed, fix, freeze, section, mount, and stain the specimen. Each step is critical for

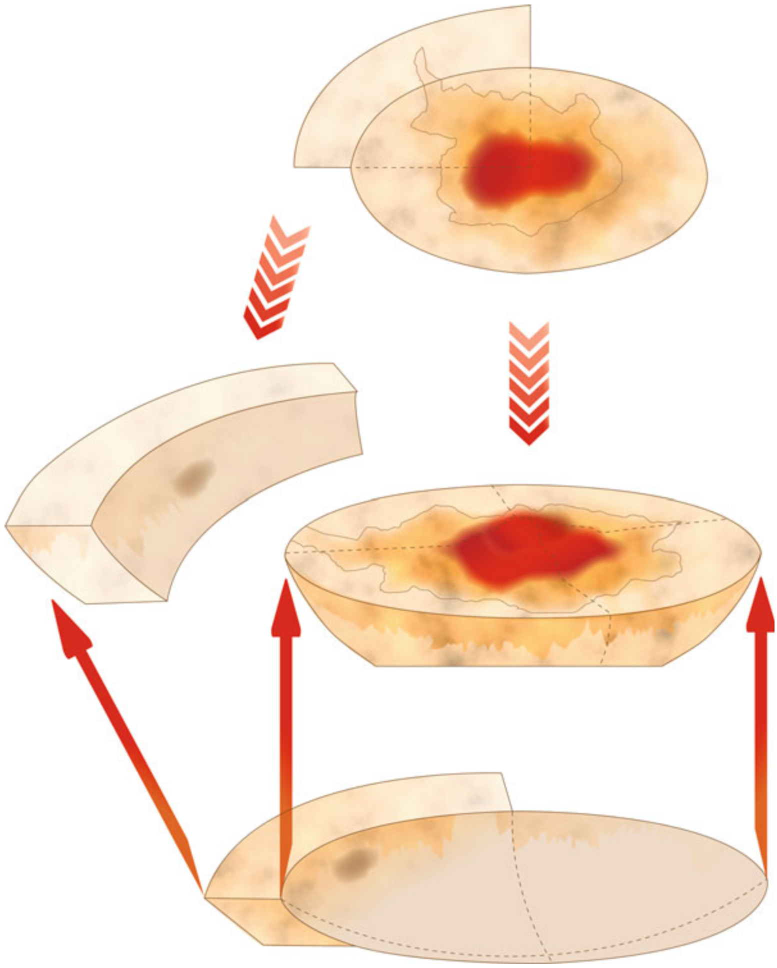

Fig. 10.2 Moh's technique. This figure depicts the principles of Moh's excision, the Moh's map (made of four quadrants here) and re-excising one positive quadrant to achieve clear margins

accurate evaluation. Orientation is always maintained with the lesion flattened and kept parallel to the deep margin.

- Sectioning and staining are performed in-house and fixed to glass slides and stained with H + E for evaluation.
- Horizontal sections are evaluated to ensure edges are clear.
- If an area is positive, the surgeon goes back to the "map" made and more tumor is removed from only this area, thus maximally preserving normal skin in other segments (Fig 10.2)
- The process is repeated until all the margins are clear.
- The defect can be reconstructed immediately or staged.
- Staged reconstruction calls for wound care and dressings (as per leaving a wound to heal by secondary intension) and is typically performed in a matter of days.

Variations in the Mohs Technique

- Single section method—for shallow lesions, highly bevelled specimen, usually left for secondary healing
- Wide excision Mohs—Wider margin taken on higher risk lesions to prioritize tissue processing speed.

Deep and Bone Involvement

Bone involvement is also seen with difficult cancers in certain sites, such as a desmoplastic SCC of the scalp or a high-grade BCC over the maxillary sinus. In addition, an SCC or BCC with perineural invasion can gain access to the bony canal through which the nerves pass.

Although bony invasion is infrequent, when it does occur, the following strategies are used to control its growth: (1) establish the diagnosis and mode of invasion of the tumor histologically; (2) obtain imaging to assess both local and regional (namely lymph node) involvements (3) refer to a related subspecialist for wide excision and reconstruction as indicated.

Even when bone is exposed during tumor surgery, healing by second intention is possible. Other options include coverage with an acellular dermal matrix or a split-thickness skin graft. These three methods of wound management may be preferred over more complex flaps that may hide and bury residual tumor.

Cure Rates and Outcomes of MMS

MMS is widely accepted as offering the highest cure rates of all modalities of treatment for skin cancers (Tables 10.4 and 10.5). The resources needed and escalating cost of medical care do lead to a shift from evidence-based practise to cost-effective care. Certainly all skin cancers need not be treated by MMS and many be successfully treated with satisfactory oncological and cosmetic outcomes with standard excision or otherwise.

Table 10.4 Reported cure rates with MMS

BCC	99 % primary 90–93 % recurrent
SCC	92–99 % primary 90 % recurrent
SCC in-situ	90 %
Keratoacanthomas	98 %
Melanoma in situ	98 %
Merkel cell carcinoma	84 %

Table 10.5 Five-year cure rate for primary BCC and SCC per modality of treatment

Treatment modality	5 year cure rate	
	BCC %	SCC %
Standard surgical excision	90	92
Electrodissection and curettage	92	96
Radiation	91	90
Cryotherapy	92	n/a
All non-MOHS	91	92
Mohs surgery	99	97

One large RCT comparing facial BCC's, randomized to be treated with either Mohs or standard excision, did report a lower recurrence rate at follow-up with Mohs, although figures were not statistically significant. The cost of Mohs was significantly higher, being almost twice as costly. The tables below outline the effectiveness of Mohs.

Considerations for Reconstruction of Mohs Defects

All factors already discussed, including both patient factors (namely age, skin type) and lesion factors (size, location and need for surveillance), must be taken into consideration. Reconstruction can be performed immediately or delayed.

A step-wise reconstructive ladder approach can be taken on all defects, also discussed in chapter 2.1

- Secondary healing
- Primary closure
- Flaps—local, distal, regional/axial
- Grafts—split skin, full thickness, composite
- Free tissue transfer

Most Mohs defects will be either left to heal via secondary healing, closed using primary closure, or closed with local tissue transfer. Anticipation of future forces of scar contracture may require structural reinforcement prior to skin closure (i.e., cartilage reinforcement of nasal sidewall or tip reconstructions or lamella reinforcement during eyelid reconstruction).

Secondary Intention Healing and Wound Care

Secondary intention healing may result in excellent cosmetic results in areas that are concave, such as the temple and ala-nasolabial groove. Particularly for recurrent tumors in which flaps or grafts may hinder surveillance of the treatment site, secondary intention will allow monitoring and allow for delayed reconstruction if need be.

Patients must be willing to meticulously cleanse and monitor the area over a 2- to 8-week healing period. Typically, wound care regimens involve cleansing the wound daily with a saline solution or soapy water, applying a layer of ointment, and then covering with a non-adherent dressing. Wound care after cutaneous reconstruction is similar to that of secondary intention healing, although limited to 1–2 weeks.

Primary Closure

For small lesions, primary closure is typically undertaken. Consideration of relaxed skin tension lines (RSTL) and minimizing tension, particularly in critical functional and aesthetic areas like the peri-orbital region, is of high importance. RSTL result from the orientation of collagen intrinsic to facial skin and manifest in the aging face as creases and rhytids.

Mohs defects ready for primary closure should be fashioned and orientated to sit parallel to the facial RSTL so that any undermining performed will be perpendicular to this and therefore tension will be distributed in the lines of maximal extensibility (LME).

Adjacent Tissue Transfer

When primary closure cannot be accomplished, defects are often able to close using local tissue transfer (random flaps) or regional flaps (i.e., forehead flap). These techniques are discussed in detail in Chapter 2.1 Flaps and Grafts, examples are in Table 10.6.

Table 10.6 Examples of flaps often used for Mohs reconstructions

Nose	Bilobe, forehead rotation flap
Lip	Abbe-estlander, karapandzic, melolabial, vermillion advancement
Cheek	Rhomberg, cervicofacial rotation advancement

Challenges in Mohs Surgery

Excisional

- Patient skin characters—thickness, color, contour, and severely sun-damaged skin
- Sites of complex tissue components—muscle, cartilage, bone
- Fatty tissue—requires intense freezing, may lead to freeze artefacts
- Excessive use of cautery—may lead to artefacts in histological analysis

Lab Processing + Interpretation

- Improper cutting—too thick/thin or folded specimen
- Poor quality staining with H&E may compromise tumor cell recognition
- Inability to recognise small tumor foci

Complications and Pitfalls of Mohs

Complications are overall uncommon. As with all surgeries, the risk of bleeding, nerve damage, infection, pain, and allergic reaction exist. Reconstructive complications include haematoma, wound dehiscence, skin necrosis, poor cosmetic or functional outcome, as well as tumor recurrence adjacent or deep to reconstruction.

Thorough preoperative evaluation of anticoagulants, use of cautery intra-op and post-op bandaging will minimize bleeding risks. The patient should be counselled pre-op about any possible major sensory or motor verve loss, particularly for lesions in the temporal region.

Infection rates post MMS are <1 % and post-operative antibiotics should be considered for cases adjacent to the nares or mouth, as well as in cases of multiple or large reconstruction.

Future Trends

Continuous innovation in this field is occurring given the rise of skin carcinomas. The use of perioperative confocal scanning laser microscopy and digital technology allowing for tele-pathology confirmation is being explored. New immunohistochemistry stains are being discovered and produced to enhance the specificity and sensitivity of pathologic tissue analysis will aim to further improve both detection and cure rates.

Chapter Acknowledgement—Fig 10.2 by Amir M. Badiee, Beeware Graphics.

Questions

1. The most aggressive form of non-melanoma skin cancer is. . ..
   Answer—Merkel
2. Which of these is the least concerning location for recurrence for the mohs surgeon?
   (a) Tragus
   (b) Chin
   (c) Ala crease
   (d) Collumella
   Answer (b)
3. From a histopathological perspective, Mohs differs from standard histology examination by –
   (a) Staining used
   (b) Horizontal verus vertical sections
   (c) Type of slides used
   (d) Temperature of freezing
   Answer (b)
4. Variations of Mohs include all but
   (a) Wider excision
   (b) 90 deg cut
   (c) Topical Mohs
   (d) Single Section
   Answer (c)
5. Which scenario of these options would be best left to heal secondarily?
   (a) Primary bcc on nasal tip
   (b) Primary bcc on alar rim
   (c) Recurrent bcc on temple
   (d) Recurrent bcc on cheek
   Answer (c)
6. The most aggressive form of BCC subtype is . . ..
   Answer—Morpheaform
7. Which is the most absolute indication for Mohs vs standard excision?
   (a) 2 cm primary bcc on forehead
   (b) 1 cm Recurrent bcc on tragus
   (c) 2 cm primary scc on cheek
   (d) 1 cm recurrent bcc on lower neck
   Answer (b)
8. A major drawback of offering Mohs to all cutaneous malignant lesions is
   (a) Defects are left larger
   (b) Having the same doctor performing all aspects could be limited
   (c) Cost, time and resources needed
   (d) The procedure is more painful
   Answer (c)
9. Melanoma in situ has optimal cure rates with which modality
   (a) Excisional surgery
   (b) MMS
   (c) Topical immunotherapy
   (d) Radiation
   Answer (b)
10. Recurrence rate of BCC tend be higher in the . . .. Of the face
    Answer Embryonic fusion planes
11. The Stain most commonly used in Mohs histopathology is . . ...
    Answer –H + E

Additional Resources

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11 Neoplasm and Reconstruction

Jon Robitschek

Cutaneous Malignancies

Basal Cell Carcinoma (BCC)

80 % of all cutaneous malignancies, rarely metastatic, 70 % occur in the head and neck (nasal tip/alae → most common). RISK FACTORS—acute, intense/intermittent UV exposure with long latency interval as opposed to chronic exposure for SCC, arsenic exposure, immunosuppression. *Nevoid BCC syndrome* (aka Gorlin's)—AD, keratocystic odontogenic tumor in 75 % of patients (most common finding), early age onset, palmoplantar pitting, intracranial calcifications, rib anomalies. No pathologic BCC precursor with five clinical subtypes:

1. Nodular: 70 %, favor head and neck, pigmented, round, pearly, flesh-colored papule, telangiectasias.
2. Superficial: 20 %, favors trunk or shoulders, erythematous, well-circumscribed patch or plaque, whitish scale (can be mistaken for psoriasis/fungal/eczema).
3. Infiltrative: aggressive, dermal infiltration, poorly defined clinical border.
4. Micronodular: ulceration typically absent.
5. Morpheaform: white/yellow, waxy, sclerotic plaque, ulceration absent; flat /fibrotic/firm.

Infiltrative/Micronodular/Morpheaform → require larger margins given possible subdermal spread

Basosquamous → histologic features mirror SCC, aggressive behavior (candidate for Mohs resection)

High-Risk Tumors → recurrent tumors, located in embryonic fusion planes (eyelids, nose, ear, upper lip, scalp), immunosuppressed patients, previous radiation therapy, perineural invasion (Bader and Harris 2014)

Squamous Cell Carcinoma (SCC)

15 % of cutaneous malignancies, 2:1 ratio men to women, 90 % with p53 mutation, linked to cyclo-oxygenase (COX) and epidermal growth factor receptor (EGFR) mutations. RISK FACTORS—cumulative UVB (290–320 nm) exposure, Fitzpatrick skin type I and II, immunosuppression, HPV, infection (lupus vulgaris, dissecting scalp cellulitis, acne conglobate, fungal, hidradenitis suppurativa), inflammation (Marjolin ulcer-very aggressive); precursor lesion is actinic keratosis. Histologic subtypes:

1. SCC in situ (CIS/Bowen disease): hyperkeratosis/parakeratosis, cellular pleomorphism

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Table 11.1 BCC and SCC TMN staging

Tis: Carcinoma in situ (limited to epidermis)	N1: single ipsilateral LN $\leq$ 3 cm
T1: <2 cm with <2 high-risk factors[a]	N2a: single ipsilateral LN >3 and <6 cm
T2: >2 cm or any size with >2 high-risk factors[a]	2b multiple ipsilateral LN <6 cm
T3: Facial bone invasion	2c contralateral LN <6 cm
T4: Skeletal bone invasion, skull base invasion	N3: any LN >6 cm
Stage 0	Tis, N0, M0
Stage I	T1, N0, M0
Stage II	T2, N0, M0
Stage III	T3, N0, M0; T1–3, N1, M0
Stage IV	T1-3, N2, M0; T4; any T, any N, M1

M0—no spread M1—spread to distant organ site
[a]Tumor thickness > 2 mm, perineural invasion, ear/non-hair-bearing lip, poorly/undifferentiated

Table 11.2 Surgical management of primary

Low risk (trunk/extremities)	Electrodessication/curettage/cryotherapy (−195 °C)/surgical excision topical 5-fluorouracil (5-FU)/5 % imiquimod {nonfacial BCC}
Low-risk head and neck	Surgical excision 4–6 mm margin; including subcutaneous tissue
High risk	7 mm margin versus Mohs surgery (MS[a])

[a]*Indication for Mohs Surgery*—tissue preservation, recurrent tumors, high-risk tumor

2. Well differentiated: abundant cytoplasm, keratin pearl, limited nuclei atypia
3. Moderately differentiated: intermediate lesions
4. Poorly differentiated: limited keratinization, significant nuclear atypia, high nuclear-to-cytoplasmic ratio
5. Adenoid (acantholytic): pseudoglandular histology, clinically aggressive
6. Spindle cell: clinically aggressive

Low-Risk SCC: <2 cm, well differentiated

High-Risk SCC: Tumor location (eyelid, non-hair-bearing lip, ear, scalp, scar), tumor size >2 cm (1.5 cm on ear/lip), depth of invasion (>2-mm thickness, Clark level IV); poorly differentiated or undifferentiated, recurrent tumor, perineural invasion. Reference Table 11.1 for TMN staging and Table 11.2 for surgical management of primary.

Surgical Management of the Neck: Regional neck dissection for N1 disease with consideration of elective neck dissection/parotidectomy in the context of high-risk tumors with an N0 neck.

Additional Therapy Considerations: Radiotherapy for poor surgical candidates or postoperative for improved locoregional control (perineural invasion, regional metastasis). Primary adjuvant agents in high risk/metastatic include oral 5-fluorouracil (5-FU), EGFR inhibitors (cetuximab, chimeric immunoglobulin G1 monoclonal antibody), and systemic therapy regimens 5-FU/platinum/taxanes (Lawrence and Cottel 1994; Monroe and Meyers 2015).

Malignant Melanoma (MM)

5 % of all cutaneous malignancies, 20 % occur in the head and neck (more common along the trunk in men, lesions in women are thinner/non-ulcerated/occur on the lower extremity). Precursor lesions: dysplastic nevus, cellular blue nevus, congenital/acquired nevus. Reference Tables 11.3 and 11.4 staging. Table 11.5 for surgical management. RISK FACTORS—acute, intense UV exposure over typically unexposed skin as opposed to chronic exposure on exposed surfaces. Two growth phases, radial and vertical, and multiple pathologic subtypes:

Table 11.3 Various melanoma classification schemes

Classic Breslow	Clark levels	T classification
Stage I: ≤0.75 mm	Level I—Above basement membrane (in situ)	Tis in situ
Stage II: 0.76–1.50 mm	Level II—Extends into papillary dermis	T1: ≤1 mm (a/b, w/o-w ulceration)
Stage III: 1.51–2.25 mm	Level III—Papillary/reticular dermis interface	T2: 1.01–2.0 mm (a/b)
Stage IV: 2.26–3.0 mm	Level IV—Into reticular dermis	T3: 2.01–4.0 mm (a/b)
Stage V: >3.0 mm	Level V—Invasion of subcutaneous tissue	T4: >4.0 mm (a/b)

Table 11.4 Melanoma TMN staging

Stage 0	Tis, N0, M0
Stage IA	T1a, N0, M
Stage IB	T1b, N0, M0; T2a, N0, M0
Stage IIA	T2b, N0, M0; T3a, N0, M0
Stage IIB	T3b, N0, M0; T4a, N0, M0
Stage IIC	T4b, N0, M0
Stage III	Any T, N 1–3, M0
Stage IIIA	T1–4a, N1a, M0; T1–4a, N2a, M0
Stage IIIB	T1–4b, N1/2a/c, M0; pT1–4a, N1/2b, M0
Stage IIIC	T1–4b, N1/2b, M0; any T, N3, M0
Stage IV	Any T, any N, any M

Table 11.5 Traditional margins for wide local excision of malignant melanoma (WLE)

Tis or T1 → 1 cm	T2 or T3 → 2 cm	T4 → 2–3 cm.	Scalp → 3 cm

1. Superficial Spreading: 70 % of cases, classically described as progression in a stable pigmented dysplastic nevus
2. Lentigo Maligna: 10–15 % of cases, favors sun exposure history/surfaces with areas of hypopigmentation
3. Nodular: 10–15 % of cases, favors trunk; high risk given limited radial growth phase
4. Mucosal Lentiginous 3 % of cases with GI, GU, respiratory sites; older patient, aggressive
5. Acral Lentiginous: 1:1 among blacks/whites; favors soles, subungal, palms; high risk given limited radial growth phase
6. Desmoplastic: rare, highly variable clinical presentation, +/− neurotropism, comparatively low metastatic rate

Table 11.6 Surgical management options

Tis/N0 or T1a/N0 → observation
T4/N0 → regional node dissection (RLND)
T1b-T3 → options include SLND versus ELND for staging

N1	Single LN A: micrometastasis[a] (clinically occult) B: macrometastasis[b] (clinically apparent)
N2	2–3 LN A/B/C (in-transit metastasis external to LN, w/o metastatic node)
N3	≥4 LN/matted LN/(in-transit metastasis external to LN, w/ metastatic node)

[a]Diagnosed after sentinel node (SLND) or elective node dissection (ELND)
[b]Clinically detectable (confirmed metastasis on regional node dissection or extracapsular extension)

M1a Distant skin, subcutaneous, distant LN met
M1b Lung metastasis with normal LDH
M1c All other visceral metastases or any distant metastases with an elevated LDH level

Surgical Management of the N0 Neck: Direct correlation of tumor thickness to LN metastasis

Sentinel Lymph Node Dissection (SLND)—Accurate staging tool based on lymphatic uptake following intradermal injection of technetium-99-labeled sulfur colloid/blue dye. False-negative rate is comparable to elective neck dissection (ELND) of approximately 4 %. Advantages include limited morbidity as well as identifying anatomic variability in lymphatic drainage basin. Reference Table 11.6.

Indications—depth >1 mm, Breslow depth 0.76–1.0 mm in setting of age < 40, deep positive margin, ulceration, elevated mitotic rate, angiolymphatic invasion, regression

Surgical Management of the N1 Neck: <30 % 10-year survival rate; recommend level I-V ND

Adjuvant Therapy Considerations: Indicated in advanced-stage disease (stage IV) or high risk of recurrence. Options include high-dose interferon alfa-2b; interleukin-2 (activation of NK and T cells); granulocyte-macrophage colony-stimulating factor (GM-CSF); vemurafenib (*BRAF* inhibitor—mutation in 40–60 % of tumors); radiotherapy for isolated brain mets. Traditional first-line chemotherapy regimen includes dacarbazine or temozolomide (alkylating agents) (Grin et al. 1990; McLeod and Black 1991; Medina 1993).

Merkel Cell Carcinoma (MCC)

Highly aggressive (55 % nodal involvement) dermal tumor of neuroendocrine origin (mechanoreceptor). Challenging pathologic diagnosis; relying on immunohistochemistry/electron microscopy (dendritic core granules); similar to oat cell lung carcinoma → enolase (NSE), amine precursor uptake and decarboxylation (APUD) and neurofilament protein {unique to MCC}. Over half occur in the head and neck (most common in periorbital sites followed by cheek/forehead). Classically described as a painless, rapidly enlarging, purple nodule on the face. RISK FACTORS—UV exposure, history of SCC. Treatment is WLE with 2 cm margins, neck dissection for clinically positive disease (strong consideration in N0), and radiotherapy for high-risk tumors. Typical systemic therapy includes cyclophosphamide/doxorubicin.

Cutaneous Angiosarcoma: Rare, multifocal, highly aggressive vascular tumor, 2:1 ratio of men to women, half occur in the head and neck. RISK FACTORS—radiotherapy, foreign body (bone wax, Dacron), chronic lymphedema (increased risk among mastectomy patients). Classically described as a painless, rapidly enlarging bruise or blue/purple nodule on the scalp/face. Treatment is multimodality with full-thickness WLE with 2–3 cm margins, *radiotherapy* (80 % local control rate), and systemic therapy (doxorubicin).

Microcystic Adnexal Carcinoma (MAC): Rare, locally invasive with high recurrence rate; low-grade tumor of sweat gland origin; favoring whites (90 % of cases). RISK FACTORS—radiotherapy, UV exposure. Presents as an indolent, yellow indurated plaque, favoring the upper lip (reported 80 % perineural invasion). Mohs excision is the preferred treatment with radiotherapy offered in select cases.

Sebaceous Gland Carcinoma: Locally invasive tumor originating predominately from meibomian glands (minority from glands of Zeis) of the upper > lower eyelid. Classically described as a firm, painless nodule with loss of cilia on the upper eyelid (women > men). Common delay in diagnosis with noted foamy cytoplasm, pagetoid spread on histology (fat/oil red O stain). Locally invasive with 10–20 % LN metastatic rate. WLE/Mohs is primary treatment with orbital exenteration in select cases.

Muir-Torre Syndrome —AD, combination of visceral malignancy and sebaceous gland carcinoma.

Atypical Fibroxanthoma: Uncommon, spindle/giant cell tumor, appearing in elderly patients with sun-damaged skin as a locally aggressive, rapidly enlarging tumor that strongly favors the head and neck. Considered a cutaneous equivalent of malignant fibrous histiocytoma with a 1:1 ratio of men to women. RISK FACTORS—UV exposure, radiotherapy. Low risk for metastasis with WLE/Mohs being offered as primary treatment.

Dermatofibrosarcoma Protuberans (DFSP): Uncommon, intermediate/low-grade dermal sarcoma thought to arise from fibroblasts/histocytes (CD34 positive → utilized in margin control), locally invasive with high recurrence rate. Presents between ages 20 and 50, 1:1 male to female without racial predilection, as an indolent, painless violaceous plaque on the trunk with <20 % occurring in the head and neck. RISK FACTORS—trauma, burn/surgical scar.

WLE with 2–3 cm margins (including fascia) is the primary treatment. Limited role for radiotherapy with systemic therapy for unresectable/metastatic cases using imatinib mesylate {tyrosine kinase/platelet-derived growth factor receptor inhibitor) (Papel et al. 2009).

Oral Cavity and Oropharyngeal Squamous Cell Carcinoma (SCC)

Oral Cavity SCC

More prevalent among men and blacks. RISK FACTORS—tobacco, ETOH, betel nut quid, diet (citrus fruit and beta-carotene vegetables → protective), lower socioeconomic status. Primary surgical excision (5 mm pathologic margins) is a typical first-line therapy with radiotherapy (RT) offering similar outcomes in lower stage disease and a consideration in poor surgical candidates. LN metastasis is the most significant prognostic indicator. Reference Table 11.7 for TMN staging (Dhar et al. 2000).

Table 11.7 Oral cavity and oropharyngeal SCC TMN staging

Tis carcinoma in situ	N1 single ipsilateral LN ≤ 3 cm
T1: ≤2 cm	
T2: >2 cm but ≤ 4 cm	N2a single ipsilateral LN >3 and <6 cm
T3: ≥4 cm	2b multiple ipsilateral LN <6 cm
T4a: Invasion to extrinsic muscle, cortical bone, skin	2c contralateral LN <6 cm
b: Invasion to pyterygoid plates, masticator space, skull, or ICA encasement	N3 any LN >6 cm
Stage 0	Tis, N0, M0
Stage I	T1, N0, M0
Stage II	T2, N0, M0
Stage III	T3, N0, M0; T1–3, N1, M0
Stage IVa	T1-3, N2, M0; T4aN0-2, MO
Stage IVb	Any T, N3, Mo; T4b; any T, any N, M1

M0—no spread, M1—spread to distant organ site

Anatomic Sub-site Considerations

Oral Tongue—Most common; risk of LN metastasis directly related to tumor depth (>2–4 mm)

Lip—SCC higher prevalence on lower lip with a better prognosis compared to the upper lip, BCC favors upper lip skin

Floor of Mouth—Locally invasive with a high risk of occult LN metastasis

Buccal—Relatively high recurrence rate w/ functional reconstruction required (skin graft, free tissue transfer) to prevent permanent trismus

Retromolar Trigone—High recurrence rate/risk of mandibular invasion (edentulous more at risk than patients with healthy dentition)

Hard Palate—Rare; bony resection indicated in most cases, low incidence of occult LN metastasis

Surgical Management of the N0 Neck: Selective neck dissection (level I–III) generally indicated for Stage I tumors with >2 mm tissue invasion and all stage II–IV. Caveats include:

1. Lower lip (T1 → observation; T2 → level I neck dissection)
2. Include perifacial LN dissection in buccal tumors
3. All stages of retromolar trigone/lower alveolar ridge → neck dissection

Adjuvant Therapy Considerations: Indications for postoperative RT include perineural/lymphovascular invasion on primary tumor and/or positive/close margins, bone invasion, metastatic LN. Concurrent chemotherapy is considered in advanced-stage disease (stage III/IV), extracapsular spread (ECS).

Oropharyngeal SCC: Risk Factors—Tobacco, ETOH, HPV (tonsil, base of tongue)

Anatomic Sub-site Considerations

Soft Palate—Typically undergoes nonsurgical management given postsurgical functional deficit

Table 11.8 Management of the neck

N0/N1 neck → RT or selective ND (II–IV)	N2/N3 → RT/CHX or modified radical ND (I–V)

Tonsil—HPV cases with 85 % HPV 16; oncoprotein E6/7; younger, nonsmoker, more responsive to organ preservation therapy

Base of Tongue—Most aggressive sub-site; 20–40 % risk of LN metastasis

Low-stage disease → single-modality treatment (surgery/RT)

Advanced-stage disease → organ preservation therapy (concomitant—RT/CHX) is generally favored as first-line therapy w/ exception of bony mandible invasion where composite resection is indicated. Reference Table 11.8.

Soft-Tissue Reconstruction: Wound Closure and Local Flaps

Primary Closure: Basic tenets include tension-free suture line, skin edge eversion (beveled away), adequate undermining, preservation of facial aesthetic subunits (replacement of entire subunit if >50 % involved); incorporation of relaxed skin tension lines (RSTL) and lines of maximal extensibility (LME run perpendicular to muscle fibers).

Secondary Intention: A bed of granulation tissue is formed and the wound heals from deep to superficial with contraction of wound edges. Basic tenets include maintaining a moist wound surface, removal of necrotic tissue, wound insulation, drainage of any fluid collections, and open/fresh wound edges.

Skin Grafts: Utilized as an alternative to local flaps or to offer temporary wound coverage and/or tumor surveillance. Primary limitation is color mismatch, thickness (men > women; adults > newborn), and texture match to bordering tissue. Graft survival depends on adequate recipient blood supply and patient risk factors (smoking, vascular disease, history of radiation). Reference Table 11.9.

Table 11.9 Physiology of graft survival

Plasmatic imbibition	First 24–48 h → fibrin layer allows adherence of the graft to the wound
Inosculation	After 48 h → anastomoses form between graft and recipient blood vessels
Neovascularization	2–6 days → vascular ingrowth of recipient blood vessels into the graft

Table 11.10 Gauge of STSG thickness

Thin → 0.007–0.011 in.	Medium → 0.012–0.016 in.	Thick → 0.017–0.020 in.

Graft Failure—**Hematoma** (most common); seroma, infection, graft movement, and wound tension.

Split-Thickness Skin Grafts (**STSG**)—Includes epidermis and portion of the dermis. Donor sites: abdominal wall, thigh, buttocks, and scalp (potential for repeated harvesting Q7 days without risk of alopecia). Reference Table 11.10 regarding variable thickness:

Advantages—Lower metabolic rate, shorter vascularization time, covers large surface area, can be meshed for greater wound coverage

Disadvantages—poor color/texture/thickness match, limited durability, increased contraction

Full-Thickness Skin Grafts (**FTSG**)—Includes epidermis and entire dermis (w/hair follicles). Donor sites: post/preauricular, upper eyelid, and supraclavicular skin. Useful in nasal, auricular, eyelid defects.

Advantages—color/texture/thickness match, durable, wound contraction less than STSG

Disadvantages—higher metabolic rate, longer vascularization time, take rate < STSG, donor site morbidity

Composite Graft—Skin and cartilage w/ vascularization occurring through the dermis

Advantages—provides defect contour, wound coverage, and stability

Disadvantages—contraction, graft size limited to ~1 cm in size, donor site morbidity

Table 11.11 Pivotal flaps

Rotation	Tissue pivoted around a stationary point/fixed arc of rotation (radius → 4× defect, scalp 6×)
Transposition	Tissue mobilized and transposed over an incomplete tissue bridge (rhombic)
Interposition	Mirrors transposition flap; "incomplete bridge of tissue" is mobilized for closure (Z-plasty)
Interpolation	Tissue mobilized over an intact tissue bridge (forehead, island flap)

Dermal Grafts—An FTSG in which the epidermis has been removed (both surfaces undergo vascularization); useful in supplying bulk to facial defects. Allograft materials may also be used in the same manner, i.e., AlloDerm and DermACELL.

<u>**Tissue Expanders:**</u> Gradually stretch local tissue for coverage of a planned defect. Process occurs through mechanical and biological creep. Expanded tissue can be used to cover scalp defects, RFFF donor sites, serial excision of old scar/defect. Physiologic observations include:

1. Subtle thickening of the epidermis with increased fibroblast activity
2. Thinning of the dermis and adipose tissue layers (40–50 %)
3. Myofibroblast hyperplasia with vascular proliferation
4. Creation of a fibrous capsular (facilitating wound contracture and flap thickening)

<u>**Local Flaps:**</u> Classification scheme based on blood supply (random/axial/pedicled), tissue content (cutaneous, fascia, muscle), and mode of transfer (rotation, advancement). Reference Table 11.11.

Advancement Flap—Linear tension vector, random blood supply (dermal-subdermal plexus) with favored site being the forehead/brow. Dog ear/standing cutaneous deformity occurs with terminal angles >30°; necessitating conversion to W-plasty or Burrow triangle.

Cervical Facial Flap—Shared elements of rotation and advancement for closure of sizeable cheek defects. Superior/medial tension vector with recommended acute angle at the medial tip. Primary pitfall → inadequate suspension to the periosteom (zygoma/orbit).

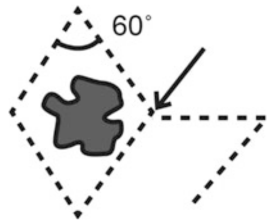

Fig. 11.1 Original Limberg design based on 60 and 120° rhomboid

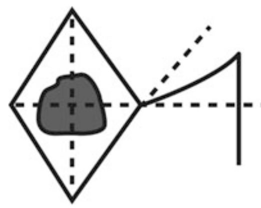

Fig. 11.2 Dufourmentel modification

Rhombic Flap—Full-thickness transposition flaps based on a random blood supply. Favored sites include cheek, lip, nose, with the forehead being less favorable. Basic tenets of design:

1. Incorporating RSTL
2. Respecting aesthetic subunits
3. Preservation of bordering tissue contour and function
4. Site of maximal tension is at donor site closure (reference arrow in Fig. 11.1); suture line parallels lines of maximum extensibility (LME)

   Limberg: A parallelogram with angles of 60° and 120°.

   Dufourmentel: Offering a broader range of acute-angle wound closure from 60 to 90°. Design based on a parallelogram; employing a bisecting line between an extension line from the short diagonal and adjacent defect side as well as a line parallel to the long axis of the defect (Fig. 11.2).

   W*ebster* (*30° flap*): Achieves a 30° rotation angle via a W-plasty at the defect base,

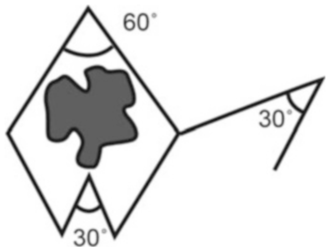

Fig. 11.3 Webster modification with W-plasty

reducing the wound tension closure and risk of standing cone deformity (Fig. 11.3).

Mesolabial Flap—One- (transposition) or two-stage (interpolation) flap favored for nasal alar/lobule defects. Inferiorly based → pedicled off the angular artery; superiorly based → axial pattern

Forehead Flap—One/two/three-stage workhorse for large nasal defects. Pedicled blood supply (1–1.5 cm width) from supratrochlear artery; running superficial to the corrugator muscle (divided during elevation) and deep to the orbicularis. Vascular pedicle runs in a paramedian position; piercing the frontalis muscle 2 cm above the rim. Depth of elevation varies: *pedicle* → subgaleal w/ frontalis (subperiosteal for enhanced rotation); *skin paddle* → subcutaneous or subgaleal (favored in the context of small vessel disease or intermediate-stage cases). Three varieties:

- *Paramedian*: Reputed to have increased dermal vascularity (despite similar viability) given center position over pedicle with a *less* desirable scar line than the midline flap
- *Midline*: Offers a longer skin paddle with a more favorable scar line.
- *Single Stage*: Limited to young, healthy patients without small vessel disease; requires de-epithelialization and tunneling under glabella

Flap Delay: Physiologic phenomenon where flap viability is significantly improved following a 2-week delay from making initial incisions to tissue mobilization; various theories include the following:

Table 11.12 Flap failure

Venous congestion	More common; classic bluish color, warm, edematous w/ dark blood on pin prick
Arterial ischemia	Dry pin prick test, cool to the touch, pale appearing, does not blanch w/ pressure

A-V Shunts: Loss of sympathetic tone → closure of A-V shunts and improved perfusion

Adrenergic Tone: Loss of norepinephrine input, relaxed vascular tone with improved perfusion

Complications: Contributing factors to flap failure include tobacco use, radiotherapy, prior scar, collagen/vascular disease, diabetes mellitus, and poor flap design. Interventions include relaxation of suture line, hyperbaric oxygen (pre/postop), and leech therapy for venous congestion {*Hirudo medicinalis*—thrombin inhibition via hirudin with vasodilation; risk of infection from *Aeromonas hydrophila* (gram-negative rod, beta lactamase-resistant) with aminoglycoside/fluoroquinolone considered first-line therapy}. Reference Table 11.12.

Pin-cushioning (*trapdoor deformity*): More common in curvilinear flaps than geometric flaps. Factors include oversized flaps with excess subcutaneous fat, lymphedema (more favorable with inferiorly based flaps), and a lack of contact inhibition, allowing wound contraction in the recipient bed. Avoided by wide undermining beyond the base of the flap as well as squaring the corners of the flap and defect to convert a round flap into a rectangular one. Management includes surgical debulking or steroid injection.

Soft-Tissue Reconstruction: Regional Flaps and Free Tissue Transfer, Reference Table 11.13 (Lai and Cheney 2000; Papel et al. 2009).

*Transverse Cervical (TCA), Dorsal Scapular (DSA), Occipital, (OA), Paraspinal (PS) Arteries

Table 11.13 Fasciocutaneous, myocutaneous, and myofascial regional flaps

Named flap	Artery	Innervation	Favored sites
Pectoralis major (PM)	Thoracoacromial	Medial/lateral pectoral	Oral cavity, oropharynx, neck
Latissimus dorsi (LD)	Thoracodorsal	Thoracodorsal	Oral cavity, oropharynx, neck
Temporalis (TP)	Deep/anterior temporal artery	Trigeminal	Orbit, cheek, dynamic facial reanimation
Trapezius (TZ)	Transverse cervical (TCA), dorsal scapular (DSA), occipital (OA), paraspinal (PS)	CN XI	Lower face, neck, oropharynx
Supraclavicular artery island flap (SCAIF)	Supraclavicular artery	Supraclavicular	Face, oral cavity, pharynx, neck, auricle/T-bone, lateral skull base
Sternocleidomastoid (SCM)	Thyrocervical, occipital, superior thyroid	CN XI	Oral cavity, oropharynx, neck
Temporoparietal fascial flap (TPF)	Superficial temporal	N/A	Orbital defect
Deltopectoral (DP)	Internal mammary (2/3rd)	Supraclavicular	Oropharynx, neck

Flap	Advantages	Disadvantages	Additional highlights
PM	One stage, large cutaneous component, carotid coverage, single surgical position	Bulk, breast distortion, deficit in shoulder adduction/ rotation	Superficial to pec minor; ligate lateral thoracic artery for rotation, not indicated in patients with Poland' syndrome
LD	Sizeable bulk	Bulk, surgical position	Ligate cicumflex scapular → rotation
TP	Offers dynamic motion	Short rotation arc, no cutaneous component	Prudent anterior dissection (*frontal branch*); limited use with TPF flaps
SCAIF	Quick harvest, reliable, versatile	Minimal bulk	Contraindicated with hx of ND where pedicle may be compromised
TZ	Thin, pliable, long rotation arc	CN XI loss, surgical positioning, donor site	Three separate flaps (*lower*-longest arc off TCA and DSA; *lateral*-TCA; *superior*—OA,PS*); possible ligation on prior ND
SCM	Easily accessible, single stage	Limited in $\geq$ Stage III	Preserve at least two pedicled vessels
TPF	Thin, pliable	Minimal bulk	Donor site alopecia
DP	Carotid coverage, surgical position	Donor site, two stage	Distal portion → random flap; flap delay

Free Tissue Transfer

Radial Forearm (**RFF**)—Fasciocutaneous workhorse for reconstruction of intraoral and skull base defects as well as partial or total pharyngeal reconstruction. *Blood supply* is based off radial artery and associated venae comitantes/cephalic vein which are located in the lateral intermuscular septum (flexor carpi radialis medially, brachioradialis laterally). Lateral antebrachial cutaneous nerve (associated with cephalic vein) provides sensation. Palmaris longus (medial to the flexor carpi radialis) is present in 85 % of patients and the tendon can be employed as a support structure for midface/lip reconstruction.

Preop: Allen test (compress ulnar and radial artery; release ulnar artery and assess thenar perfusion). Based on radial artery → deep palmar arch; ulnar artery → superficial palmar arch.

Contraindications: Positive Allen test, AV fistula, history of hand surgery (relative).

Surgical Considerations: Prudence with medial dissection to avoid transection of superficial ulnar vascular pedicle. Radial bone harvest (up to 12 cm and 40 % of cortical diameter), distal perforators preserved, oblique (keel) cuts, and intraoperative plating. Donor site-specific complications include compartment syndrome, ischemia of the first finger and thumb, and tendon exposure.

Lateral Arm—Fasciocutaneous flap with possible composite muscle (triceps) and osseous (humerus, 1 cm width) component; favored in partial glossal/pharyngeal defects with sensation provided by posterior cutaneous nerve. *Blood supply* is based on the cephalic vein and the posterior radial collateral artery; a terminal branch with negligible risk of distal ischemia. Pedicle located in lateral intermuscular septum (bordered by triceps/brachioradialis).

Surgical Considerations: Varying tissue thickness is favorable in base of tongue reconstruction (thinner skin → proximal flap; thicker skin → distal flap). Radial nerve at risk given its close proximity to the proximal lateral intermuscular septum.

Rectus—Versatile myofascial/cutaneous flap offering tissue bulk for closure of skull base and cutaneous defects. *Blood supply* based on deep inferior (more commonly used) or superior epigastric artery. Periumbilical region offers robust vascular supply and center of flap design.

Surgical Considerations: Limited option for sensory innervation. Long-term tissue bulk derived from vascularized adipose tissue. Postoperative hernia avoided by preserving posterior fascial integrity during muscle elevation at and below arcuate line (pedicle perforates rectus sheath).

Lateral Thigh (**LTF**)—Sizeable fasciocutaneous flap; favored cases include total or partial glossal/pharyngeal and facial defects. *Blood supply* based on venae comitantes and the perforators (primarily third) of the profunda femoris artery; located in intermuscular septum (bordered by biceps femoris and vastus lateralis). Sensation provided by lateral femoral cutaneous.

Contraindications: Prior thigh surgery; (relative) obesity, vascular disease, diabetes mellitus.

Surgical Considerations: Primary donor site closure. Considerable anatomic variability as to relative location and position of the third perforator; caution in harvesting second perforator which is a principal supplier to the femur.

Anterior-lateral Thigh (**ALT**)—Generous fasciocutaneous flap with similar indications as LTF. Sensation provided by lateral femoral cutaneous. *Blood supply* based on venae comitantes and the descending branch of lateral circumflex femoral artery (LCFA) located in intermuscular septum (bordered by rectus femoris and vastus lateralis). Septocutaneous perforators—10 % of cases;

1. >85 % Vertical musculocutaneous (vastus lateralis) via descending branch LCFA
2. <5 % Horizontal musculocutaneous (vastus lateralis) via transverse branch LCFA

Surgical Considerations: Perforators located within 5 cm above and below the midpoint of a line drawn from lateral patella to superior iliac spine.

Jenjunal Free Flap—Employed for hypopharyngeal reconstruction. *Blood supply* based on segmental arcades based off superior mesenteric artery with up to 25 cm of harvestable bowel. Peristalsis resumes with revascularization. Detractors include classic "wet voice," stenosis, and limited utility of tracheal puncture (Smith et al. 2007).

FLAP FAILURE: Classically described as either venous thrombosis (significantly more common, appearing at 48–72 h) or arterial thrombosis (presenting in the first 24 h). First-line treatment is urgent operative intervention with leeches offered as second-line therapy in cases of venous congestion. Early detection is paramount with options ranging from implantable or cutaneous Doppler and pin prick test. Flap salvage rate after take back averages 50 %.

Bony Reconstruction

CALVARIAL BONE GRAFT: Employed in nasal reconstruction; taking advantage of the lower comparative resorption rates of membranous bone over endochondral bone. Mesenchymal in origin; membranous bone found in the cranium (*excluding sphenoid*) and mandible with a thicker cortex than endochondral bone. Split calvarial grafts utilize outer cortical layer; leaving behind the diploic and inner layer. Harvested from parietal bone above the temporal line (below temporal line → outer/diploic layers thinner and greater curvature). Exercise caution to avoid midline and the sagittal sinus with most common complication being seroma/hematoma of the scalp (Cheney and Gliklich 1995; Weber et al. 1987).

Free Tissue Transfer

Fibula—Osteocutaenous workhorse, offering 25 cm of bone stock for maxillary/mandibular defects as well as a fasciocutaneous paddle for two-dimensional reconstruction. Skin paddle may be split based on two different perforators for reconstruction of through-and-through defects of the oral cavity. Sensation derived from lateral sural cutaneous nerve. *Blood supply* based on peroneal artery via combination of endosteal/periosteal perfusion (permitting multiple osteotomies to optimize contour) and associated venae comitantes. The skin paddle is supplied via perforators centered between the middle and distal 1/3 of the fibula:

1. Septocutaneous: 1–3 perforators, posterior crural septum (separates soleus/peroneus longus)
2. Musculocutaneous: Through soleus muscle (cuff of muscle taken with graft)

Preop: Pedal pulses (dorsalis pedis, tibialis posterior) and signs of vascular disease (edema, color, ulceration). Gold standard is angiography with Doppler, CTA, and MRA as alternatives.

Contraindications: Peroneus magnus (vascular abnormality with a dominant peroneus artery supplying the leg; significant venous stasis, diabetes mellitus, history of leg trauma).

Surgical Considerations: Mandibular defect → contralateral fibula; temporomandibular joint → ipsilateral fibula. Proximal bone cut → 6 cm of fibula preserved (avoids peroneal injury). Distal bone cut → 6–8 cm of bone (maintain ankle integrity). Potential loss of great toe flexion secondary to flexor hallucis longus dissection.

Iliac Crest—Composite flap offering cutaneous and inferior oblique muscle component with up to 16 cm of curved cancellous bone (anterior to posterior iliac spine) for mandibular reconstruction. *Blood supply* derived from deep circumflex iliac artery/vein. Sensory innervation based on 12th thoracic nerve; lateral cutaneous branch.

Surgical Considerations: Inferior oblique elevated off transversus abdominis with pedicle on muscular deep surface. Primary detractors include donor site morbidity (sensory deficits most prevalent), bulky muscle component, and limited rotation arc for the skin paddle.

Scapula—Versatile with three possible skin paddles (latissimus/scapular/parascapular) and osseous component (lateral border—10 cm; 14 cm with scapula tip) for mandibular and through-and-through defects. *Blood supply* derived from circumflex scapular artery and its terminal cutaneous branches (transverse → scapular; descending → parascapular). The scapular tip's *blood supply* is based on the angular branch of the thoracodorsal. Limited option for sensory innervation.

Surgical Considerations: Surgical positioning, thin bone, and functional morbidity at donor site are principal detractors. Transverse pedicle runs 2 cm below spine; descending at 2 cm medial to lateral border. Dissection plane is above infraspinatus musculature.

Site-Specific Reconstructive Highlights

LIP: *Upper lip* → derived from fusion of lateral maxillary and mandibular prominence; ipsilateral lymphatic spread, threedistinct subunits, venous drainage via cavernous sinus, longer than lower lip

Lower lip → derived from mandibular prominence; bilateral lymphatic spread, two subunits, CN VII innervates superficial belly of mentalis, labial artery lies in submucosal plane. Reference Tables 11.14 and 11.15 (McCarn and Park 2005).

HYPOPHARYNX: Reference Table 11.16.

Table 11.14 Full-thickness lower lip defects

<1/3	Wedge excision, primary closure, local (advancement/transposition) flap
1/3 → 2/3 Medial	**Abbe flap**: Two stage, full thickness, cross lip, ½ width of defect, based on contralateral labial artery, de-innervated, orbicularis muscle direction maintained, divided at 2–3 weeks **Karapandzic**: Modification of Gillies (a full-thickness, rotation/advancement flap); partial thickness w/ preservation of neurovascular pedicle; limited by microstomia
1/3 → 2/3 Commissure	**Estlander**: Single stage, cross lip, ½ width of defect, de-innervated, muscle direction of orbicularis maintained; **Gillies/Karapandzic** **McGregor**: Modification of Gillies, requires vermillion mucosal flap; fan-shaped flap w/ arc of rotation at commissure; orbicularis muscle direction rotated 90°
>2/3	**Bernard-Burrow-Webster**: Full thickness, horizontal advancement, triangles with skin only to maintain neurovascular bundle; vermillion derived from tongue/mucosa **Bilateral abbe**, **nasal labial flap**, **free flap**, **regional** (SCM, deltopectoral)

Table 11.15 Full-thickness upper lip defects

<1/3	Wedge excision, primary closure, local (advancement/transposition)
1/3 → 2/3 Medial	**Perialar crescentic advancement**: Innervated flap, can be offered in conjunction with Abbe for central defect **Abbe**: Design flap using full width of defect (as opposed to ½ in lower lip)
1/3 → 2/3 Commissure	**Estlander**: Use full width of defect in flap design
>2/3	**Karapandzic**, **Abbe**, **nasal labial flap**

Table 11.16 Flap of choice based on location and size (diameter and length)

<270° Circumference and above thoracic inlet	RFF, LTF, ALTF; jejunal free flap w/ divided antimesenteric border[a]
>270° Circumference, above thoracic inlet and <10 cm in length	Tubed—RFF, LTF, ALTF; jejunal free flap
>270° Circumference, above thoracic inlet and >10 cm in length	Tubed—LTF; jejunal free flap

Questions

1. A patient presents with a diagnosis of microcystic adnexal carcinoma (MAC) following a punch biopsy of a preauricular cutaneous lesion. Which of the following statements is **NOT** correct regarding the typical clinical presentation/behavior of MAC?
   (a) Low-grade tumor arising from the sweat glands
   (b) More common among Caucasians
   (c) Low risk of perineural invasion
   (d) Risks factors include prior history of radiotherapy
2. A patient presents with a 1.5 cm diameter, ulcerative, pigmented scalp lesion. On physical exam, a prominent lymph node is palpated at level II. Following excisional biopsy, WLE, and regional neck dissection,

a diagnosis of melanoma is made with a tumor thickness of 2.7 mm and two positive LNs. What is the correct stage for the patient?
   (a) T2bN2bM0—Stage IIIB
   (b) T2bN2aM0—Stage IIIC
   (c) T3bN2aM0—Stage IIIB
   (d) T3bN2bM0—Stage IIIC
3. Of the following treatment options for a stage I BCC, which has the highest recurrence rate?
   (a) Surgical excision
   (b) Radiation therapy
   (c) Cryotherapy
   (d) Mohs micrographic surgery
4. Following a rhombic flap closure of a cutaneous cheek defect, a pin-cushion (trapdoor) deformity is noted. Which of the following statements is **NOT** correct regarding this complication?
   (a) Complication is more prevalent with superior based flaps
   (b) Occurs secondary to inadequate undermining
   (c) Higher incidence in geometric flaps compared to curvilinear flaps
   (d) Treatment includes surgical debulking and/or steroid injection
5. For a patient who has undergone a re-excision of a cutaneous SCC, which finding is associated with the highest metastatic rate?
   (a) Previously treated lesion (recurrence)
   (b) Perineural invasion
   (c) Poor differentiated histology
   (d) >4 mm tumor thickness
6. A 65-year-old heavy smoker, diabetic, with a large, near-total, cutaneous dorsal/tip nasal defect presents for closure following a Mohs resection for SCCa. On exam you note a low anterior hairline. Which is the BEST choice in reconstructive options?
   (a) Paramedian forehead flap—two stage
   (b) Midline forehead flap—two stage
   (c) Paramedian forehead flap—three stage
   (d) Midline forehead flap—three stage
7. Which of the following is **NOT** an arterial blood supply for the trapezius musculocutaneous flap?
   (a) Occipital artery
   (b) Paraspinal perforators
   (c) Dorsal scapular artery
   (d) Thoracodorsal artery
8. A patient is undergoing reconstruction of a pharyngeal defect with a lateral thigh free flap. When harvesting the flap, which vessel (if ligated) is most likely to cause postoperative ischemia of the femur?
   (a) Third perforator of the profunda femoris
   (b) Second perforator of the profunda femoris
   (c) Septocutaneous perforator of the lateral circumflex femoral artery
   (d) Musculocutanoeus perforator of the lateral circumflex femoral artery
9. Which of the following statements regarding lip anatomy is **INCORRECT**?
   (a) Upper lip is longer than the lower lip
   (b) Paresis of marginal mandibular nerve results in ipsilateral lip depression
   (c) Mentalis contraction leads to lip protrusion
   (d) Upper lip has three separate subunits
10. A patient is noted to have persistent venous congestion following a RFF flap for an oral cavity defect. Unable to return to the operating room, leech therapy is started. After 24 h, the patient develops signs of cellulitis at the graft site. Which antibiotic is most appropriate?
   (a) Ciprofloxacin
   (b) Augmentin
   (c) Mupirocin
   (d) Cephalexin

Answers

1. (c), 2. (d), 3. (c), 4. (c), 5. (b), 6. (d), 7. (d) 8. (b) 9. (b), 10. (a)

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Scar Revision and Dermabrasion

12

James A. Owusu

Histology of the Skin

Epidermis is avascular and composed mostly of keratinocytes that mature and migrate from the basal layer to the surface where it is lost through desquamation. Other cells are melanocytes, Merkel cells, and Langerhans cells. The layers of the epidermis are:

- **Stratum corneum**: dead and dying cells filled with mature keratin eventually lost through desquamation.
- **Stratum lucidum**: well defined in only thick skin, i.e., palms of hands and soles of the feet. It is the transition zone between the strata granulosum and corneum.
- **Stratum granulosum**: composed of cells with dense keratohyalin granules (dark pigmentation) connected with tight desmosomes creating a watertight barrier that prevents fluid loss.
- **Stratum spinosum**: divided cells from the stratum basale accumulate desmosomes on their outer surface to form this prickly layer.
- **Stratum basale**: composed of germinal cells necessary for regenerating the layers of the epidermis. It is separated from the dermis by a thin basement membrane.

Dermis is vascular and composed mostly of fibroblast that secretes collagen, elastin, and ground substance and is responsible for thermoregulation.

- **Papillary dermis**: composed of loose connective tissue with vascular network responsible for thermoregulation and supporting the avascular epidermis.
- **Reticular dermis**: composed of dense connective tissue with glands and hair follicles. The papillary dermis has smaller collagen bundles, higher cellularity, and higher density of vascular elements compared to the reticular dermis.

Skin Lines

- **Relaxed skin tension lines (RSTLs)**: lines of intrinsic skin tension produced by the action of underlying muscles. They run perpendicular to the underlying muscle fibers. Skin incisions should ideally be placed in or parallel to RSTLs (Fig. 12.1).
- **Lines of maximum extensibility (LMEs)**: perpendicular to RSTLs, skin is most extensible in the direction of LMEs (Fig. 12.1).
- **Langer lines**: derived from cadaveric studies corresponding to alignment of collagen fibers in the skin.

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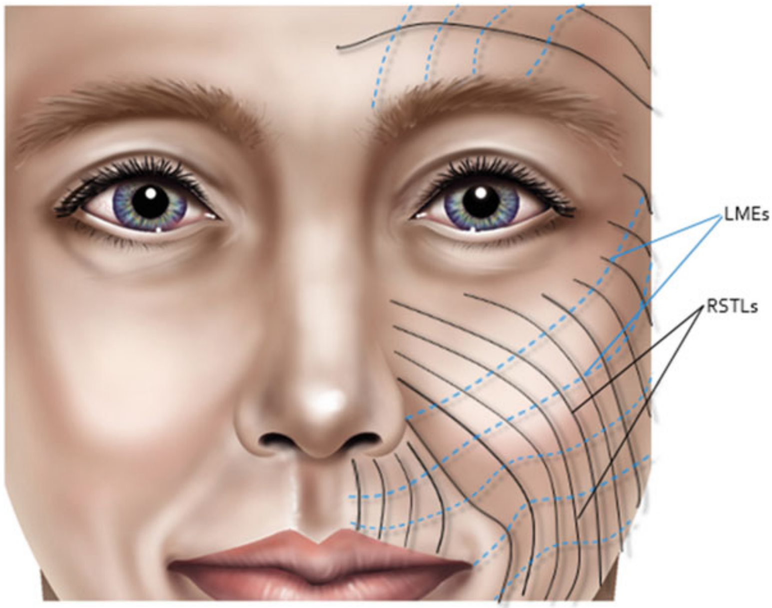

Fig. 12.1 Relaxed skin tension lines and lines of maximum extensibility. Ideal scars are parallel or fall within RSTLs

Wound Healing Phases

- **Inflammatory** (0–7 days): vasoconstriction and activation of the coagulation cascade, histamine release, vasodilation with infiltration of neutrophils, monocytes, fibroblasts, endothelial cells, PMNs, and macrophages.
- **Proliferative** (24 h to 6 weeks): re-epithelialization begins in this phase with differentiation of basal cells and separation from the basement membrane. Fibroblasts produce **type III collagen** starting around day 3. Neovascularization and wound contraction occur in this phase. Wound contraction is mediated by myofibroblasts that become oriented along lines of tension and pull collagen fibers together contracting the wound.
- **Remodeling/maturation** (2 weeks to 18 months): type III collagen is replaced by type I collagen. Collagen becomes cross-linked increasing the tensile strength of the wound. Maturation is affected by several factors including age. Maturation occurs faster in adults compared to children. Scars eventually achieve a tensile strength that is approximately 80 % the tensile strength of normal skin. At maturation collagen remodeling continues and there is a balance between collagen synthesis and collagen breakdown by collagenases and metalloproteinases. Collagen becomes increasingly organized and water is resorbed from the wound.

Factors Affecting Wound Healing

- Moisturization with a hydrophobic ointment during the initial stages of healing inhibits bacterial growth and promotes re-epithelialization.
- Microangiopathic disease including diabetes reduces blood flow and oxygen delivery and impairs wound healing.
- Nicotine causes vasoconstriction that can lead to poor wound healing (Table 12.1).

Management of Keloids and Hypertrophic Scars

- Excision with post-op steroid injection (decreases fibroblast and glycosaminoglycan production, reduces inflammation).

Table 12.1 Hypertrophic scars and keloids

Keloid	Hypertrophic scar
– Scars extend beyond the confines of the wound margin	– Scars stay within the confines of the wound margin
– Does not regress	– May regress with time
– 50–100 % recurrence rate following excision	– Most do not recur following excision
– Disorganized collagen fibers	– Fibroblastic nodules with fine randomly organized collagen fibers
– Reduced gap junction intracellular communication with very low expression of connexin leading to inability to receive inhibitory growth signals	– Reduced gap junction intracellular communication with low expression of connexin with decreased ability to receive inhibitory growth signal

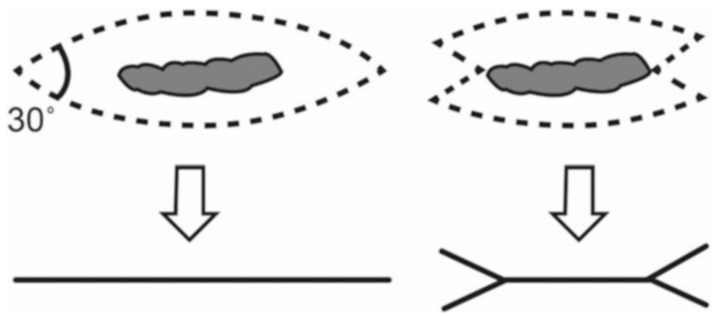

Fig. 12.2 M plasty reduces the length of the overall incision length and the amount of normal skin excised

- Topical Imiquimod decreases production of collagen and glycosaminoglycan and decreases recurrence of keloids following excision.
- Silicone gel improves the appearance of scars through its hydrating effect.
- Radiotherapy at a dose of 5 Gy improves keloids by destroying fibroblast which are not replaced.

Scar Revision

The ideal scar is flat, narrow, level with the surrounding skin, good color match, within or parallel to relaxed skin tension lines, or on the border of a facial subunit. Scar revision may be considered for scars that are widened, perpendicular to RSTLs, and webbed; interrupt facial subunits; or distort facial features, hypertrophic or atrophic.

Timing of Scar Revision

Scars that are parallel to RSTLs will continue to improve over 6–12 months. It is best to allow complete scar maturation, i.e., 6–12 months prior to revision. Scars with unfavorable location or disrupt facial features may be revised sooner.

Scar Revision Techniques

- **Fusiform excision** is ideal for scars in good position. The superficial aspect of the scar is excised in a fusiform shape with end angles <30°. The deeper aspect of the scar is preserved to prevent depression. An M plasty can be performed at the end of the excision to shorten the overall length of the incision and minimize excision of normal skin (Fig. 12.2).
- **Serial excision** is useful for wide scars with surrounding elastic skin that cannot be completely excised in one stage. The scar is excised in multiple stages 6–8 weeks apart. This technique relies on biologic creep and is an alternative to tissue expansion.
- **Tissue expansion** stretches the tissue adjacent to the scar creating adequate skin to completely excise the scar. Adjacent tissue has the advantage of providing the best color and texture match. The thickness of the epidermis is preserved through epidermal mitotic

activity and keratinocyte proliferation while the thickness of the dermis is reduced.

- **Shave excision** is ideal for scars with raised or uneven edges or standing cutaneous deformity. The lesion is excised tangential to the skin and the wound is allowed to heal by secondary intention.
- **Scar repositioning**: Scars close to RSTLs or facial aesthetic unit boundaries, or hairline, can be repositioned by excising the intervening normal skin.
- **Scar irregularization** camouflages scars making them less perceptible to the eye.
- **Z plasty** breaks up and lengthens long contracted scars and is used to realign distorted facial features and to reorient scars in a more favorable position. The degree of lengthening is dependent on the angles used to design the flaps. Classic Z plasty involves transposition of 60° equilateral triangles that lengthens the scar by 75 %. Thirty degree and 45° angles lengthen the flaps by 25 % and 50 %, respectively (Fig. 12.3).
- **Z plasty variations:** Combinations of Z plasty allow longitudinal lengthening scars without creating excessively angulated or elongated flaps. Multiple Z plasty can be combined in parallel to reorient and elongate a long scar. Mirror images of two Z plasty can be combined to create a double-opposing Z plasty. The double-opposing Z plasty is particularly usefully in areas with impaired skin vascularity as the large central flap is less prone to necrosis (Fig. 12.4).
- **W plasty**—Consecutive triangular excisions irregularize the scar without increasing its length. The width of each flap should be 5–7 mm. The deeper aspect of the scar is preserved to avoid creating a depressed scar. Dermabrasion 6–8 weeks following excision may be indicated to improve appearance. It is ideal for curvilinear scars (Fig. 12.5).
- **Geometric broken lines** use irregularly irregular pattern of scar excision using geometric figures with a width of 5–7 mm. Again the deeper aspect of the scar is preserved. The

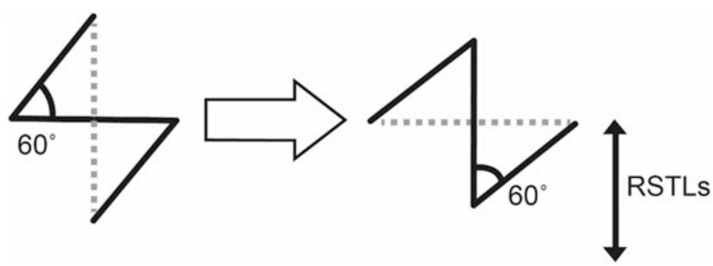

Fig. 12.3 Z plasty is ideal for lengthening and repositioning scar into a more favorable orientation

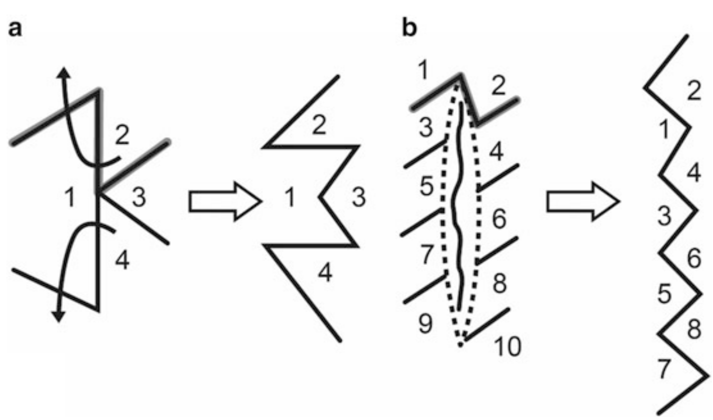

Fig. 12.4 (**a**) Double-opposing Z plasty creates a large central flap particularly useful in areas with compromised vascularity. (**b**) Multiple Z plasty in parallel is useful for reorienting long scars

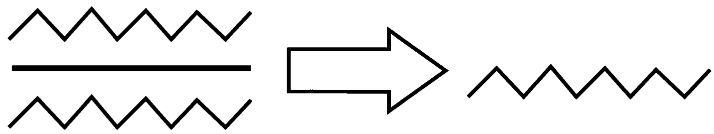

Fig. 12.5 Running W plasty is ideal for curvilinear scars, the limbs of the flaps are oriented parallel to RSTLs

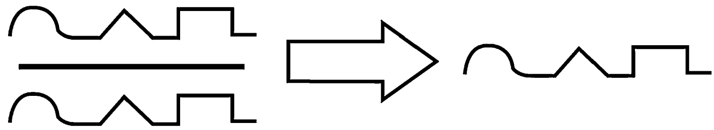

Fig. 12.6 Geometric broken lines—the width of each flap should be between 5 and 7 mm. The irregular pattern makes the scar less predictable compared to running W plasty

irregular pattern makes the resulting scar less perceptible compared to "W" plasty and does not lengthen the scar. Scars may be further improved with dermabrasion. It is ideal for scars that cross RSTLs. This is the best scar irregularization technique (Fig. 12.6).

Skin Resurfacing

- **Dermabrasion** uses controlled abrasion of the skin down to the depth of the papillary to superficial reticular dermis to improve scar appearance. The depth of the papillary dermis is characterized by pinpoint bleeding; parallel white lines characterize the superficial reticular dermis. Abrasion deep into the reticular dermis may lead to increased scaring. Ideally, dermabrasion is performed 6–8 weeks following injury when fibroblast activity is high. Dermabrasion improves scars by increasing collagen organization. Dermabrasion upregulates expression of the glycoprotein tenascin in the papillary dermis and expression of alpha 6 and beta 4 integrins in the stratum spinosum.
  - **Indications:** acne scars, traumatic scars, early operative scars, fine lines and wrinkles, photodamage.
  - **Contraindications**: recent use or isotretinoin (within 6–12 months), active herpes breakout. Isotretinoin causes apoptosis of pilosebaceous units, which are responsible for regenerating the epithelium following dermabrasion.
  - **Precautions:** perioperative antivirals (acyclovir or valacyclovir) reduce the risk of herpes breakout. Use face shield and PPE to avoid contact with aerosolized blood products.
  - **Pre-procedure** evaluation may include bleeding time, platelets, and inquire about recent isotretinoin use or herpes infection, and use of anticoagulants.
  - **Technique**: Dermabrasion is performed using powered diamond or wire brush fraises. Wire fraises are used at a lower RPM compared to diamond fraises. Abrasion is carried down to the level of the papillary dermis characterized by punctate bleeding. Injuring the reticular dermis results in scarring.
  - **Post-procedure**: Antiviral should be continued for 5–10 days following procedure. Wound moisturization with hydrophobic ointment inhibits bacterial growth and promotes re-epithelialization.
- ***Laser resurfacing***: Both ablative and non-ablative lasers are effective for improving facial scars. Ablative lasers cause vaporization of water containing tissue resulting in epidermal regeneration and reorientation of collagen fibers. Results from laser resurfacing are comparable to those of dermabrasion. The three main lasers are used in scar revision:
- **Pulsed dye laser** (585 nm) is a non-ablative laser with hemoglobin chromophore.

It penetrates the epithelium without causing de-epithelialization. Softens scars by breaking collagen disulfide bonds and reorienting collagen and inhibiting fibroblast. Also improves erythema through elimination of blood vessels. Multiple treatments spaced 6–8 weeks may be needed to achieve optimal results.
- **CO_2** (10,600 nm) is an ablative laser with water chromophore causes superficial ablation resulting in de-epithelialization. CO_2 has a deeper depth of penetration than Er:YAG.
- **Er:YAG** (2940 nm) is an ablative laser with water chromophore causing de-epithelialization. It produces minimal thermal injury with faster re-epithelialization. It is ideal for atrophic scars.

Complications of Skin Resurfacing

- **Hyperpigmentation** is common following dermabrasion and most resolve without treatment within 3–6 months. It is exacerbated by sun exposure and estrogen use. Persistent hyperpigmentation can be improved with chemical peel. Patients should be counseled to use sunscreen and avoid sun exposure following skin resurfacing.
- **Hypopigmentation** is also commonly seen following resurfacing. It is more common with laser resurfacing than dermabrasion. It may present late, i.e., 6–12 months following laser resurfacing, and can be permanent. Bleaching creams may be used to blend in the surrounding areas. Hypopigmentation following dermabrasion usually resolves within 6–19 weeks without intervention.
- **Infection**—De-epithelialized skin is susceptible to bacterial and fungal infection. Most bacterial infections are caused by *Staphylococcus*, S*treptococcus*, and *Pseudomonas*. Bacterial infections present with discolored crusting and malodorous drainage 2–5 days following the resurfacing. Fungal infections are mostly caused by candida and present with erythematous erosions. Fungal infections can be treated with acetic acid soaks and fluconazole.
- **Herpes reactivation** can occur following resurfacing. A 5–10 course of antivirals (acyclovir of valacyclovir) starting a day before the procedure decreases risk of herpes breakout. Patients who develop a breakout while on oral antivirals may need IV antivirals.
- **Milia** result from epithelial inclusions during re-epithelialization. May be treated with gentle abrasion, unroofing, or controlled cauterization.
- **Delayed healing**: Re-epithelialization is usually completed in 5–7 days. It is considered delayed if not completed within 14 days. This may result from patient comorbidities and poor wound care. Treatment is reversing the underlying cause.
- **Erythema** is common following resurfacing. It generally decreases and ultimately resolves with time. It may be due to a reaction from topical antibiotic ointment. Persistent erythema can be treated with topical steroid cream.

Depressed scars are commonly seen as pitting scars associated with acne. These scars can be improved with a combination of techniques including excision followed by dermabrasion or laser resurfacing. Scars can also be improved with filler/fat injection. Subcision is performed using a needle, the connection between the skin and deeper scar tissue is released, and the depressed area is filled with fat or filler. Filler options include autologous fat, calcium hydroxyapatite, and hyaluronic acid derivatives.

Adjunctive Techniques

Steroids can be helpful in the management of hypertrophic scars and keloids. The most common form used is injectable triamcinolone acetonide (Kenalog) in concentrations between 10 and 40 mg/ml. Topical steroids may be used to diminish erythema 2–3 weeks following skin resurfacing. Dermal and subcutaneous atrophy may occur if an excess amount of steroid is used.

Silicone sheets and gels may be used alone or in combination with other techniques to improve the appearance of hypertrophic scars and keloids. The exact mechanism of improvement is unknown but is believed to be partially due to increased hydration of the scar.

Mechanical forces: Massage of scars following complete epithelialization decreases adherence to deeper structures and improves the appearance.

Cosmetics can conceal scars using a foundation or diminish the appearance of scars using the color theory. The color theory uses opposite shades of a color to tone down its appearance. Examples: A red scar is camouflage with green concealer, blue or purple scar with yellow concealer, and brown and yellow tones neutralized with purple concealer.

Questions

1. The best technique to lengthen a contracted scar is:
   (a) "W" plasty
   (b) Geometric broken lines
   (c) "Z" plasty
   (d) Fusiform excision with "M" plasty
2. An 18-year-old lady undergoes revision of a facial scar with geometric broken line excision. The ideal time to perform dermabrasion is:
   (a) Immediately following closure
   (b) 6–8 weeks following the procedure
   (c) 6–12 months following the procedure
   (d) 2 weeks following the procedure
3. Which of the following lasers is the best option of improving a hyperemic scar?
   (a) Er:YAG
   (b) CO_2
   (c) KTP
   (d) Pulsed dye
4. Which of the following is a contraindication for skin resurfacing?
   (a) Isotretinoin
   (b) Tretinoin
   (c) Hydroquinone
   (d) Triamcinolone
5. Two weeks following dermabrasion a patient presents with concerns about persistent redness at the site. On exam re-epithelialization is complete and there are no signs of infection. What is the best management option?
   (a) Treat with topical steroid cream
   (b) Antibiotics to reduce the inflammation
   (c) Reassurance
   (d) Triamcinolone injection
6. A patient with hyperemic scar following revision is interested in camouflaging the scar appearance. The best concealer tone for this patient is:
   (a) Dark brown
   (b) Yellow
   (c) Blue
   (d) Green

Answers

1. (a)—Z plasty reorients and elongates scars, W plasty and geometric broken line irregularize scars without lengthening.
2. (b)—dermabrasion should ideally be performed 6–8 weeks following scar revision when fibroblast activity is high.
3. (d)—pulsed dye laser has a hemoglobin chromophore and is ideal for treating hyperemic scars.
4. (a)—isotretinoin causes apoptosis of pilosebaceous units that regenerates epithelium following skin resurfacing. Resurfacing procedures should be delayed for 6–12 months following use of isotretinoin.
5. (c)—erythema is expected following skin resurfacing and resolves with time. Persistent erythema can be improved with topical steroid cream.
6. (d)—a red scar is best camouflaged with a green concealer.

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Trauma

13

John Harbison

Evaluation of Trauma Patient

Always start with ABCs (airway, breathing, circulation)

Basic airway management: Clear all debris/blood/secretions → Jaw thrust (caution: can cause up to 5 mm of distraction in patients with C5/6 instability).

Indications for airway intervention: Apnea/inadequate oxygenation, GCS <9, unstable midface trauma, laryngeal injuries, aspiration risk, large flail segment.

Types of airway intervention: Oral airway, LMA, Nasopharyngeal intubation (good for spontaneous ventilating patient, contraindicated in skull base fx), oral intubation (minimize C-spine manipulation), tracheostomy, cricothyroidotomy.

Hemorrhagic shock: Indicated by hypotension/tachycardia → Initial treatment is 2L crystalloid bolus (20–30 % stays intravascular) → colloid bolus → consider PRBCs if patient is still unstable after 2L crystalloid bolus) (Papel 2002).

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Life-threatening injuries in facial trauma patients (most common to least): cerebral trauma → hemorrhagic shock → airway compromise → pulmonary injury (Tung et al. 2000).

Soft Tissue Injuries

Lacerations—Generally should be repaired with 4–6 h of injury if possible. Delayed primary closure may be considered for "dirty wounds." Tx: copious irrigation, parental abx, and wound care followed by closure 12–24 h later (Binns 1984).

Human bite: Considered more contaminated and broad spectrum abx needed against anaerobes and aerobes. Also consider delayed primary closure for severe bites and all avulsion injuries. Also must consider HIV, Hep, herpes exposure. Always check tetanus vaccination status.

Animal bite: Generally less risk of infection; may usually be closed after irrigation. Must consider rabies. Cleansing with povidone iodine can significantly decrease risk. If high suspicion, administer immunoglobulin and vaccine immediately, then vaccinate on days 3, 7, 14, 28. For small puncture tracts (Cat bites) consider healing by secondary intention or excision of the tract (Lazaridou et al. 2012).

Facial nerve—management depends on the degree, mechanism, and location of injury.

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Temporal bone fractures: incomplete or delayed paralysis can be managed with initial observation, EnoG after 72 h, if >90 % degeneration surgical exploration recommended. For immediate, complete paralysis in the presence of temporal bone fracture, immediate exploration is advocated if patient is otherwise stable.

Penetrating trauma: High likelihood of nerve transection if paralysis is present. If extratemporal lesion proximal to lateral canthus → explore within 72 h so that nerve is identifiable with stimulation. For more distal lesions → observation with higher likelihood of recovery.

Parotid gland injury: Most at risk for penetrating injuries that occur below a line from the tragus to the upper lip. Must consider degree, location, and mechanism of injury. Superficial injuries not involving the duct can often be closed primarily after careful debridement and irrigation. Wounds anterior to the posterior border of masseter muscle are at increased risk of damage to Stensen's duct (wounds posterior to this are less likely to result in clinically significant ductal leak). Signs of ductal damage: leakage of saliva into wound with massage, presence of buccal branch weakness (travels closely with duct).

If ductal injury is present: Cannulate duct with silastic stent or large nylon sutures, perform reanastomosis over stent after creating fresh wound edges, and apply pressure dressing as well as sialostatic medications (Lazaridou et al. 2012).

Nasolacrimal Trauma

Anatomy: Superior and inferior puncta 5 mm lateral to medial canthus. A 2 mm vertical limb → 8 mm horizontal limb → common canaliculus → lacrimal sac sitting in lacrimal fossa → emptying into the inferior meatus.

Lacerations through the medial eyelid should raise suspicion for ductal injury. Symptoms (epiphora) may not present initially especially in the setting of multiple injuries. Before closing the laceration, the puncta and proximal duct should be cannulated to identify proximal segment, if a complete laceration exists, identifying the distal segment can be difficult. Cannulation of the opposing lid affords ability to flush air or dye into the system to locate distal end. Once identified, a silastic or silicone stent is placed and reanastomosis is performed. Tarsal anchoring sutures aid is decreasing tension on repair.

Eyelid

Traumatic lacerations to the eyelid can create a series of problems, including telecanthus, ptosis, and nasolacrimal disruption. It is important to evaluate all of these at time of repair. The general order is to repair posterior medial canthal tendon first → nasolacrimal system second (as above) → marginal eyelid lacerations → peripheral lacerations → ptosis repair at a later date.

Medial canthus injury: Disruption of the **posterior** tendon results in telecanthus, and repair/attachment to lacrimal crest should be done with microplating or transcanthal wires.

Nasolacrimal system (see above).

Marginal lacerations should be meticulously repaired to align lid margin. Topical and injected local anesthetic as well as corneal protectors should be used. Slight eversion with vertical mattress suture helps prevent notching. Primary repair of tarsus may be necessary at this time.

Peripheral lacerations should be repaired only after margin alignment is satisfactory (Sykes and Dugan 1994).

Fracture Biology and Surgical Basics

Bone Healing/Fracture Repair Basics

Bone healing occurs in several stages. The inflammatory phase starts soon after injury. A blood clot initially forms and then inflammatory cells/phagocytes begin breaking down bone fragments and soft tissue → (3 days to 4 weeks) a soft callus forms, made of collagen produced by fibroblasts in the wound → (2–12 weeks) a hard callus forms, made by osteoclasts forming early, unorganized bone → (3–9 years) bone remodeling done mainly by osteoclasts removes extra bone refinishes site (Papel 2002).

Fracture fixation:

Splinting: Applying rigid device to the fracture (i.e., MMF) helps to reduce fracture segments but there will always be some movement at the fracture site.

Compression: Can be achieved with plates or lag screws. Works by compressing two pieces of bone together, creating a friction and a "preload" on the bone. As long as functional forces do not exceed "preload," the bone will not move.

Surgical Approaches to Facial Skeleton

Mandible

Intraoral approaches can be used to access parasymphyseal, body, and mandibular angle regions. Relatively safe, care must be taken to identify mental nerve as well as resuspend mentalis muscle.

Submandibular approach can be used to access the mandibular body as well as angle, often used for complex comminuted fractures. Care must be taken to avoid the marginal branch of the facial nerve.

Submental approach provides access to the anterior body and symphyseal region. Relatively safe approach.

Retromandibular incision gives access to the entire ramus and up to the subcondylar region. Care must be taken to dissect carefully and bluntly to avoid damage to the facial nerve.

Preauricular approach provides access similar to the retromandibular.

Facelift incision provides similar access to the ramus and subcondylar region, with a more cosmetically favorable incision.

Orbit

Subciliary approach uses a lower lid blepharoplasty incision and dissection underneath the orbicularis muscle to approach the inferior orbital rim/floor. This does leave a visible incision and carry slightly higher risk of postoperative lid malposition.

Transconjunctival approaches to the inferior orbital rim, lateral orbital rim, and orbital floor use an incision in the fornix. After incising the conjunctiva, the surgeon has a choice of dissecting behind the septum (retroseptal) or just superficial to the septum (preseptal) approach. A lateral canthotomy and inferior cantholysis can significantly improve exposure and allow access to the lateral orbital rim.

Eyebrow approach provides access to the superior orbital rim as well as the zygomaticofrontal suture area. No significant neurovascular structures are involved with this approach.

Upper eyelid (blepharoplasty) approach provides a more cosmetically appealing access to the superolateral orbital rim.

Maxilla

Vestibular approach is the most common and versatile approach to the maxilla; provides access up to the inferior orbital rim as well as the zygomaticomaxillary suture and majority of anterior midface. The only major neurovascular structure encountered during the approach is the infraorbital neurovascular bundle. This is located 7–10 mm below the infraorbital rim and just medial to the zygomaticomaxillary suture. This can be combined with intranasal incisions for a midfacial degloving exposure. Care must be taken to properly resuspend the nasal support to avoid loss of projection and tip support.

Zygoma—Isolated zygomatic arch fractures can be approached via two incisions.

1. Gilles incision within the temporal hairline. An incision is made 2.5 cm superior and anterior to

the root of the helix, and then dissection is carried down through the superficial temporal fascia, down to the deep temporal fascia. The deep temporal fascia is incised and an elevator is used to dissect between the fascia and the underlying muscle until it lies deep to the zygomatic arch. At this point, the arch can be reduced.

2. A keen incision can be made intraorally at the zygomaticomaxillary suture. The dissection is carried subperiosteally up to the arch and manual reduction can be done with an elevator.

Bicoronal Approach

This is an important surgical approach to the superior facial skeleton, ZMC complex, nasal bones, and NOE region. Incision is placed 1 cm back into the hairline and generally placed from the root of the helix on either side. Must consider need for pericranial flap in facial reconstruction. The frontal region is generally raised in a supraperiosteal plane, down to the supraorbital neurovascular bundles. If a true foramen is encountered (less common), an osteotome is used to release bundle into the orbit. The pericranium is then incised superiorly and laterally and then raised to fill defect, if needed.

Lateral to the temporal line, the dissection is along the deep temporal fascia (the frontal branch of CN VII is within the superficial temporoparietal fascia). When the temporal fat pad is encountered, the dissection transitions to just under the fascia, but with as little trauma as possible to fat pad (temporal wasting common). At this point, the periosteum of the zygomatic arch is incised and dissection is subperiosteal plane → expose fractures.

Facial Fractures

Nasal fractures: Most common facial fracture. Despite the high frequency, controversy still exists on proper management of nasal fractures. Classically, these are best treated with closed nasal reduction within 2 weeks. While closed reduction does achieve adequate results a majority of the time, open treatment has been shown to get better results. For complex fractures, those involving a largely deviated septum, or those outside of a 2-week window, open reduction +/− osteotomies should be considered. Further if there is significant septal deformity, releasing the ULCs as well as raising mucoperichondrial flaps can release deformational forces and allow proper realignment (Staffel 2002).

Osteotomies are avoided by many during the acute time period due to fear of instability; however, it has been shown to be an effective maneuver for achieving symmetry (often only need to osteotomize one side, due to trauma already breaking the first).

In the setting of severely comminuted nasal bones, fixation should always be attempted first with mini plating systems. If there are not fragments remaining → calvarial (or iliac) bone grafting should be done with the initial repair. This should not be placed over any remaining bone to avoid over-augmentation.

ZMC fractures: Common midface fracture that can be difficult to treat. Nondisplaced fractures in this region can often be treated nonsurgically. If significantly displaced or comminuted → ORIF necessary. Exposure and surgical approach depends largely on coexistent fractures. If there is not otherwise an indication to perform a bicoronal incision, a ZMC fracture can often be repaired without one. The main principles are to align the zygomaticofrontal buttress, infraorbital rim, and zygomaticomaxillary buttress. This can often be achieved with lateral blepharoplasty incision, transconjunctival incisions, and sublabial approaches, respectively. A zygomatic arch fracture is not necessarily an indication for a coronal approach. Closed reduction can be done as above. As with all fractures, proper reduction is imperative. This can be aided with wide subperiosteal elevation to mobilize the segment or application of a Carroll-Girard Screw (Screw placed through small skin incision into body of zygoma to allow manipulation) (Hollier et al. 2003; Gruss and Mackinnon 1986).

Several complications can be encountered. Most commonly is numbness over the cheek region which is often due to damage to the infraorbital nerve, but injury to zygomaticotemporal or zygomaticofacial nerves can contribute. Diplopia can result for trauma to extraocular muscles, entrapment of muscle between fracture segments, or nerve damage.

NOE Fractures

Anatomy: Rigid Bone-nasofrontal process of maxilla, origin of the nasal bones, and the internal angular process of the frontal bone. Fragile bones include ethmoid labyrinth and orbital floors.

Medial Canthal Tendon → 3 heads are the superior limb attaching to the frontal process of the maxilla, the posterior limb attaching to the lacrimal fossa, and the anterior limb fanning out to attach to the nasal bone. The normal intercanthal distance is 30 mm. Pathologic posterolateral movement of the lacrimal bone from fracture may cause telecanthus. If not repaired well initially, it is near impossible to correct telecanthus in a delayed fashion.

Fracture classification:

Type I: A single isolated fragment that contains the attachments of the medial canthal tendon. Often a greenstick, non-comminuted.

Type II: Complete fracture, may be single or comminuted, but the medial canthus remains attached to a single segment of bone.

Type III: Comminution through the entire region, the tendon may be intact but not attached to a large or reducible segment of bone.

Treatment:

Type I fractures require exposure from above (coronal incision) as well as sublabial access. Accurate reduction must be achieved to prevent telecanthus. Two microplates are needed:
1. Fixation of the frontal bone to the central fragment.
2. Fixation of the maxilla to the central fragment.

Type II fractures require more extensive exposure from above and below as well as wide subperiosteal elevation to locate the medial canthal tendon and the central segment of bone. Drill holes are placed above and below the tendinous insertion and 26–28 gauge wire is passed through the drill holes. Transnasal wires are then passed posterior and superior to the lacrimal fossa on the contralateral side and secured to a screw or plate, reducing the central bone segment. Drilling must always be done below the frontoethmoid suture to avoid damage to the cribriform plate. Lastly, microplates are used as in type I fractures to get adequate reduction (Markowitz et al. 1991).

Type III fractures involve severe comminution and frequently unstable nasal bones. Again, wide exposure and subperiosteal elevation should be done. Additionally, a medial canthus incision may be needed to locate the tendon. At this point, bilateral wiring may be needed. The wire is first passed through the medial canthal stump, next it is placed through a central bone fragment. If insufficient bone fragments available, may require a calvarial bone graft to fill medial canthal defect(s). After a drill holes through the bone fragment or graft, transnasal fixation to the contralateral orbital rim should be done once again. Lastly, the bony remnants are secured in place with plate fixation.

Loss of nasal bone and adequate projection can occur in NOE fractures, particularly type III. If such injury is present, repair in the initial setting offers the best change for reestablishing native anatomy. This is best done with a cantilevered calvarial bone graft. The length is determined intraoperatively based on patient anatomy. The graft is secured to the frontal bone with screws or miniplate. Care must be taken to establish the proper nasofrontal angle. Drilling a groove into the glabella may facilitate a more secure graft and cosmetically favorable angle.

In severe NOE fractures, there may also be injury to the nasolacrimal system. In this setting, internal stenting is indicated to help maintain patency. This is usually done with silastic stents.

Frontal Sinus Fractures

Anatomy: Frontal sinus is not present at birth, and has quite variable anatomy throughout the adult population. It is closely associated with the orbit, frontal lobe, and cribriform plate, and consists of anterior and posterior tables with the posterior being thinner. Thin membranous bone forms the orbital roof. Within the sinus, mucosa lines the bone, and canals of Breschet are invaginations within the bone containing mucosa and diploic veins that ultimately drain into superior longitudinal sinus. The nasofrontal duct is the sole drainage of the sinus and most commonly located on the posteromedial floor. The duct ranges for 2 mm → 2 cm. Variable entrance locations into the nasal cavity. Other variations to consider: Single unilateral structure in 10 % of the population, small rudimentary sinus in 5 %, and agenesis in ~5 %.
Fracture classification:

1. Structures involved including anterior table, posterior table, nasofrontal duct.
2. Severity of fracture: Comminuted, simple, displaced, nondisplaced, open/closed.

Treatment: See Fig. 13.1

The treatment of frontal sinus fractures depends largely on the structures involved and the severity, which is why accurate classification/diagnosis is imperative. Frontal sinus obliteration, if needed, is performed after carefully removing all remaining mucosa and drilling down the inner table of bone. Packing of the sinus with fat or synthetics is then performed. It should be mentioned that there has been increasing advocation to repair the sinus primarily and to stage the treatment of the nasofrontal duct endoscopically. If cranialization is to be performed, it is important to preserve a pericranial flap to separate the sinus from the nasal cavity (Manolidis 2004).

Orbital Fractures

Anatomy: The orbit is a four-sided pyramid with many bony contributions. The orbital apex houses the optic nerve, while the superior orbital fissure contains CNs III, IV, V1, and VI and the inferior orbital fissure CN V2. The superior aspect of the orbit is formed largely by frontal bone, while laterally it is the zygoma and sphenoid. Medially are the ethmoid and lacrimal bones, and inferiorly is the maxilla, palate, and zygoma.

Fracture classification: Important to identify all the structures involved, displacement, size, and location of orbital defects.

Treatment:

Initial measures include evaluation of extraocular mobility (forced duction), pupil reactivity, visual acuity, ocular pressure. Comorbid injuries to the globe are common. If necessary, treat any corneal injuries with topical abx/anesthesia. Several emergent issues can arise including severely elevated intraocular pressure (can be from retrobulbar hematoma, emphysema, or severe shift in orbital contents). Muscle entrapment (especially in pediatric population) as indicated by severe pain, decreased ocular mobility, CT findings (Maus 2001).

Isolated orbital floor fractures may be observed, repaired within 2 weeks, or repaired immediately depending on the patient (Hosal and Beatty 2002). Immediate repair is indicated in the presence of severe enophthalmos, persistent oculocardiac reflex, and white eyed fracture (young pt with minimal findings other than decreased mobility and pain).

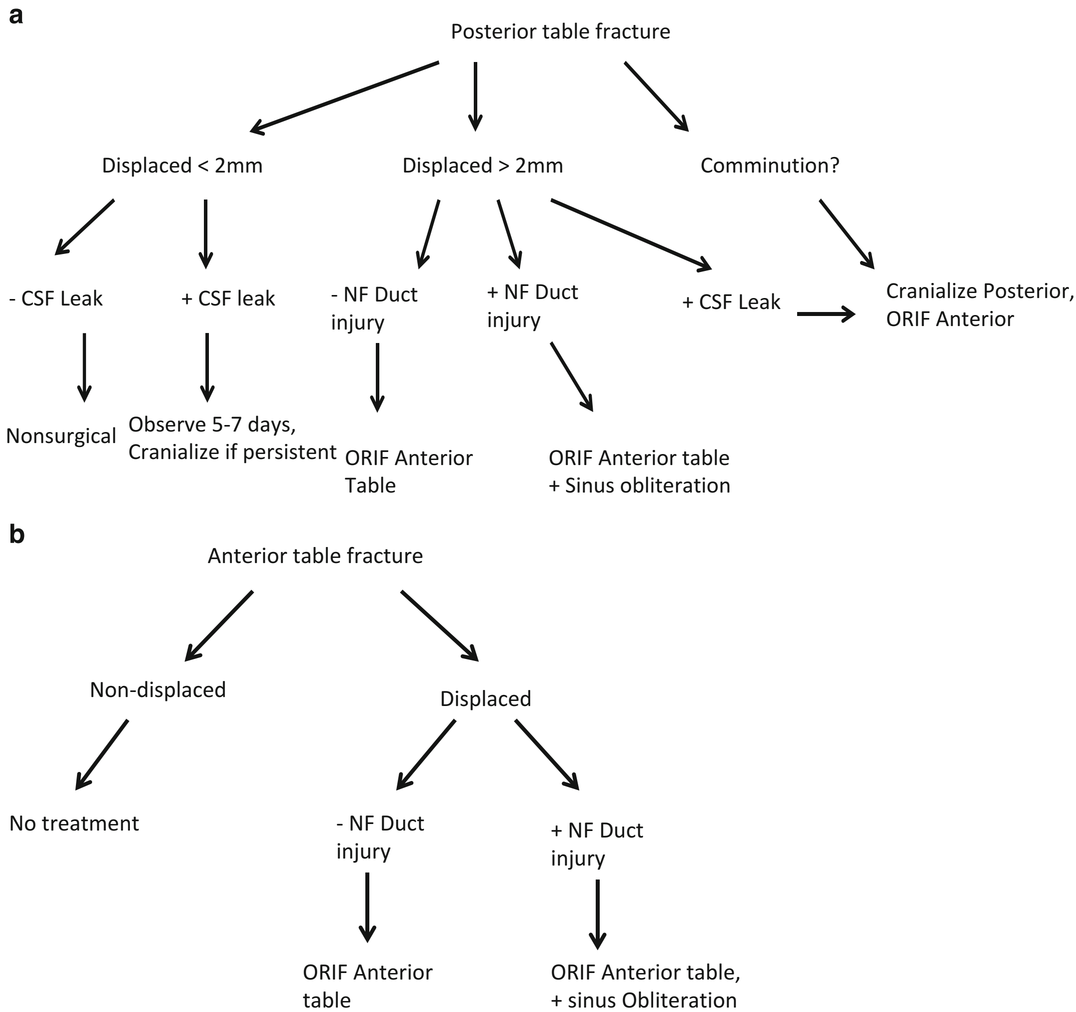

Fig. 13.1 (**a**, **b**) Management of frontal sinus injuries. Note that degree of involvement of the nasofrontal duct, posterior table, and anterior table all influence management

May be repaired in 2 weeks if large fracture (>50 % of floor), persistent diplopia with positive forced duction, progressive V2 hypesthesia, enophthalmos/hypophthalmos. Observation is for fractures with minimal diplopia with good mobility.

When treatment is indicated, a number of approaches and options exist. Both transconjunctival (preseptal and post-septal) and transcutaneous (subciliary, use of existing lacerations) exist. No matter the approach, once the orbital rim is reached it is important to dissect and elevated the periosteum/septum to help retract orbital contents. The contents of the fracture are elevated completely with ribbon retractor, and the floor is reconstructed. Titanium mesh, bone grafting, or allografting material are all available options.

Medial orbital fractures can often be managed with observation as they are rarely symptomatic. However if significant diplopia, CT

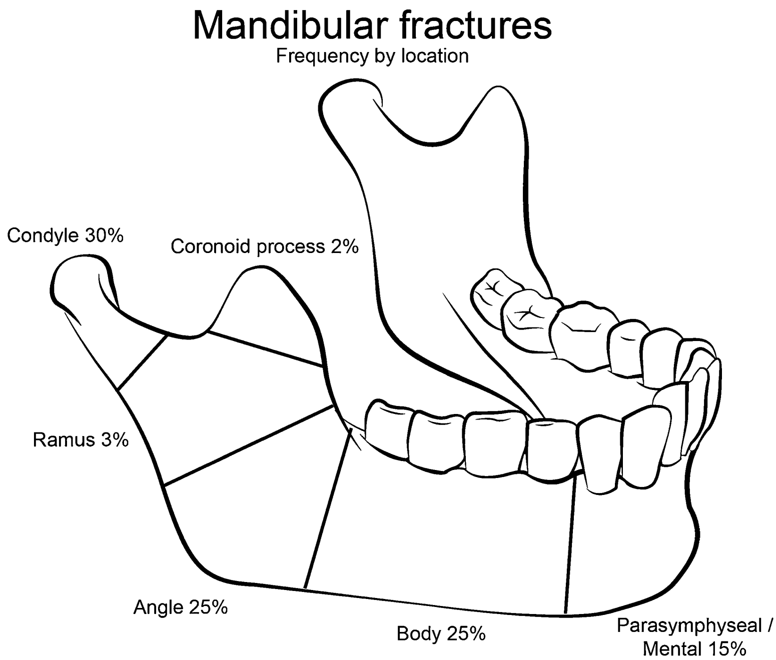

Fig. 13.2 Prevalence and location of mandible fractures. Accurate diagnosis of fracture(s) is important to determine proper management

evidence of entrapment, displacement of orbital contents toward globe, or enophthalmos are found, repair is warranted.

Mandible Fractures

Anatomy:

Dental Numbering:
Eight teeth per quadrant: 3 molar → 2 premolar → 1 canine → 2 incisors.
Numbering: 1 → 32 (R maxillary third molar → L mandibular third molar).
Occlusion
Class I (Normal Occlusion): Mesiobuccal cusp of first maxillary molar sits within mesiobuccal groove of first mandibular molar.
Class II (Overbite)—retrognathia.
Class III (Underbite)—prognathia.
Open bite—Normal relationship of molars, anterior dentition does not come together.
Cross bite—Any/all of upper dentition fit into wrong side of lower dentition.

Fracture classification

Largely based on the location of the fracture (see Fig. 13.2).
Other distinctions include comminuted versus simple, open/closed, favorable/unfavorable.

Treatment

Evaluate ABCs, c-spine status, intraoral exam (occlusion, missing dentition, laceration/open fractures, and stability of mandible), facial lacerations, lower face deviation, condylar head through EACs, Abx (cephalosporin or clindamycin) for open fractures. Teeth in fracture site do not necessarily need to be pulled unless carious or fractured root. Timely treatment is important but rarely an emergency (classic teaching was within 24 h, however increasing data and practice trends point to repair within 6–10 days without increase risk of complications).
Subcondylar fractures have classically been managed with MMF and early mobilization. However, there are absolute indications for

open repair that have been proposed that include dislocation of condyle into middle fossa or lateral extracapsular displacement, inability to obtain occlusion, open wound/foreign body. Relative indications include bilateral fracture in the presence of severe midface fractures or with the inability to achieve premorbid occlusion (edentulous, or unable to splint). Approaches include retromandibular, preauricular, endoscopic (Brandt and Hag 2003).

Body and parasymphyseal fractures: Generally best treated with ORIF through intraoral incisions. Severely comminuted, greenstick, or unstable patients can be treated with closed reduction (Ellis et al. 2003). Intraoral incision is made leaving cuff of gingival soft tissues, dissection subperiosteally to expose fracture and mental nerves. A 2.3 or 2.7 mm plate is placed inferiorly with ≥2 bicortical screws on each side. Next, a tension band (2.0 mm plate) is placed superiorly over the fracture (two monocortical screws on either side).

Angle fractures can be repaired in several ways. Nondisplaced or favorable fractures can be treated with 6 weeks of MMF. Champy plate can be placed with intraoral incision. This utilizes compressional forces; the plate is placed after MMF and is located along the oblique ridge. Alternatively, two miniplates can be placed inferiorly and superiorly over the fracture (frequently need percutaneous screw placement). Severe fractures may require and external approach.

Pan-Facial

Anatomy: See Fig. 13.3

Four vertical buttresses: Nasomaxillary, vertical portion of mandible, zygomatico-maxillary, pterygomaxillary.

Three horizontal buttresses: Frontal bar, infraorbital rim/nasal bones, maxillary alveolus/hard palate.

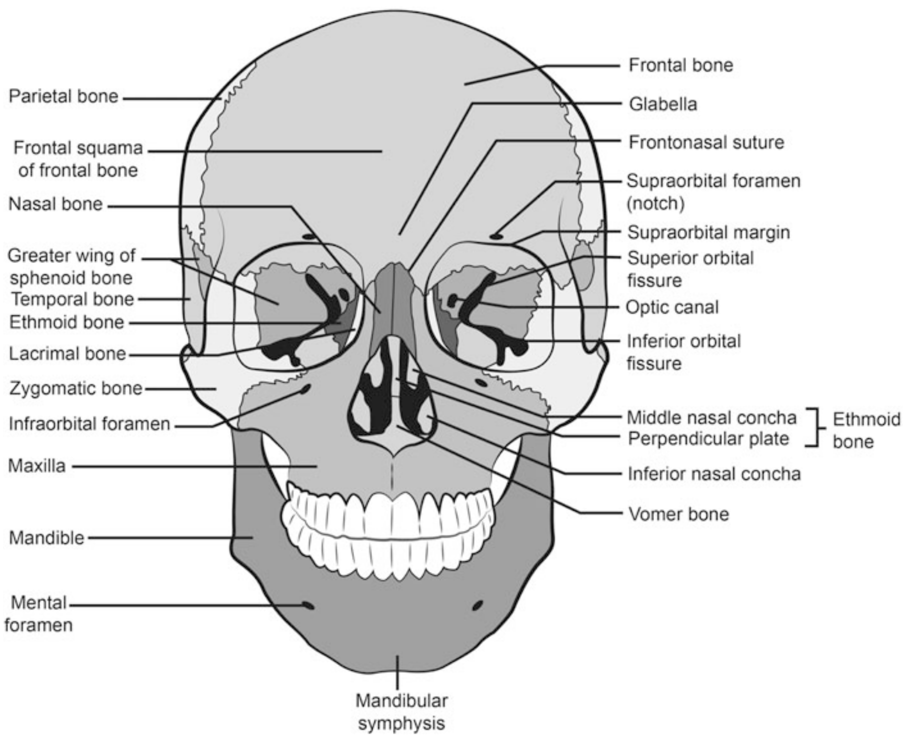

Fig. 13.3 Facial skeleton anatomy. Complex relationship of the facial bones form the vertical and horizontal buttresses for stability

Treatment

When multiple units are involved, treating fractures and restoring premorbid skeletal support can be challenging (Wenig 1991). Generally, if cranium is intact, it is best to start superiorly and move downward. In the presence of panfacial fractures with palatal sagittal split and mandibular fractures (body/parasymphyseal and bilateral subcondylar), the correct facial width cannot be determined and there is a tendency for too wide and underprojected correction. Re-establishing the frontal bar and zygomatic projection first can help set the correct width. Alternatively, if occlusion is able to be determined and reduced with MMF, one may repair mandible fracture and work upward.

Pediatric Considerations

Anatomy: Pediatric anatomy differs from adults in a manner that protects again midface and mandible fractures. These areas a relatively underdeveloped when compared to the frontal area and cranium, leading to a less protruded mandible and less aerated midface (increased stability).

Treatment: When fractures do occur, many of the same adult principles apply; however, there are some key distinctions:

Bones heal much more readily/quickly in the pediatric population and closed reduction time should be reduced accordingly (2–3 weeks is often adequate for mandible fracture).

The presence of unerupted tooth buds significantly complicates ORIF of mandible and maxillary fractures; thus, MMF is used much more frequently.

There is concern that rigid fixation with permanent materials has the possibility to restrict bone growth and cause facial asymmetry.

MMF can be challenging to obtain in patients with mixed dentition (~9 years old). Fixation can be aided by using the pyriform aperture as a fixation point.

Although rare, midface fractures can happen, controversy about the degree of growth restriction. Increasing use of absorbable plates to solve this problem.

Nasal trauma is common in this population. The nasal bones have not fused yet, and the cartilage is relatively larger and more pliable than adults. Conservative reduction is recommended and there should always be a high index of suspicion for septal hematoma.

Questions

1. When evaluating a patient in the ED with complex laceration to the right cheek and orbital area, you note the patient has a full-thickness eyelid laceration through the upper lid, extending medially, as well as MRD1 of 1. Which is of least concern when repairing at bedside?
   (a) Meticulous alignment of tarsus
   (b) Evaluating for corneal integrity
   (c) Correction of ptosis by reapproximating lid retractors (done in a delayed fashion)
   (d) Evaluating and stenting lacrimal duct
2. When evaluating the same patient in the ED, you note another knife wound to the right cheek, approximately 2 cm anterior to the tragus and just below the zygomatic arch. Facial motion is intact throughout. Upon massage, you note some saliva within the wound. Next step in management?
   (a) Allow to granulate in, place on abx
   (b) Cannulate the duct and perform anastomosis (Injury to duct should be recognized when possible)
   (c) Close the parotid parenchyma and layered would closure, abx
   (d) Close skin only, ENOG after 72 h, repair facial nerve if needed

3. Upon reviewing the CT scan of an ED consult, you note a left NOE fracture. Intraoperatively while exposing the fracture, you note the bone is mildly comminuted but the medial canthal tendon is attached to a single piece of bone. This would be what type of NOE fracture?
   (a) Type I
   (b) Type II
   (c) Type III
   (d) Type IV
4. When repairing this NOE fracture, it is most important to get which head of the medial canthal tendon stabilized and medialized?
   (a) Anterior
   (b) Posterior (displacement of the lacrimal bone leads to telecanthus)
   (c) Superior
   (d) Inferior
5. When evaluating an assault victim in the ED, a patient complain that he was "sucker punched" and his jaw hurts, teeth do not feel to be coming together right. On exam you note that the mesiobuccal cusp of the first maxillary molar is medial to the first mandibular molar. What type of malocclusion is present?
   (a) Class I
   (b) Class II
   (c) Anterior crossbite
   (d) lateral buccal crossbite
6. When treating a symphyseal fracture, which is not an acceptable option?
   (a) Intraoral approach followed by inferior and superior plates, with two screws on either side of fracture
   (b) Intraoral approach with inferior plate, and leaving a mandibular arch bar in place
   (c) MMF for 3–4 weeks (MMF should be > weeks for symphyseal fx)
   (d) External fixation device
7. Which is not an indication to repair an orbital floor fracture?
   (a) Defect of 40 % (surgery when > 50 %)
   (b) Persistent trigeminal nerve anesthesia
   (c) Persistent diplopia
   (d) Young male patient with pain out of proportion to exam findings, CT with mildly displaced fracture
8. Which is not an indication for open reduction of nasal fracture?
   (a) Presentation after 2 weeks post injury
   (b) Severely fractured and displaced septum
   (c) Short nasal bones
   (d) Failed closed reduction
9. Which is not an indication to repair a subcondylar fracture(s)?
   (a) Bilateral subcondylar fractures with loss of height
   (b) Medial displacement of the condylar head
   (c) Inability to obtain premorbid occlusion
   (d) Associated contralateral parasymphyseal fracture
10. What is the most appropriate management of a patient presenting after MVC with a posterior table fracture 1 mm, intact anterior table, noted to have persistent, clear rhinorrhea?
   (a) ORIF of posterior table fracture
   (b) Cranialization of frontal sinus
   (c) Placement of lumbar drain, bed rest, stool softeners (Cranialize if CSF present after a week)
   (d) Obliteration of frontal sinus

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Part III

Congenital Malformations

Cleft Lip and Palate

14

Christian P. Conderman

Introduction

Cleft lip with or without palate (CL ± P) and cleft palate in isolation (CPO) constitute the **most common congenital defects of the face** (second most common overall developmental defect following clubfoot). Despite similarities and overlapping characteristics, CL ± P and CPO should be considered as individual disorders with different embryologic, etiologic, and epidemiologic factors. Most current evidence points to CL ± P and CP to being multifactorial diseases with myriad contributions of both genetic and environmental factors. Additionally, patients with these conditions can have concomitant health issues including otologic disease (e.g., OME, ETD, rAOM, cholesteatoma), nutritional deficits, speech and language problems, dental deformities, sleep apnea, concurrent facial growth deformities, and psychosocial difficulties. Given the complexity inherent to these disorders and their treatment, a comprehensive treatment plan requires a multidisciplinary approach including the otolaryngologist, plastic surgeon, speech-language pathologist, geneticist, pediatrician, nutritionist, orthodontist, and orthognathic specialist. Antepartum diagnosis is now standard practice in most communities and early diagnosis allows for parental counseling and enrollment into a cleft treatment program.

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Epidemiology

- Distribution of clefts: 50 % cleft lip and palate (CL ± P); 30 % isolated cleft palate (CPO) and 20 % cleft lip (CL) alone
- CL ± P—in North America 0.2–2.3 cases per 1000 population and varies by ethnic groupings—3.6/1000 in Native Americans 2.1 per 1000 in Asians, 1 in 1000 in Caucasians, 0.41/1000 in African-Americans
  - Males:females::1.5:1
- CPO—0.1–1.1 cases per 1000; females: males::2:1, females more likely to develop cleft palate (due to later closure of palatal shelves during development)
- CL—distribution 6:3:1 for left-sided CL, right-sided CL, and bilateral CL, respectively
  - Right-sided CL more commonly associated with syndromes
- CL ± P associated with syndromes (<20 % of total cases)—most commonly associated syndrome is van der Woude (see below)
  - Approximately 85 % of bilateral cleft lips and 70 % of unilateral CL associated with cleft palate

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Table 14.1 Risk of cleft lip with or without palate and cleft palate in isolation in subsequent children based on prior history of cleft disorders in relatives (table adapted from KJ Lee Essential Otolaryngology, and Bailey's 5th edition, Ch. 103, Comprehensive cleft care)

Percentage likelihood of next child having cleft defect		
	CL ± P	Cleft palate
No family Hx of CL ± P or cleft palate	0.10 %	0.04 %
Parents normal, first child is affected		
No affected relatives	4 %	2 %
Affected relatives	4 %	7 %
Parents normal, two affected children	9 %	1 %
Parents normal, two affected relatives	9 %	10 %
One parent affected, no children affected	4 %	6 %
One parent affected, one child affected	17 %	15 %

- CPO more commonly associated with syndromes than CL ± P—most commonly associated with autosomal dominant syndromes with microdeletion or addition at chr 22q11.2 (DiGeorge, velocardiofacial, conotruncal anomaly face syndrome)
  - 22q11.2 syndromes have incidence of 1 in 4000 live births
  - CPO associated with syndromes 55 % of the time
- Approximately 30–65 % of facial clefts appear to be associated with named syndromes
- Recurrence risks: Table 14.1

Etiology

Environmental

- Multifactorial for Most Non-syndromic Cases of Clefting
- Maternal health—pre-pregnancy DM (though not gestational diabetes), maternal obesity increases risk; maternal age shown by meta-analysis not to be a factor
  - Alcohol consumption during pregnancy, although definitive relationship with in utero alcohol consumption remains unclear
  - Smoking, particularly high levels, consistently associated with increased risk for clefting in numerous studies, but risk seems stronger for CL ± P than CPO
  - Poor folic acid and vitamin intake, folate antagonists associated with increased risk of clefting (folate supplementation may play protective role though evidence more definite for protective effect in neural tube defect)
- Use of valproic acid, phenytoin, retinoic acids, dioxin, thalidomide, corticosteroids

Syndromes/Associated Disorders

- **Van der Woude Syndrome** (**VWS**)—most common syndrome associated with CL ± P; autosomal dominant (AD) inheritance, lower lip pits/sinus tracts, hypodontia; mutations of **interferon regulatory factor gene (IRF6)** felt to contribute to this disorder
- **Pierre Robin Sequence (PRS)—micrognathia, glossoptosis, and CP**
  - Micrognathia prevents tongue descent; retrodisplacement of the tongue → abnormal palatal development with clefting (characteristically U-shaped) or high-arched palate and respiratory distress especially in the supine position; most commonly **associated with Stickler syndrome** (14–34 % of cases)
  - **Children with PRS should undergo routine ophthalmologic evaluation in the first year of life** to rule out concurrent eye issues

- **Stickler syndrome**—Autosomal dominant with variable expression; SNHL, characteristically contains Pierre Robin sequence, ocular abnormalities, and arthropathies. Ocular anomalies include early (first decade) myopia that can be severe, retinal abnormalities and glaucoma. Arthropathies relate to connective tissue disorders—marfanoid features, hyperextensible joints, kyphosis, scoliosis
- **22q12 deletion**: Most frequent interstitial deletion known to be causally associated with clefting in humans
  - Associated with wide phenotypic spectrum including DiGeorge syndrome, velocardiofacial syndrome (VCFS)
  - Palatal anomalies; most commonly VPI (29–50 % of cases)
  - Also associated with cardiovascular malformations, immune deficiencies, and neurodevelopmental disabilities
  - Additional features: elongated, flattened midface with malar hypoplasia, broad nasal base, low-set ears, thickened helical rim, micrognathia, microcephaly, dysphagia, pharyngeal hypotonia, middle ear disease, CHL, and chronic suppurative OM
  - Adenoidectomy and pharyngeal surgery should be performed carefully as incidence of VPI is high following surgery; **medial course of carotid artery** may contribute to increased risk of carotid injury during pharyngeal surgery
  - **Dx: FISH testing**
- **Velocardiofacial syndrome** (**Shprintzen** syndrome)—deletion at 22q (same locus as **DiGeorge** syndrome and overlap exists between the two syndromes); affected children have clefts, cardiac anomalies, and characteristic facies (as above)
  - Patients with clefts and the following associated findings should be tested for DGS/VCF deletion: any cardiovascular malformation, short stature, microcephaly, developmental delay, immune deficiency, hx/Fhx of psychiatric disease, and facial dysmorphism
- **Ectrodactyly-ectodermal dysplasia-clefting syndrome**: lobster claw anomaly of all four extremities, typically have bilateral CL with CP; but unilateral CLP and CP alone reported; ocular findings: related to absence of lacrimal puncta → epiphora, blepharitis, keratoconjunctivitis, corneal ulcers
- **Popliteal pterygium syndrome—IRF-6** gene disturbance; similar to VWS with CL ± P and presence of popliteal pterygium/webbing, syndactyly, genital abnormalities, intraoral adhesions (syngnathia), pyramidal skin on hallux, ankyloblepharon
- Other disorders associated w/ clefts: Down's (trisomy 21), oculo-auriculo vertebral, hemifacial microsomia/Goldenhar (constellation of first, second branchial arch abnormalities), Kabuki (CP, arched eyebrows, long palpebral fissures, flat nose), Treacher Collins (AD, colobomas, low-set ears), orofacial-digital syndrome (x-linked, oral clefting, mandibular hypoplasia)

Embryology

The development of the lip and palate occurs sequentially rather than coincidentally and varying degrees of clefting can occur; the degree of clefting is based on the point in fetal development when the fusion process is interrupted.

Lip Development

Begins at the end of the fourth embryological week, five structures surround primitive stomodeum that will ultimately give rise to structures of the face, nose, and lips: frontonasal prominence and neural crest-derived facial prominences appear from first pair of pharyngeal arches—right and left maxillary and mandibular prominences.

Frontonasal Prominence (FNP): Mesenchymal proliferation ventral to developing forebrain

- FNP → nasal dorsum, forehead, contributes partially to septum (downgrowth from postero-superior aspect of FNP; other contribution from fused MNPs)

Nasal Placodes: Ectodermal thickenings at ventro-lateral aspect of FNP; placodes invaginate (at fifth week) to form nasal pits → primitive nasal cavity internally and medial (MNP) and lateral nasal processes (LNP)

- LNP—forms nasal alae and sidewall; nasolacrimal groove between LNP and maxillary process (failure of fusion → oblique cleft [rare])
- MNP—right and left MNP fuse to form **intermaxillary segment** (sixth week; failure of fusion → midline cleft, associated with holoprosencephaly); fusion forms the philtrum, medial upper lip, nasal tip, and columella
  – Intermaxillary segment → primary palate (see below)

Maxillary Prominences (MP): First arch derivative; sixth to seventh weeks; MPs grow medially and ultimately fuse with MNPs (mid-fifth week) to give rise to upper lip; MPs → lateral upper lip; also have significant contribution to secondary palate (see below).

NOSE: Formed from five facial prominences FNP = bridge/dorsum; fused MNPs = tip and columella, and LNPs = nasal alae and sidewall.

UPPER LIP: MNPs = medial upper lip, philtrum; MPs = lateral upper lip (from philtral column laterally); NO contribution of LNPs to formation of upper lip; development usually complete by the end of seventh week.

- **Lack of fusion between maxillary process and medial nasal process → CL**

Palate Development

Weeks 5–12 (palatal fusion completed later in females) MPs grow and push the MNPs medially → MNPs fuse not only at surface giving rise to lip but also at deeper levels to form premaxilla, alveolus, and primary palate; once primary palate fully developed, the secondary palate begins to develop; 6th week of embryonic development, palatine shelves are directed obliquely downward on either side of tongue; seventh week → palatine shelves migrate inferomedially to lie horizontally above the tongue; palatal fusion occurs from anterior to posterior and simultaneously fuses with nasal septum which descends from above (derived from FNP) at eighth week, tongue begins to withdraw/descend from its position between lateral maxillary prominences (which form secondary palate).

Primary Palate—derived from intermaxillary segment after fusion of MNPs = central lip (philtrum), columella, nasal tip, premaxilla, central maxillary alveolar arch that houses four incisor teeth (medial and lateral incisors) and hard palate anterior to incisive foramen.

- **Lack of fusion between maxillary process and medial nasal processes/intermaxillary segment → primary CP**

Secondary Palate: Part of hard palate posterior to incisive foramen as well as lateral hard and soft palate; formed by fusion of palatine shelves (from maxillary prominences); majority of palate including hard palate posterior to incisive foramen and all of soft palate; development begins after completion of primary palate.

- **Lack of fusion in the midline between two palatine shelves (from lateral maxillary processes) → secondary CP**

Fusion of alveolus **between canine (cuspid) and lateral incisor**, i.e., **alveolar defect** between these teeth and clefts in this location can affect development and eruption of adult canine.

Types of Clefts/Classification

Cleft Lip

- **Complete unilateral CL**—entire vertical thickness of upper lip and often associated with alveolar cleft because the lip and primary palate share same embryologic origin; implies separation of medial and lateral lip with absence of all layers—skin, muscle, mucosa, alveolar bone with extension to nasal sill/floor

- **Incomplete unilateral CL**—can contain muscle fibers within the cleft, residual fibers known as **Simonart's band** (bridge or bar of lip tissue of variable size that usually consists of skin only, although some histological studies have shown that some muscle fibers lie within band)
- **Microform** CL—diastasis of orbicularis fibers with present alveolus, skin, and mucosa
- **Bilateral CL**—prolabium of complete bilateral clefts is devoid of muscular fibers and is attached at columella only (tenuous blood supply), although may have muscle fibers in incomplete clefts; premaxilla can be horizontally oriented and may require molding/manipulation of cleft components prior to definitive repair

Cleft Palate—unilateral or bilateral and extent may be classified as complete or incomplete. CP is classified according to relative location to the incisive foramen

- **Clefts of primary palate** occur **anterior** to incisive foramen
- **Clefts of secondary palate** occur **posterior** to incisive foramen
  - Unilateral cleft of secondary palate is defined as one in which the palatal process of the maxilla on one side is fused with the nasal septum
  - Bilateral complete cleft of the secondary palate has no point of fusion between the maxilla and the nasal septum
  - Cleft palate in isolation (CPO) usually involves the secondary palate only and has varying degrees of severity
- **Incomplete CP**—clefting of **secondary palate only**
  - Least severe incomplete cleft is submucous cleft palate (SMCP)—bifid uvula, thinning of central soft palate with translucent appearance, and palpable notch in posterior aspect of hard palate; patients at high risk for VPI as levator veli palatini has similar configuration to what is seen in true cleft palate with central diastasis and abnormal longitudinal orientation of muscle fibers → Furlow palatoplasty may be effective Tx (see below)
- **Complete CP—**palate involves both the primary and secondary palate and includes one or both sides of the premaxilla/alveolar arch and frequently involves cleft lip
- **Veau Classification of Cleft Palate**
  - I—Soft palate only
  - II—Hard and soft palate
  - **III**—Unilateral complete cleft
  - **IV**—Bilateral complete cleft

Muscular and Vascular Anatomy

LIP—Divided into red (convex) and white lip (concave) separated by muco-cutaneous junction/vermilion border

- **White roll—**epithelium just above vermilion border, reflects ambient light and is critical landmark in cleft lip reconstruction
- **Vermilion**—dry portion of lip's red mucous membrane, lacks pilosebaceous units, salivary glands, eccrine glands
- **Superior labial artery**—major blood supply to upper lip; normally anastomoses in midline; courses on undersurface of orbicularis muscle
  - In unilateral cleft—aberrant vascular supply on lateral aspect of cleft is better developed than on medial side; artery courses along margin of cleft, anastomosing with either angular or lateral nasal artery at base of nose
  - Incomplete cleft—thin, terminal branch of Sup. Labial artery crosses bridge
  - Bilateral clefts—artery is underdeveloped in central, prolabial segment which primarily derives its blood supply from the septal, columellar, and premaxillary vessels

- **Orbicularis Oris**—principal muscle of the lip; not a true sphincter as superficial and deep parts of muscle arise separately from modiolus; critical role in lip function and appearance and reestablishment of muscular sphincter is critical in achieving appropriate surgical outcome; superficial layer arises from dermis and passes obliquely to insert into the mucous membrane lining the inner surface of the lips, deep fibers arise from maxilla and mandible
  - Orbicularis in CL: Muscle is hypoplastic and has abnormal attachments/insertion in CL—no muscle crosses the cleft in complete clefts; the skin bridge in incomplete clefts also contains no functional muscle (muscle fibers do not cross gap unless skin bridge at least 1/3 total lip height); muscle is more hypoplastic on medial side of cleft; abnormal insertion at alar base and anterior nasal spine; fibers parallel cleft margin

Palate

Muscular Anatomy of Palate and Pharynx

- Tensor veli palatini (TVP): **V3**; tenses palate and open ET during swallowing; from base of internal pterygoid plate and lateral aspect of torus tubarius; terminates in tendon/aponeurosis after winding around hamulus
- **Levator Veli Palatini (LVP)**: **Pharyngeal Plexus** (derived from IX, X, and VII) origin: petrous bone and medial torus, fibers occupy central 40–50 % of soft palate and fuse with contralateral LVP; palatal sling causes upward and posterior motion of the soft palate; causes elevation of soft palate during deglutition
- Musculus uvulae: pharyngeal plexus; adds bulk to dorsal surface of soft palate
- Palatoglossus: pharyngeal plexus; forms anterior pillar; lowers and positions velum, elevates tongue
- **Palatopharyngeus**: pharyngeal plexus; forms posterior tonsillar pillar; constricts pharyngeal isthmus **narrows VP orifice**, superior heads (2) clasp LVP as it enters velum; fibers intermingle with SPC at posterolateral pharyngeal wall, action: retrodisplacement and downward motion of the velum; antagonist to LVP and position of velum during normal function is the net result of action of LVP and palatopharyngeus; stretches posterior free margin of velum; acts with SPC for medial movement of lateral pharyngeal wall below the level of the hard palate
- **Superior Pharyngeal Constrictor (SPC):** pharyngeal plexus; **medial movement of lateral pharyngeal walls**; relative activity of SPC may contribute to different patterns of VP closure (coronal—minimal SPC fxn, sagittal—high degree of SPC activity during closure, circular—moderate); **main component of Passavant's ridge**

In CP, VP muscles can be hypoplastic and generally have abnormal course and attachment

- TVP—normally attached to posterior hard palate; in CP, aponeurosis is incomplete with abnormal attachment at posterior hard palate, results in ETD
- LVP—in CP and SMCP has abnormal longitudinal orientation with **abnormal insertion to posterior aspect of hard palate, SPC, and TVP aponeurosis;** abnormal LVP appears to be primary constituent of VP dysfunction

Arterial Supply of Palate

- Hard palate—Greater palatine artery with some anterior contributions from arterial branches in incisive canal (anterior palatine artery)
- Soft palate—Ascending palatine (facial artery), greater palatine (internal maxillary), ascending pharyngeal branch, and contribution of lesser palatine (branch of greater palatine)

Treatment

Table 14.2 provides a general outline for timing of intervention in patients with cleft lip and palate.

Rule of tens—10 weeks old, hemoglobin 10 g/dL, weight 10 lb; partially based on anesthetic safety; incomplete clefts have less urgency to repair as Simonart's band tends to hold alveolar segments in place as growth occurs.

Oral intake can be compromised as a result of inability to feed (sucking mechanism impaired—child is unable to form a seal due to incomplete muscular sphincter and/or escape of air through cleft palate); goal should be weight gain of 0.5–1 ounce/day; **Mead-Johnson, Haberman, or Pigeon** nipple can be used to facilitate feeding; feeds should be done in upright position, as cleft patients tend to swallow more air and require frequent burping.

Presurgical Infant Orthopedics (PSIO)

Preoperative manipulation of alveolar segments in complete CL ± P is performed, done especially in wide clefts to facilitate closure; most important in bilateral complete cleft lip in which control of premaxillary segment is critical in achieving satisfactory surgical outcome; ideally, PSIO should be started in first 1–2 weeks of life.

Table 14.2 Timing of intervention in patients with CL ± P and CPO (table adapted from Park Facial Plastic Surgery: Essential Guide)

Timing of intervention in patients with cleft deformities	
Presurgical orthopedics/ intervention	1–2 weeks
Speech eval—feeding	
Cleft lip repair	3 months
Primary rhinoplasty	
Tympanostomy tube placement	
Palatoplasty/palate repair	9–18 months
T-tube/long-term PE tube placement	
Speech evaluation	3–4 years old (as early as 2 years)
Velopharyngeal work-up/surgery	4–6 years old
Repair of alveolus	6–8 years old
Intermediate rhinoplasty	7–10 years old
Definitive septorhinoplasty	16–19 years old
Orthognathic surgery	

Techniques

- **Taping**—requires family compliance to properly apply tape across cleft, doesn't address nasal deformity
- **Head bonnet**—applies pressure across premaxilla; easier than taping, removable
- **Latham** appliance—mold with pins used to create more favorable alveolar position
- **NAM (nasoalveolar molding)**—molding and repositioning of alveolar processes, nasal cartilages, and lengthening of deficient columella to create lasting aesthetic outcome and reduce need or minimize the extent of secondary surgical revision procedures; significantly improves nasal symmetry over surgery alone; once alveolar segments in close proximity, nasal stent is added to mold distorted nasal cartilages; the alar cartilage lifted by stent to achieve normal elevation and symmetry
  - **NAM in bilateral cleft patients** used to lengthen columella, reposition nasal cartilages toward the tip, and align the alveolar segments; first stage in bilateral molding consists of retracting and straightening the everted premaxilla into space between two lateral alveolar segments; second stage—nasal stents incorporated into anterior rim of molding plate

Gingivoperiosteoplasty—closure of soft-tissue alveolar segments; possible if there is close approximation of the cleft alveolar segments; use of NAM and presurgical approximation of alveolar gap provides the surgeon with the option to perform GPP at the time of lip closure.

Lip adhesion procedure in which cleft segments united via small flaps, essentially creating an incomplete cleft and this can contribute to molding of the alveolar segment and reducing width of cleft; secondary procedure then converts the lip adhesion to a formal lip repair; alternative in a patient who may not tolerate NAM or alternative orthopedic.

Cleft Lip Repair

Goals: creation of symmetrical nasal tip and alar bases, cupid's bow, and lip fullness without loss of normal philtral contour with fullness of labial mucosa that is equivalent on both sides.

Techniques

Straight-line repair: poor orbicularis closure may result in lip shortening, tissue waste, and unappealing scars with potential for scar contracture; largely abandoned.

Geometric closures, modified z-plasties, quadrangular flaps, triangular flaps—designed to decrease the amount of lip shortening that occurred and to improve orbicularis oris muscle function

Tennison-Randall Repair—triangular repair, second most commonly used technique for repair of unilateral cleft lip, designed as modified z-plasty

- Disadvantage—violation of normal philtral column on the non-cleft side, creates a scar which crosses the boundaries of known anatomic subunits; require exacting presurgical measurement and lack flexibility in surgical application

Millard Rotation-Advancement Flap—most commonly used technique in US

- Goals: restoration/reconstruction of normal lip anatomy function by reestablishing continuity of orbicularis; secondary goals-closure of the nasal floor and correction of nasal tip asymmetry
- Must be designed to correct vertical height discrepancy from cupid's bow to the columellar base on the cleft and non-cleft sides of the lip; difference accounts for length and design of rotation flap and back-cut
- Technique (Fig. 14.1): Methylene blue used for skin marking as outlined below; rotation flap incision is made first (point 3 → 5 with back-cut to x as needed) and is taken through entire thickness of orbicularis and oral mucosa to allow for complete release; c-flap remains and may be used to add additional height to columella; the advancement flap starts with incision from point 8 → 9 and this incision is

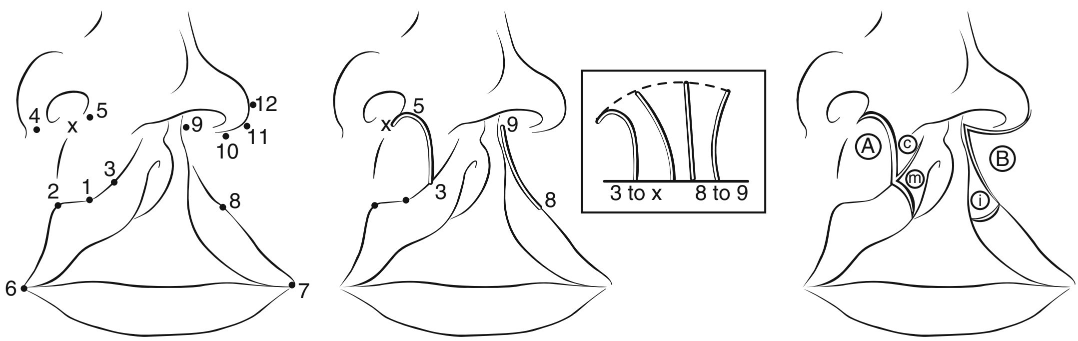

Fig. 14.1 *Left*: Anatomical landmarks used in the Millard rotation-advancement flap technique for repair of unilateral cleft lip deformity. *Middle*: The length of the rotation flap (non-cleft side) and advancement flap (cleft side) is equivalent in length (see *inset*). *Right*: Following incision, the flaps are advanced and rotated (A and B) while c contributes to repair of the nasal sill [after Sykes and Tollefsen Management of Cleft Lip Deformity, depicting Millard Rotation-Advancement Flap]

then continued along the alar base; the gingivo-labial sulcus then also incised and incisions are taken down to face of maxilla; bilateral undermining assists in closure; first deep-stitch reapproximates orbicularis at back-cut and second stitch at vermilion; mucosa, muscle, and skin closure follows

- **Advantages**: flexible—can be applied to a wide variety of cleft lips, allows continuous modifications during the design, incisions, and execution of the repair, minimal discarding of tissue, good nasal access, camouflage of suture line
- **Disadvantages**: requires experienced surgeon, possible excessive tension—may cause constriction of maxillary growth, extensive undermining required, vertical scar contracture with possibility of vermilion notching if improperly designed, tendency towards small nostril

Bilateral Cleft Repair (Fig. 14.2)

The premaxilla can be quite protrusive and may be "locked out" from palatine segments requiring pre-op manipulation to achieve an appropriate repair via PSIO or lip adhesion → gives three segments best configuration to achieve subsequent repair; reestablishing continuity of orbicularis is critical for optimal functional and aesthetic result; single-stage repair of bilateral deformity usually provides best chance of symmetrical outcome; staged repair of the bilateral cleft tends to create an asymmetrical result due to disparities of the two sides in terms of facial growth following "re-vascularization" of repaired lip; asymmetry is oftentimes difficult to correct at a later stage and staged repair precludes muscle from being advanced across the pro-labial segment.

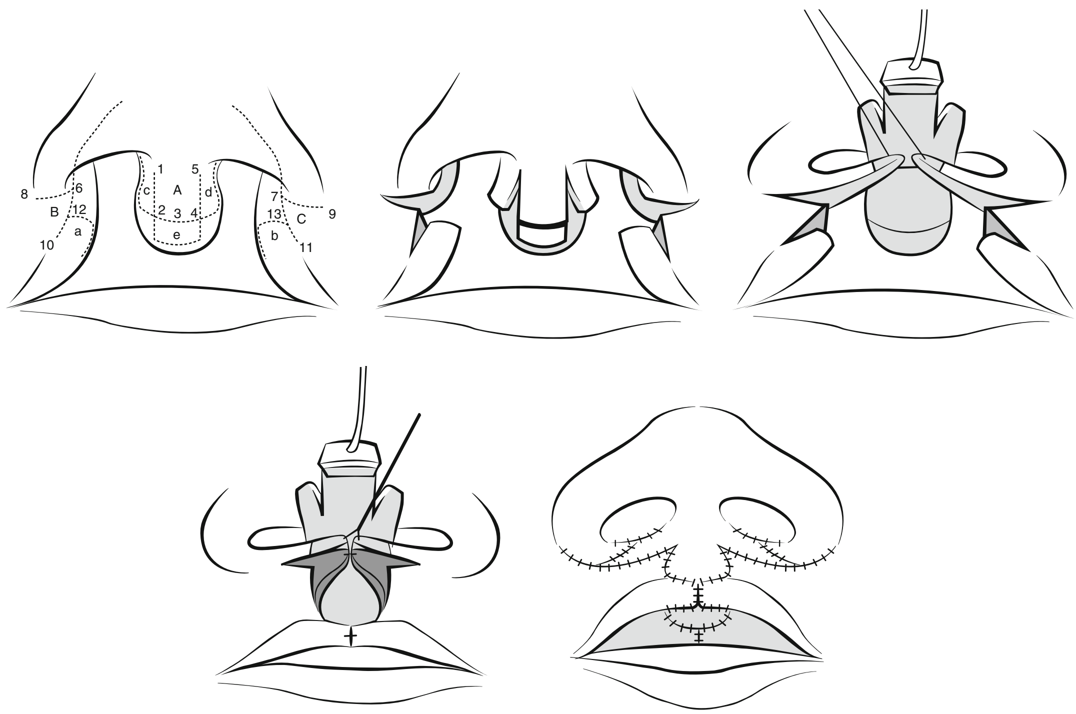

Fig. 14.2 *Top left*: Anatomical landmarks and incisions used for repair of the bilateral cleft lip deformity. *Top middle*: Incisions made in prolabial and lateral flaps in anticipation of flap advancement. *Top right*: de-epithelialized tips of lateral flaps advanced and sutured in place medially to the premaxillary periosteum. *Bottom left*: Tips of lateral flaps sutured medially and reconstruction of orbicularis muscle sling. *Bottom right*: Prolabium and fork flaps sutured in place (after Seibert Surgical Repair of the Bilateral Cleft Lip Deformity)

Cleft Nasl Deformity

Unilateral Cleft Nasal Deformity (Fig. 14.3)

- Abnormal insertion of orbicularis muscle at anterior nasal spine and alar base on cleft side
- Cleft alar base displaced **inferiorly, laterally, and posteriorly** due to maxillary insufficiency and action of the orbicularis
- Septum: caudal and inferior septum deviated to non-cleft side, upper and posterior portions of the septum deviate to the cleft side and cleft side may have inferior turbinate hypertrophy
- Columella is shortened on the cleft side and the nasal tip is deflected to the cleft side by inferior displacement of the medial and lateral crura (with more obtuse angle btw medial and lateral crus)
- LLC has normal size; however it is positioned more caudally with poorly projecting dome and steal phenomenon of lateral crus, i.e., lateral crura adopts lengthened position by "stealing" cartilage from medial crus
- Deficiency and displacement of maxillary segment with lack of piriform aperture
- Alar-facial groove is often absent and the ala attaches to the face at an obtuse angle, contributing to the abnormal horizontal orientation of the naris on the cleft side

Fig. 14.3 Anatomical findings associated with unilateral cleft lip nasal deformity (after Dutton, Bumsted Management of the cleft Lip Nasal deformity)

- Absence of nasal floor and sill commonly seen, and relative stenosis of the internal nostril on the cleft side
- Internal nasal valve collapse may occur due to the relative flaccidity of the ULC on the cleft side
- External valve collapse also possible due to introversion of cleft ala

Bilateral CL—similar defects to those seen in unilateral CL nasal deformity, but present on both sides to varying degrees (if asymmetry of CL exists)

- Poorly projected tip with wide alar base
- Alar bases positioned similarly to unilateral CL due to pull of abnormally inserting orbicularis oris and bilateral absence of maxillary segment → posterior, lateral, inferior displacement
- Extremely short columella and the medial crura are displaced into the prolabium
- Prolabium and premaxilla can be significantly anteriorly displaced with poor overall blood supply
- Nasal tip is broad and flattened and the nasal domes are separated resulting in a bifid appearance
- Depending on presence/absence of CP, septum may not articulate with palatine shelves in bilateral complete CP; unilateral complete CP → septum attaches to non-cleft side

Treatment of Nasal Deformity—correction begins as early as 1 week after birth with NAM (see above) → positions CL and LLC for primary repair; primary repair done at the time of lip repair; intermediate repair usually occurs at ages 7–11 years after alveolar bone grafting; definitive septorhinoplasty follows completion of growth after adolescence; staged nasal repair allows smaller corrections with each procedure

- Goals: reconstruction of nasal floor and sill, repositioning of alar base, columellar lengthening on cleft side, correction of deformed ala, provision of adequate nasal tip support and symmetry, straightening of nasal dorsum, attainment of adequate nasal airway

Primary Rhinoplasty

- Does not affect nasal and midface growth
- Done at the time of Millard rotation-advancement technique
- Cleft LLC separated from overlying skin-soft-tissue envelope via alar base (laterally, the alar base is separated from its attachment to displaced maxilla and abnormal orbicularis insertion) and columellar incisions with intercrural dissection
- Alar base sutured in more medial position after reconstruction of nasal floor (mucoperiosteal flaps from lateral nasal wall and mucoperichondrial flap from septum)
- LLC sutured in a more anatomic position and secured via internal and external bolster

Intermediate Rhinoplasty

- Most secondary deformities can be repaired at age 7–8 years when lower nasal complex can be addressed
- Alveolar bone grafting usually precedes intermediate rhinoplasty as eruption of lateral incisor and canine following alveolar bone grafting provides adequate base for nasal repair
- Nasolabial fistula also corrected prior to intermediate rhinoplasty to release abnormal pull on alar base
- Judicious septal surgery at the time of intermediate rhinoplasty does not appear to interfere with subsequent growth of the face or nose
- Repositioning of the caudal septum in the midline and reconstruction of the nasal tip and alar cartilages is appropriate at this stage
- Performed via open technique for adequate visualization and accurate repair
- Technical points (although these may be delayed depending on severity of deformity at the time of intermediate rhinoplasty)—dissecting pocket between the medial crura, freeing the caudal septum from abnormal attachment with suture correction/suspension in the midline at anterior nasal spine, repositioning abnormal dome in more medial and superior location (lateral crural steal), V-Y advancement from upper lip to lengthen cleft side columella

Definitive Septorhinoplasty

- Definitive correction includes septoplasty, osteotomies, dorsal revision done after completion of nasal growth
- Complete and aggressive restructuring of internal and external anatomy can be performed
- Done via open approach with or without alotomy
- Graft materials: usually from septum, via separate hemitransfixion approach with preservation of dorsal and caudal struts with correction of bony and cartilaginous deviation
- Columellar strut with fixation of LLCs enhances nasal projection with more advancement of cleft-side LLC
- Repositioning of LLC may be necessary with suturing to ULC
- Tip graft can improve tip definition
- Unilateral spreader on cleft side can be used to address INV collapse

Cleft Palate Repair

Surgical repair of CP is done to ensure normal speech development and closure of oronasal fistula to prevent regurgitation by separation of oral and nasal cavities, reconstitution of palatal sling with adequate VP function for speech and swallowing, and preservation of midfacial growth

- Development of normal speech is primary concern that dictates timing of repair (usually ~12 months). Improved speech outcomes (repair before 18 months) seen with early closure of palatal defect

Techniques

All techniques rely upon adequate flap mobilization, atraumatic tissue techniques, and multilayer closure of oral and nasal mucosa and musculature

- Von Langenbeck—bipedicled flaps with anterior and posterior blood supply; incisions placed along cleft margin and adjacent to alveolus; useful in narrow clefts and incomplete clefts; disadvantages: leaving anterior pedicle → decreased flap mobility; vascular pedicle (~1 cm medial to upper second molar) not visualized (Fig. 14.4).
- **Two-Flap Palatoplasty** (Bardach)—commonly used for repair of complete unilateral and bilateral CP, incisions extend along cleft margin, posterior to alveolus, and around last molar tooth; great care taken not to damage tooth buds during flap elevation; posteriorly based pedicle (greater palatine artery); combined with vomer flaps (advanced laterally and sutured to lateral undermined nasal mucosa for nasal closure); does not lengthen soft palate; dissection in space of Ernst (posterior to vascular pedicle) or fracturing of the hamulus allows additional mobilization of flaps (Fig. 14.5).
- **Furlow (Double-Opposing Z-Plasty)**—used for closure of soft palate and in SMCP, lengthens and thickens soft palate while reorienting LVP; also useful in surgery for VPD (see below); can be used for soft palate closure in conjunction with two-flap hard palate defect although soft palate should be addressed before undermining flaps (Fig. 14.6).
- V-Y Pushback/Three Flap—used for clefts of secondary palate; incisions similar to bipedicled technique, but oblique cut at the level of canine connects incisions, converting

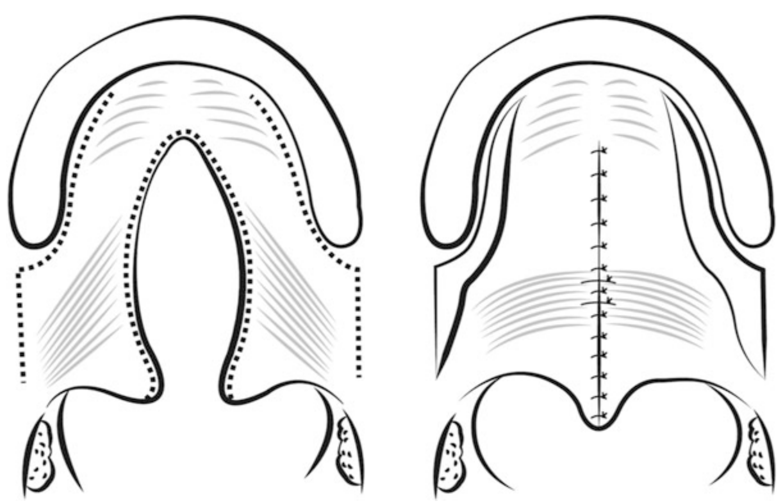

Fig. 14.4 Von Langenbeck palatoplasty. *Left image*: Incision design for right and left bipedicled flaps. *Right image*: Right and left flaps advanced for closure of cleft palate with residual exposed underlying hard palate laterally. Underlying levator sling is reconstituted with appropriate orientation of muscle fibers (after Strong Management of the Cleft Palate Facial Plastic Surgery Clinics Feb 2001)

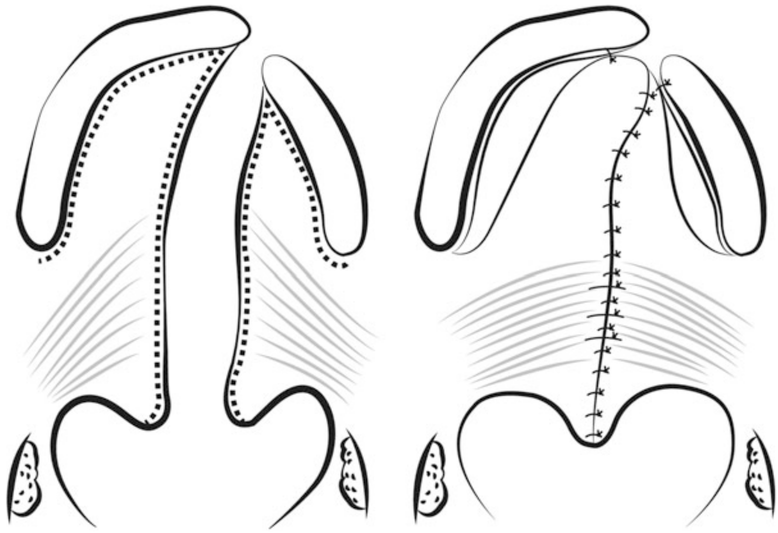

Fig. 14.5 Two-flap palatoplasty. *Left image*: Incision design for posteriorly based pedicle (off greater palatine vessels). *Right image*: Following elevation, mobilization and medialization of flaps for closure of cleft palate. Levator sling reconstituted in appropriate orientation (after Strong Management of the Cleft Palate Facial Plastic Surgery Clinics Feb 2001)

Fig. 14.6 Furlow (double-opposing Z-plasty) palatoplasty. *Leftmost image*: Incision design of opposing Z-plasties with cleft as central limb. Second image from *left*: Elevation of flaps—anteriorly based flaps are mucosa-only, while posteriorly based flaps are mucosa and palatal musculature. *Center image*: Incisions made through nasal mucosa. Second image from *right*: Nasal flaps transposed. *Rightmost image*: Transposition and closure of oral flaps (after Furlow Cleft Palate Repair by Double Opposing Z-plasty)

to posteriorly based pedicle; subperiosteal release of flap and release of muscle allow repositioning of musculature in transverse orientation; lengthen palate; preserve mucosa over primary palate with bilateral posteriorly based unipedicled flaps (Fig. 14.7).

Complications of Palate Repair

- Velopharyngeal Dysfunction—most common complication following palatoplasty; lower rates seen with double-opposing z-plasty than with other methods; abnormal orientation and insertions of LVP must be corrected to achieve appropriate functioning of soft palate following CP repair
- Fistulization can occur at varying rates depending on type and severity of cleft; sites of fistulization typically are the anterior hard palate and the junction of the hard and soft palate (**most common**)
- Airway problems following palatoplasty can occur as a result of tongue and FOM swelling (commonly due to relative hypoperfusion due

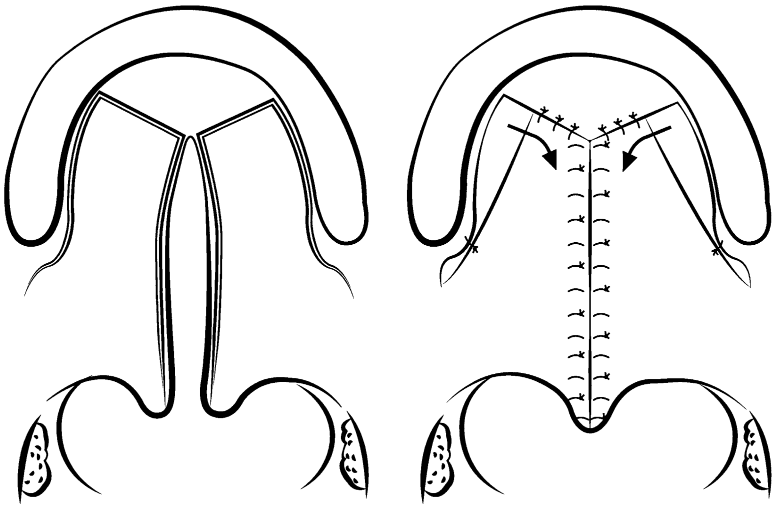

Fig. 14.7 V-Y (three-flap) palatoplasty. *Left image*: Incision design with right and left posteriorly pedicled flaps. *Right image*: Elevation, mobilization, medialization, and posterior advancement of flaps result in closure of defect and posterior lengthening of palate (after Strong Management of the Cleft Palate Facial Plastic Surgery Clinics Feb 2001)

to Dingman retractor or other retractor-exerted pressure → released every 30–45 min to decrease risk of post-op swelling); most likely to occur in children with Pierre Robin sequence

- Bleeding—minimized with infiltration of epinephrine solution and appropriate tissue-handling; exposed areas should be covered after repair with absorbable hemostatic material (e.g., avitene, surgical) to promote healing and hemostasis

Velopharyngeal Dysfunction

Velopharyngeal Inadequacy—inability to fully close VP during speech or swallowing

- VP **Insufficiency**—structural, seen with cleft palate
- VP **Incompetence**—neurologic dysfunction
- Causes: previously repaired (inadequate lengthening of the velum at the time of primary palatoplasty and abnormal function of the levator musculature and cicatricial contracture of the velum) or unrepaired CP is the most common cause of VPI; SMCP, neurogenic VPI, iatrogenic VPI following maxillary resection, UPPP, or adenoidectomy
- Dx: speech evaluation/assessment of nasal/non-nasal phonemes; mirror exam—fogging during speech when held under nares; nasal endoscopy during phonation provides visualization of the velum, assessment of lateral pharyngeal walls and posterior pharynx during attempted VP closure; video fluoroscopy
- Configuration of VP closure: can impact choice of surgical intervention; coronal (most common) > sagittal > circular
  - **Coronal**—closure mainly due to action of velum in anterior-to-posterior direction
  - Sagittal—closure due mainly to medial motion of lateral pharyngeal walls
  - Circular (± contribution by Passavant's ridge)—closure relies on combination of both A-P and medial/lateral motion for complete closure

Treatment of VPI

Treatment decision made jointly by surgeon, SLP, and dentist/prosthodontist.

Speech Therapy

- Initial treatment indicated for children with mild VPD → aggressive speech Tx for 6 months, failure to improve with 6–12 months of speech therapy may indicate need for surgical intervention; with improvement → long-term aggressive speech therapy focused mainly on articulation
- Not successful in remediating structural defects and surgical tx should not be delayed in these cases, e.g., children with VPD and nasal regurgitation secondary to obvious palatal abnormality such as a partial soft palate cleft or SMCP
- Children with good articulation may be candidates for prompt surgery if no VP closure manifested on nasal endoscopy with appropriately articulated phonemes

Surgical Therapy

Surgery preferred for long-term management in children. Patients with structural causes of VPD or persistent VPD after speech therapy should be considered for surgical intervention.

- **Intravelar veloplasty**—reorientation of inappropriately oriented LVP sling with three-layer closure and reapproximation of (attenuated) muscle fibers in midline
- **Furlow (Double-Opposing Z-plasty) Palatoplasty**—increasingly popular, reorients LVP, lengthens, thickens palate, and provides bulk in posterior VP; if VPD persists, sphincter pharyngoplasty can be performed; also used for primary closure of CP, repair of SMCP, or as a secondary procedure if the LVP longitudinally oriented; **sagittal** closure with VP gap of greater than 9 mm
- **Pharyngeal flap**: permanent, central, passive obturator; brings posterior wall tissue to center of VP; relies on adequate function of lateral pharyngeal closure for full velopharyngeal closure; superiorly based flap more common
  - Most common complications: bleeding, airway obstruction (first 24 h following surgery); late complication: OSA, cor pulmonale, flap breakdown, nasal obstruction, and aspiration (associated with post-op hemorrhage)
  - VCFS—**pre-op angiography** should be obtained to evaluate course of carotid arteries as these patients can have a medial retropharyngeal course leading to significant intraoperative hemorrhage if unrecognized
- **Sphincter pharyngoplasty** (dynamic sphincter pharyngoplasty, orticochea): narrows VP, decreased risk of postoperative airway obstruction; bilateral myomucosal flaps elevated from lateral pharyngeal wall/posterior tonsillar pillar wall and sutured to posterior NP wall to obturate the posterior and lateral portions of the VP; presence of adenoids may limit superior extent of flap placement → low adenoidectomy ~6 weeks prior to sphincter pharyngoplasty; inset of flaps should be as high as possible (at or above the level of anticipated closure) to maximize function and minimize residual VPD and passive obstruction while in supine position (snoring common after sphincter pharyngoplasty); appropriate for correction of **coronal** and **circular** patterns of closure
- **Posterior wall augmentation**: filler or graft provides bulk near Passavant's ridge to aid in VP closure; suitable technique in child with small posterior midline gap causing VPD

Prosthetic Therapy

- Obturators—can be used if patient is poor candidate for surgical repair
  - Palatal lift prosthesis pushes palate up and back to contact pharyngeal wall
  - Speech bulb prosthesis—with movement, walls of VP contact obturator

Treatment of Alveolus/Bone Grafting

Alveolar bone grafting should occur during the period of mixed dentition; performed to restore normal architecture of maxillary arch and closure of oronasal fistula (if present, done prior to eruption of adult canine); secondary bone grafting allows eruption of permanent teeth (specifically lateral incisor and the canine) and provides base for subsequent correction of nasal deformity, orthognathic and orthodontic tx (including endosteal implant). Fresh, autogenous, cancellous bone is ideal source because it supplies living, immunocompatible osteocytes that integrate fully with maxilla and are indispensable for osteogenesis. Grafting of alveolar bone defect has become standard of care at most cleft centers. Presence of bone in cleft creates odontotrophic milieu facilitating eruption of teeth into cleft and allowing movement of teeth into cleft → dental aesthetics are enhanced by improvement of dental and gingival alignment.

Timing of Alveolar Repair

- Dental age/stage of dentofacial development more important than chronological age
- Done as early as possible without causing deleterious effects on growth of maxilla or damage to tooth buds
- Root of permanent canine provides a guide to timing of therapy: should be formed 1/3–1/2 of definitive length at the time of graft placement (usually occurs sometime btw age 7 and 11 years old)
- Primary grafting: usually done before or during palatoplasty; has potential to inhibit midface growth, less common
- Secondary grafting: performed after CP repair; **early** (if done <2 years old, may cause growth disturbances), **intermediate** (favored, during mixed dentition), or **late**
  - Late grafting performed after exposure of cementum can lead to root absorption and ankylosis of teeth, predisposing to tooth loss and complicating later orthodontic management; graft resorption is also increased in grafts placed after eruption of teeth adjacent to the cleft

Source of Grafting Material

- Allogeneic bone (treated homologous bone)
- Alloplastic materials—calcium phosphate based, eliminates donor-site morbidity
- Autologous bone grafts considered gold standard because it provides osteogenic cells and osteoinductive factors; rapid incorporation, better dental support, resistance to infection; cancellous bone is preferred over cortical bone as it is more resistant to infection and undergoes less resorption
- Iliac crest: major source of grafting material but postoperative gait disturbances can be seen
- Alternative sources: cranium/calvarium, tibia, mandibular symphysis, rib (used for primary grafting in Rosenstein protocol)
- Bone Morphogenetic Proteins (BMPs)—recombinant BMP-2 in a soluble collagen matrix applied to alveolar cleft defect
  - May be useful in skeletally mature patients with unilateral alveolar clefting; improved bone growth as compared to control group in this population
  - When performed in mixed dentition results are similar to autologous grafts

Correction of Secondary Defects

Secondary defects following correction of unilateral or bilateral cleft lip and palate are generally the rule rather than the exception and can be more complex than the initial defect. Age at the time of correction is key in decision-making process and largely based on severity of deformity; psychosocial effects must be considered, secondary procedures to correct speech or swallowing/feeding difficulty should be performed regardless of age; most commonly—preschool age (4–5 years old) or early adolescence; cessation of facial growth is another critical factor in timing of repair.

LIP—assessment in repose and during dynamic function; secondary defects classified as major/minor based on anticipated repair, i.e., if primary repair needs to be taken down to correct secondary defect; **secondary deformity of vermilion and cupid's bow are most common secondary deformity** following primary CL repair.

Deformities of Vermilion—misalignment or peaked appearance of vermilion may be due to short vertical dimension of lip; mild deformities common in early period following rotation-advancement; early massage may be useful, if persistent for >1 year → surgical tx

- **1–2 mm Vermilion misalignment → diamond-shaped excision** of scar and closure which increases length of scar and brings vermilion border down
- >**3 mm—**problem is likely related to **inadequate rotation at the time of initial repair**: in these cases the repair should be taken down and rotation-advancement should again be performed
- Misalignment of vermilion-white roll is noticeable even if less than 1 mm: in these cases, a small Z-plasty can be designed to correctly align these structures
- Deficient vermilion may be due to overaggressive mucosal resection at the time of initial repair or due to inadequate muscle alignment at the time of primary repair
- **Whistle deformity**—mild deformities corrected with V-Y advancement (V apex towards sulcus carried through vermilion and orbicularis, incision carried to mucocutaneous junction, V-shaped flap then advanced to augment vermilion); vermilion augmentation with grafting materials (e.g., autologous fat) also an option but may be limited in patients with significant scar contracture
- Vermilion Excess: imprecise alignment at initial repair, treated by direct excision and closure

Other Secondary Deformities:

- Mucosal deficiencies—can consider buccal mucosal graft, especially in sulcus
- Short Lip—Z-plasty for mild defects; if orbicularis discontinuity exists (dx—have patient pucker his/her lips → visible bulge adjacent to cleft repair), must take lip down and reapproximate muscle; medial dissection should not extend past midline to avoid obscuring natural philtral dimple
- Tight Lip—relative underprojection of upper lip; especially following closure of wide cleft; if severe can consider **Abbe cross lip flap**
- Wide Lip—results from excessive width of initial design and more common in bilateral cleft lip repair; corrected by excising excessive portion along prior scar; reconstructed philtrum has tendency to stretch over time and should not be made wider than 4–5 mm initially to avoid **post-cleft repair wide philtrum**

Questions

1. **What ethnic group is most at risk of developing cleft lip and palate? Least at risk?**

   Native Americans are the ethnic population at highest risk for the development of cleft lip and palate. African-Americans have the least risk.

   Overall incidence: 3.6/1000 in Native Americans, 2.1 per 1000 in Asians, 1 in 1000 in Caucasians, 0.41/1000 in African-Americans.

2. **How does gender affect the likelihood of cleft lip with or without palate? Cleft palate in isolation?**

   Males are more likely to develop cleft lip with or without palate (1.5:1 males:females).

   Females are more commonly affected by isolated cleft palate (2:1 females:males). This is thought to be due to later fusion of the palatal shelves in females.

3. **What is the likelihood of cleft palate in the next child in normal parents with one**

affected child (assuming no other relatives are affected)?

2 %; see Table 14.1 for likelihood of next child having cleft lip or palate based on the number of previously affected relatives.

4. **What are some of the issues facing children with Pierre Robin sequence? Why is ophthalmology referral warranted in these patients?**

   Management of the airway is critical in patients with Pierre Robin sequence. Due to the retro-positioned nature of the tongue, airway collapse at the pharyngeal level is common. This can oftentimes be managed by prone or lateral positioning, however these children may need further surgical intervention that may include glossopexy, tracheotomy, or mandibular distraction osteogenesis.

   Due to the high occurrence/association of Pierre Robin sequence with Stickler syndrome, these children should be evaluated at an early age by ophthalmology to rule out any retinal or ocular pathology.

5. **Why are children with Shprintzen syndrome at particular risk during pharyngeal surgery, especially during a pharyngeal flap? What should be ordered prior to surgery?**

   Shprintzen syndrome or velocardiofacial syndrome results from an interstitial deletion of chromosome 22. It is associated with a medial course of the carotid artery and significant bleeding can result during pharyngeal surgery if this goes unrecognized prior to surgery. Preoperative angiography or alternative radiographic means of identifying the course of the carotid artery should be sought prior to proceeding with surgery in this setting. Additionally, patients with VCF tend to be at higher risk of developing VPI following adenoidectomy.

6. **What gene plays a role in van der Woude syndrome and popliteal pterygium syndrome? How do these two syndromes differ?**

   Interferon regulatory factor gene (IRF6) is the gene thought to play a role in both syndromes.

   Van der Woude—most common syndrome associated with CL ± P; findings include lower lip pits/sinus tracts, hypodontia, autosomal dominant inheritance.

   Popliteal pterygium syndrome—findings similar to van der Woude syndrome with lower lip pits and absent or missing teeth. Additional findings include syndactyly, genital abnormalities, intraoral adhesions (syngnathia), pyramidal skin on hallux, ankyloblepharon.

7. **Describe the adult derivatives of the frontonasal prominence, nasal placode, and maxillary prominence? Failure of fusion between what structures causes cleft lip? What is the cause of primary cleft palate? Secondary cleft palate?**

   Frontonasal prominence derivatives: nasal dorsum, forehead, and septum.

   Nasal placode: gives rise to the medial and lateral nasal processes. Structures derived from the lateral nasal processes include the nasal alae and sidewalls. The medial nasal processes fuse and form the intermaxillary segment that forms the primary palate. Failure of fusion of the medial nasal processes results in a midline cleft lip. Additional structures derived from the medial nasal processes are the philtrum, medial upper lip, nasal tip, and columella. The maxillary prominences give rise to the lateral upper lip.

   Failure of fusion between the medial nasal processes and maxillary processes gives rise to cleft lip. Failure of fusion between the intermaxillary segment and the maxillary processes causes primary cleft palate. Secondary cleft palate results from failure of fusion of the palatal shelves (derived from lateral maxillary processes) in the midline, posterior to the incisive foramen.

8. **How does the anatomy of the orbicularis muscle and superior labial artery differ from normal in a unilateral and bilateral cleft lip deformity?**

   In the unilateral cleft lip deformity, the orbicularis muscle is abnormally attached to the alar base and anterior nasal spine *resulting in abnormal displacement of these structures. In the bilateral deformity, the orbicularis muscle is poorly formed in the central, pro-labial segment, while the lateral insertion onto the alar base is similar to that seen in the unilateral cleft lip deformity.*

The anatomy of the superior labial artery in unilateral cleft lip deformity is altered in that it travels parallel to the lateral aspect of the cleft and arborizes with branches of the angular artery. The arterial supply in the central pro-labial segment is tenuous and stems largely from the columellar, septal, and palatine blood supply.

9. **Describe the unilateral and bilateral cleft nasal deformity.**

   Unilateral cleft nasal deformity: The cleft alar base is displaced ***inferiorly, laterally, and posteriorly*** *due to maxillary insufficiency and action of the orbicularis (as above), the caudal, and inferior septum is deviated to the non-cleft side, and the upper and posterior portions of the septum deviate to the cleft side. Additionally, the cleft side may have inferior turbinate hypertrophy.*

   Bilateral cleft nasal deformity: characterized by a poorly projected nasal tip with a wide alar base, alar bases that are positioned similarly to unilateral CL due to pull of abnormally inserting orbicularis oris and bilateral absence of maxillary segment → posterior, lateral, inferior displacement; extremely short columella and the medial crurae are displaced into the prolabium; the prolabium and premaxilla can be significantly anteriorly displaced with poor overall blood supply; nasal tip is broad and flattened and the nasal domes are separated resulting in a bifid appearance.

10. **What are the stages of rhinoplasty to correct the unilateral cleft nasal deformity?**

   Primary, intermediate and definitive—primary involves separation of LLC from overlying skin with advancement and positioning closer to non-cleft dome. This is usually secured by bolstering the LLC in position following undermining and repositioning. The intermediate stage is performed prior to completion of growth and leads to further refinements in anticipation of definitive septorhinoplasty, usually performed after growth is complete to correct residual defects of the septum, and nasal configuration. See text above for further details.

11. **Describe the steps in the Millard rotation-advancement repair of the unilateral cleft lip deformity**

   Methylene blue is used for skin marking. The rotation flap incision is made first (point 3 → 5 with back-cut to x as needed) and is taken through entire thickness of orbicularis and oral mucosa to allow for complete release. The c-flap remains and may be used to add additional height to the columella. The advancement flap starts with incision from point 8 → 9 and this incision is then continued along the alar base. The gingivolabial sulcus is also incised and incisions are taken down to face of maxilla. Bilateral undermining assists in closure and the first deep-stitch reapproximates the orbicularis muscle at the back-cut. The second stitch is placed at the vermilion. The mucosal, muscle, and skin closure follows

12. **What is the treatment for unilateral complete CP? Bilateral CP? Secondary cleft palate? Submucous cleft palate?**

   See text for full discussion of these techniques.

   Unilateral and bilateral complete: two-flap palatoplasty.

   Secondary cleft palate: V-Y pushback/three flap.

   Submucous cleft palate: Furlow double-opposing Z-plasty.

13. **What is the most common complication following cleft palate repair?**

   Velopharyngeal dysfunction.

14. **How does velopharyngeal closure affect the choice of surgical repair in velopharyngeal dysfunction?**

   See text for full discussion of each technique.

   Coronal—sphincter pharyngoplasty is generally preferred.

Sagittal closure—Furlow double-opposing Z-plasty is preferred method.

Circular—sphincter pharyngoplasty preferred method.

15. **What is the purpose of alveolar bone grafting in the cleft deformity? Should this be done before or after intermediate rhinoplasty to correct the nasal deformity?**

    Alveolar bone grafting is performed to restore normal architecture of the maxillary arch and closure of oronasal fistulae (if present, repair should be done prior to eruption of adult canine tooth); secondary bone grafting allows eruption of permanent teeth (specifically the lateral incisor and canine) and provides a base for subsequent correction of nasal deformity, orthognathic and orthodontic treatment.

16. **What are the three abnormal attachments of the levator veli palatini muscle in the cleft palate deformity?**

    The levator veli palatini has abnormal insertions to the posterior aspect of the hard palate, superior pharyngeal constrictor, and tensor veli palatini aponeurosis. This is seen in clefts of the secondary palate and in patients with submucous clefting.

17. **When should primary repair of the cleft lip be performed? What is the "rule of 10s"?**

    Cleft lip repair is usually done at approximately 3 months of age. It follows the rule of 10s—10 weeks old, hemoglobin 10 g/dL, weight 10 lb; partially based on anesthetic safety.

18. **When should repair of the cleft palate be performed? Why is the timing of repair important?**

    Development of normal speech is a primary concern that dictates the timing of repair (usually done at ~12 months) Repair before 18 months of age has resulted in improved speech outcomes.

19. **Describe naso-alveolar molding? What are alternatives to NAM?**

    Naso-alveolar molding (NAM) is a process that involves molding and repositioning of the alveolar processes, nasal cartilages, and lengthening of deficient columella to create lasting aesthetic outcome and reduces need or minimizes the extent of secondary surgical revision procedures.

    Alternatives include lip adhesion procedures, taping, and the Latham appliance.

20. **Describe the arterial supply of the soft palate.**

    The soft palate is supplied by the ascending palatine (facial artery), greater palatine (internal maxillary), ascending pharyngeal branch, and contribution of lesser palatine (branch of greater palatine).

21. **Why do infants with cleft lip and palate have difficulty feeding? What can be done to overcome some of these difficulties?**

    Oral intake can be compromised as a result of inability to feed (sucking mechanism impaired—child is unable to form a seal due to incomplete muscular sphincter and/or escape of air through cleft palate). A variety of feeding devices are available to assist in feeding a patient with cleft lip and palate such as the ***Mead-Johnson, Haberman, or Pigeon*** *to facilitate feeding. Feeding can also be done in the upright position. Additionally, cleft patients tend to swallow more air and may require frequent burping.*

22. **How is the secondary tight lip treated? What predisposes to this secondary defect?**

    The secondary tight lip often results from correction of wide cleft lips and during the healing process, the pre-morbid absence of tissue leads to an underprojected lip after repair. In severe cases, this can be treated with an Abbe cross lip flap.

23. **What is the whistle deformity? How is it treated?**

The whistle deformity is a secondary deformity that may result following the repair of unilateral or bilateral cleft lip and palate repair. It is characterized by central deficiency of the vermilion that leads to a shortened vertical height and the characteristic appearance of the upper lip seen with the deformity. Mild deformities may be corrected with V-Y advancement (V apex towards sulcus carried through vermilion and orbicularis, incision carried to mucocutaneous junction, V-shaped flap then advanced to augment vermilion); vermilion augmentation with grafting materials (e.g., autologous fat) is also an option but may be limited in patients with significant scar contracture.

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15 Craniofacial Anomalies

Eugenia Chu

Embryology

- Embryonic period: first 8 weeks' gestation, fetal period: ninth week to birth
- Embryonic period divided into 23 stages based on Carnegie system
- Ectoderm: cutaneous and neural systems
- Endoderm: lining of epithelium of digestive and respiratory systems, secretory cells of liver and pancreas
- Mesoderm: cardiovascular, connective tissues, bones and muscles
- Neural crest cells→mesenchyme→form majority of facial structures except: retina, lens, epithelial tissues, vascular endothelia, skeletal muscle

Face is first recognized at stage 9 (day 20): appearance of stomodeum, optic disc present

Development of the face is a result of disappearance of grooves and bulges which enlarge with proliferating mesenchyme, instead of the migration and fusion of distinct processes

Middle 1/3 of the face associated with changes in forebrain

Lateral and lower facial regions formed by maxillary and mandibular processes of the first pharyngeal arch (first pharyngeal arch: maxillary process-premaxilla, maxilla, zygoma; Meckel cartilage-mandible, incus, malleus)

Stage 11 embryo: stomodeum (surface ectoderm) invaginates→buccopharyngeal membrane (consists of ectoderm and endoderm) breaks down→primitive oral cavity

Stages 12 and 13: third and fourth pharyngeal arches are well developed; the forebrain broadens to form frontal prominence; the nasal placode develops as ectodermal thickening of frontal prominence

Stages 14 and 15: mesoderm surrounding nasal placodes leading to the formation of lateral nasal fold and medial nasal fold, the depression of the nasal placodes becomes olfactory pits; olfactory pits divide the frontal prominence into upper and lower parts

Upper part-primitive forehead

Lower part-future external nose

Maxillary prominence develops medially and contact medial and lateral nasal folds

Two medial nasal folds form and give rise to the intermaxillary segment=>philtrum upper lip and anterior portion maxilla

Nasolacrimal groove (future nasolacrimal duct): in between maxillary prominence and lateral nasal fold

*Controversial origin of NLD: some believe the nasolacrimal groove is completely eliminated and the NLD arises as separate entity vs. NLD is remnant of nasolacrimal groove

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Stages 17 and 18: formation of external nose begins, olfactory pits open into the roof of the mouth

Primitive oral cavity forms the palatal shelves, and mesoderm forms between medial nasal folds and maxillary process forms upper lip. Lateral nasal wall develops into the inferior turbinate, then middle, and superior.

Paranasal sinuses develop from lateral walls of nasal cavity later.

Stages 19–23: Mesoderm from second pharyngeal arch develops into facial muscles. Lateral to Meckel cartilage is where mandibular ossification occurs; the TMJ develops during this stage; mesoderm fills between nostrils which gives external nasal prominence, and epineural ectoderm from the roof of nasal cavity and this also gives rise to olfactory epithelium

Sinuses in order of development: Maxillary: first to develop in utero, biphasic growth at 3, then at 7 years old

Sphenoid: second to develop; evagination of nasal mucosa into sphenoid bone (age?)

Ethmoid: most developed sinus at birth

Frontal: develops after birth; 5–6 years old

Embryology of Skull

Mammalian skull has four bones: frontal, parietal, squamosal, anterior portion occipital bone

Cranial bones→intramembranous ossification→mesenchyme→differentiate into osteoblasts and deposit ECM

Cranial sutures: fibrous tissues uniting cranial bones; allow for expansion during brain growth, major growth center in the skull for first years of life

Sagittal suture: b/w paired parietal bones

Metopic suture: btw paired frontal bones

Coronal suture: btw paired frontal and sagittal suture

Lambdoid suture: btw paired parietal and interparietal bone

Anatomy

Layers of scalp: mnemonic SCALP

S: skin

C: subcutaneous tissue

A: aponeurosis and muscle (galea) (SMAS is continuation of galea onto the face) (temporoparietal fascia is thin lateral extension of the galea aponeurosis)

L: loose areolar tissue

P: pericranium

Blood supply: Main blood vessels run superficially in the galea→supratrochear, superficial temporal artery, supraorbital and terminal branches of the occipital artery, postauricular artery (occipital and postauricular arteries run deeply before arising superficially near the scalp)

Dental Occlusion

Angle Classification for Occlusion

Class I: maxillary first molar slightly back to mandibular first molar, "mesiobuccal cusp of maxillary first molar is in line with buccal groove of mandibular first molar"

Class II: maxillary first molar even with or anterior to mandibular first molar, "buccal groove of mandibular first molar distal to mesiobuccal cusp of maxillary first molar"; facial profile→ retrognathic

Division I: maxillary central incisors normal or slightly protruded toward lips

Division II: maxillary central incisions retruded toward the oral cavity

Class III: maxillary first molar is toward back of mandibular first molar; "buccal groove of mandibular first molar is mesial to mesiobuccal cusp of maxillary first molar; facial profile→ prognathic

Cross bite: abnormal relationship of one arch of teeth to the opposing arch of teeth; maxillary incisors lingual to opposing mandibular incisors

Overbite: greater than 1/3 vertical overlap of maxillary teeth over the mandibular anterior teeth

Overjet: horizontal overlap between labial surface of mandibular anterior teeth and lingual surface of maxillary anterior teeth

Syndrome: pattern of multiple anomalies, pathologically related and have common (suspected) cause

Craniofacial syndrome affects facial features; affected patients tend to look alike, even though they share no familial relationship, e.g., Down's syndrome

Sequence: anomaly or pattern of multiple anomalies that arise from a single known or prior anomaly; one anomaly occurs due to a pre-existing anomaly, e.g., Pierre Robin sequence=> U-shaped palate, glossoptosis, micrognathia; this sequences occurs due to interference in development of the mandible during gestation which causes the tongue to remain high in the oral cavity, which leads to disruption of the closure of the velum (causing palate defects)→ ultimately causing upper airway obstruction. The sequence is caused by the inciting event during mandible development.

Association: nonrandom occurrence pattern of multiple anomalies in two or more individuals that are not part of a syndrome or sequence; diagnosis of exclusion, pathogenesis of the association is unknown; the recurrence risk in association is no greater than the general population, e.g., VATER association (vertebral, anorectal, TE fistula, renal/limb anomalies)

Craniosynostosis

Premature fusion of one or more cranial suture lines

- Affects 1/2000–2500 births worldwide nonsyndromic (single suture)
- 1/30,000–100,000 syndromic (frequently multisutured)
- Etiology multifactorial: genetic, environmental
  - Genetic: Mutations in genes that affect mechanical force signaling pathways and cytokines that mediate cranial suture patency→**fibroblast growth factor receptor** (**FGFR**) and transforming growth factor (TGF-B)
  - FGFR 1,2,3 known to be involved in syndromic craniosynostosis
  - Environmental: multiple associations: paternal occupations with agriculture, forestry; maternal age; exposure to tobacco smoke
  - Medications: nitrofurantoin, warfarin use in pregnancy
  - Nutritional deficiencies: folic acid
  - Malpositioned fetus and intrauterine constraint
- Fused sutures typically cause restriction in skull growth, dysmorphic cranial vault, and facial asymmetry
- Due to Virchow law, when suture line is fused prematurely→growth perpendicular to the affected suture is disrupted→compensatory growth advances parallel to affected suture
- For example synostosis of sagittal suture: growth proceeds in anterior to posterior direction→leads to scaphocephaly. Synostosis of coronal suture: leads to growth in mediolateral plane resulting in brachycephaly
- Most common functional consequence reported: **increased intracranial pressure**
  - Higher ICPs seen in children with multiple suture involvement
- Indications for surgical intervention early in life: visual impairment, deafness, cognitive deficits
- Condition usually occurs as isolated condition, but can manifest in association with syndrome
- Sagittal synostosis most common type: seen in 40–55 % non-syndromic cases

- Coronal synostosis: second most common (20–25 %)
- Metopic synostosis: third most common (5–15 %); metopic suture line fuses as early as 3–6 months, and normally disappears (unlike other cranial sutures)
- Lambdoid synostosis: rare (0–5 %)
- More than one suture affected in 5–15 % cases
- Surgical intervention is the only treatment for the condition

Skull Deformities (Table 15.1)

Scaphocephaly: boat-shaped head, most common manifestation of sagittal synostosis; calvarial bone growth limited perpendicular to affected sagittal suture line→narrowing head transversely, brain grows anterior posterior→ leads to frontal bossing or occipital cupping

Trigonocephaly: forehead appears more triangular; metopic synostosis causes metopic ridging in the midline forehead or combo of ridging, bitemporal narrowing, and hypotelorism

Deformational plagiocephaly: flattening of the head; most common type of plagiocephaly is positional, when skull is subject to pressure usually due to supine positioning; congenital torticollis associated with condition; repositioning maneuvers used to keep babies off affected side; when severe flattening occurs beyond 6 months, helmets used to improve cranial asymmetry when used before 12 months

Anterior plagiocephaly: unilateral coronal synostosis; affected frontal bone is underprojected, contralateral frontal bone protrudes anteriorly, can push orbit inferiorly, leading to orbital asymmetry or vertical dystopia; superior orbital rim is elevated (harlequin eye); late-presenting synostosis can cause nasal deviation, and mandibular displacement

Posterior plagiocephaly: unilateral occipital flattening can be caused by deformational plagiocephaly or lambdoid synostosis; also presents with ipsilateral mastoid bulging, posterior inferior displacement of ipsilateral ear; deformational plagiocephaly causing posterior plagiocephaly much more common than lambdoid synostosis

Brachycephaly: bilateral occipital flattening; short head deformation; may be caused by supine positioning or bilateral coronal synostosis

Cloverleaf skull: fusion of all cranial sutures, except metopic and squamosal; causes brain restriction in multiple planes→characteristic bulging occurs across two opened sutures giving cloverleaf shape; this is most challenging craniosynostosis due to bony growth restriction and limited intracranial volume can lead to increased ICP and hydrocephalus; impaired vision common due to proptosis and orbital hypoplasia

Multidisciplinary team approach: Craniosynostosis is often part of syndrome and interdisciplinary team is involved to plan complicated care for these patients. Team usually involves plastic surgeon, pediatric otolaryngologist or facial plastic surgeon trained in craniofacial surgery, pediatric neurosurgeon, oral surgeon, pediatric anesthesiologist, pediatric intensivist, pediatric orthodontist, pediatric ophthalmologist, psychologist, geneticist, audiologist, speech pathologist, and general pediatrician

Timing of surgical procedures: Depends on factors including age of patient at initial presentation, presence or absence of increased ICP, upper airway obstruction, severity of deformities, and surgeon preferences. Most recommend surgical correction by 3–12 months (publications vary on this range, 6 months is most commonly reported as optimal age); this allows for children younger than 1 year to completely re-ossify and relies on the malleability of the calvarium during this age and the tremendous brain growth that occurs during the first year

The timing and sequence of synostosis surgery are usually determined by age. See Table 15.2

Table 15.1 Syndromic craniosynostoses chart

Syndrome	Genetics	Skull abnormality	Facial features	Related symptoms	Extremity features
Apert	FGRF2; Autosomal dominant; majority sporadic	Turribrachycephaly (top of the skull is pointed or cone shaped), acrocephaly, bitemporal bulging, sagittal synostosis, bilateral coronal synostosis, bilateral lambdoid synostosis	Orbital hypoplasia, hypertelorism, proptosis, downslanting palpebral fissures, beaked nose, midface hypoplasia, mandibular prognathism, high-arched palate	Mental retardation, intracranial hypertension, cerebral atrophy, wide subarachnoid spaces	Pansyndactylies of hands and feet
Crouzon	FGFR2, FGFR3 (acanthosis nigricans); AD, sporadic, familial	Acrocephaly, coronal, lambdoid, basilar synchondroses/ synostoses	Shallow orbit, orbital proptosis, hypertelorism, strabismus, beaked nose, maxillary hypoplasia, mandibular prognathism, high-arched palate, enlarged sella turcica, jugular foramen stenosis	Mental retardation Hydrocephalus, syringomyelia, intracranial HTN, optic atrophy	Usually not affected
Pfeiffer	FGFR2, FGFR1, AD; sporadic, familial	**Type 1:** Turribrachycephaly, bilateral coronal, frontosphenoidal synostoses **Type II**: Cloverleaf deformation **Type III**: Severe turribrachycephaly, bilateral coronal, frontosphenoidal, sagittal, metopic synostoses	Orbital proptosis, palpebral retraction, jugular foramen stenosis, midfacial hypoplasia, mandibular prognathism, high-arched palate, bifid uvula, aural atresia	Intracranial HTN, hydrocephalus, optic atrophy, mental retardation (types II–III), hearing loss, sleep apnea	Brachydactyly
Saethre-Chotzen	TWIST gene mut chr 7; AD, familial mostly; sporadic	Acrocephaly, plagiocephaly, scaphocephaly, unilateral coronal, b/l coronal, metopic, b/l lambdoid synostosis	Low-set frontal hairline, flat forehead, hypertelorism, eyelid ptosis, tear duct stenosis, high-arched palate, mandibular prognathism, angulated ears	Mental retardation, conductive hearing loss	Partial cutaneous syndactyly, some brachydactyly
Carpenter	RAB23 or MEGF8 mutation; AR	Sagittal and lambdoid synostosis	Downsloping palpebral fissures, low-set ears, short neck	Mental retardation (some), short height, obesity	Variable polysyndactyly, clindactyly, brachydactyly
Muenke	FGFR3 mutation; AD	Unilateral or bilateral coronal synostosis	Variable hypertelorism, midface hypoplasia, low-set ears, hearing loss	Normal intelligence	Carpal and tarsal fusions

Table 15.2 The timing and sequence of synostosis surgery are usually determined by age

Age	Procedure
3–6 months	Correction of craniosynostosis
1–2 years	Correction of syndactyly
4–5 years	Correction midface retrusion w/distraction techniques
4–6 years	Correction hypertelorism and turricephaly
>17 years	Orthognathic surgery (Le Fort I or III in conjunction with mandibular osteotomy to correct malocclusion

Main goals for surgical treatment: excising fused suture and normalizing calvarial shape to increase intracranial volume→avert potential sequelae of increased ICP

Surgical procedures include strip craniectomies and various cranial vault-remodeling techniques

Delay in correcting craniosynostosis results→deformity of cranial base, facial asymmetry, dental malocclusion

Distraction osteogenesis: typically used for monobloc, posterior cranial vault, or midface distraction; performed by external or internal distracters; osteotomies are made with open approach, distracters placed, bone segment advanced slowly over days to weeks, allows soft tissue to stretch over time; particularly useful for syndromic patients with brachycephaly where adequate advancement is difficult to achieve through conventional surgery

Surgical Treatment of Sagittal Synostosis

Simple strip craniectomy (suturectomy): this procedure largely abandoned unless done concomitant with spring assistance or postoperative molding helmets; recent authors advocate for use of minimally invasive suturectomy which decrease hospital stay, and intraoperative bleeding and reoperations.

Complications of surgery: infection, optic nerve ischemia, seizures, bleeding, need for frequent blood transfusion, mortality rate 1.5–2 %.

Endoscopic assisted strip craniectomy with wedge craniectomy: more modern technique; can be done in patients presenting at 3–6 months and for less severe deformities. Total cranial vault reconstruction is recommended at age 9–12 months for patients who present later than 6 months or have severe deformities. Two-stage procedure often advocated when occipital and frontotemporal deformities present, first surgery done at 3–6 months, second surgery at 12 months.

Pi procedure: aka squeeze procedure; two parasagittal craniectomies performed with transverse craniectomy; used to shorten the skull in AP direction and squeeze the brain in the AP direction; bone grafting parasagittaly adds to increased biparietal width. Postoperative molding helmeting is required unless spring utilized.

Fronto-orbital advancement with reshaping: keystone procedure in trigonocephaly reconstruction in unilateral and bilateral coronal synostosis; procedure advances the unilateral or bilateral flattened superior orbital rim anteriorly and secure it in place; this construct, “bandeau,” becomes the foundation of the remainder of the cranial vault; the supraorbital/supratrochlear neurovascular bundles are released from their bony notches; once the osteotomies are made, the bandeau is reshaped; for hypertelorism, the bandeau may be divided in the midline and small bone graft is placed; often bone grafts are placed as struts along supraorbital bar to reinforce and minimize relapse or secondary deformities.

Posterior synostotic plagiocephaly treatment: lambdoid synstosis repair is done similar to coronal synstosis reconstruction; occipital bar is advanced posteriorly in the area of flattening, the occipito-parietal region is reshaped to achieve symmetry posteriorly; bone flap is secured with absorbable plates and screws; protective helmet needed to prevent relapse due to supine positioning

Questions

1. The face is first recognized by the appearance of what embryologic structure?
   (a) Nasal placode
   (b) Maxillary process
   (c) Stomodeum
   (d) Palatal shelve
2. What paranasal sinus is known to develop first in utero?
   (a) Maxillary
   (b) Sphenoid
   (c) Ethmoid
   (d) Frontal
3. A patient presents with an overbite. Describe their angle classification with relationship to the maxillary molar to mandibular molar.
4. What gene mutation is most responsible for most syndromic craniosynostosis
   (a) TWIST
   (b) FGFR
   (c) Myc
   (d) P53
   (e) Ret
5. At what age is repair of craniosynostosis best performed
   (a) 1 month
   (b) 15 months
   (c) 6 months
   (d) 24 months
6. In what syndromic craniosynostosis is a cloverleaf skull deformity most likely to be observed?
   (a) Apert
   (b) Crouzon
   (c) Pfeiffer type I
   (d) Pfeiffer type II
7. Describe options for treatment management of sagittal synostosis. What is the significance of the "bandeau"?
8. The most common functional consequence of craniosynostosis is?
   (a) Increased intracranial hypertension
   (b) Impaired vision
   (c) Mental retardation
   (d) Respiratory insufficiency
9. Posterior plagiocephaly is most commonly caused by?
   (a) Supine positioning
   (b) Lambdoid synostosis
   (c) Metopic synostosis
   (d) Sagittal synostosis
10. What skull deformity is most commonly seen in sagittal synostosis?
    (a) Anterior plagiocephaly
    (b) Brachycephaly
    (c) Trigonocephaly
    (d) Scaphocephaly
11. Describe indications for the use of distraction osteogenesis in the treatment of craniosynostosis

Otoplasty

16

Colleen Perez

Basic

Anatomy

The **auricle** lies between horizontal lines drawn from the upper rim of the orbit and nasal spine. The helical border terminates anteriorly in a crus radix, which lies horizontally above the external auditory meatus. The **antihelix** crowns the posterior conchal wall and separates and diverges into a superior and anterior crus that encloses the **triangularis fossa**. The **scaphoid fossa** is a long, deep furrow that lies between the helix and the antihelix. The conchal cavity is composed of a superior **cymba concha** and an inferior **cavum concha**, approximately 8 mm deeper than the overlying **tragus** and **antitragus**. The inferior tip of the helical cartilage is the cauda or tail. The **lobule** extends inferiorly from the cauda and is devoid of skeleton (Fig. 16.1).

The ear is covered on both sides by a thin, firm, adherent layer of perichondrium. The anterior lateral surface of the cartilage is covered with a fine, thin skin that adheres closely to the cartilaginous framework. Subcutaneous tissue is practically nonexistent; however, a diffuse subdermal vascular plane exists that supports flap viability. The posterior surface of the cartilage framework is draped with a less adherent skin that contains two layers of fat and a larger subdermal plexus of arteries, veins, and nerves (Fig. 16.2a).

Arterial supply: Two main branches of the external carotid artery—superficial temporal artery (STA) and the posterior auricular artery (PAA). STA emerges from the parotid capsule 1 cm in front of the ear deep to the veins and below the anterior auricular muscle. It gives off the superior, medial, and inferior branches that supply the anterior and anterolateral surface of the auricle. PAA supplies the posterior surface and travels parallel to the postauricular crease upward and crosses below the great auricular nerve and under the posterior auricular muscle.

Venous drainage: Complementary veins into the external jugular vein.

Lymphatic drainage: Three surrounding areas via the complex and extensive fine network of lymphatic vessels.

Innervation: Sensory supply—lesser occipital, auriculotemporal, vagus (Arnold's nerve), anterior and posterior branches of the great auricular nerve (travels 8 mm posterior to the postauricular

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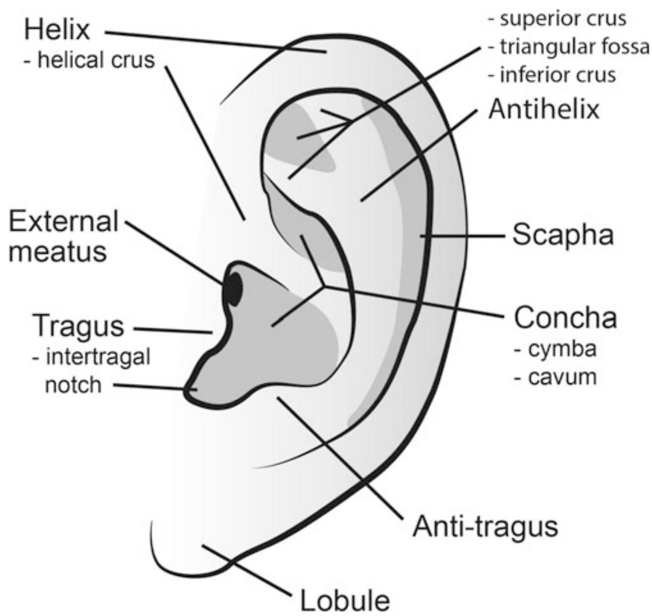

Fig. 16.1 External ear anatomy

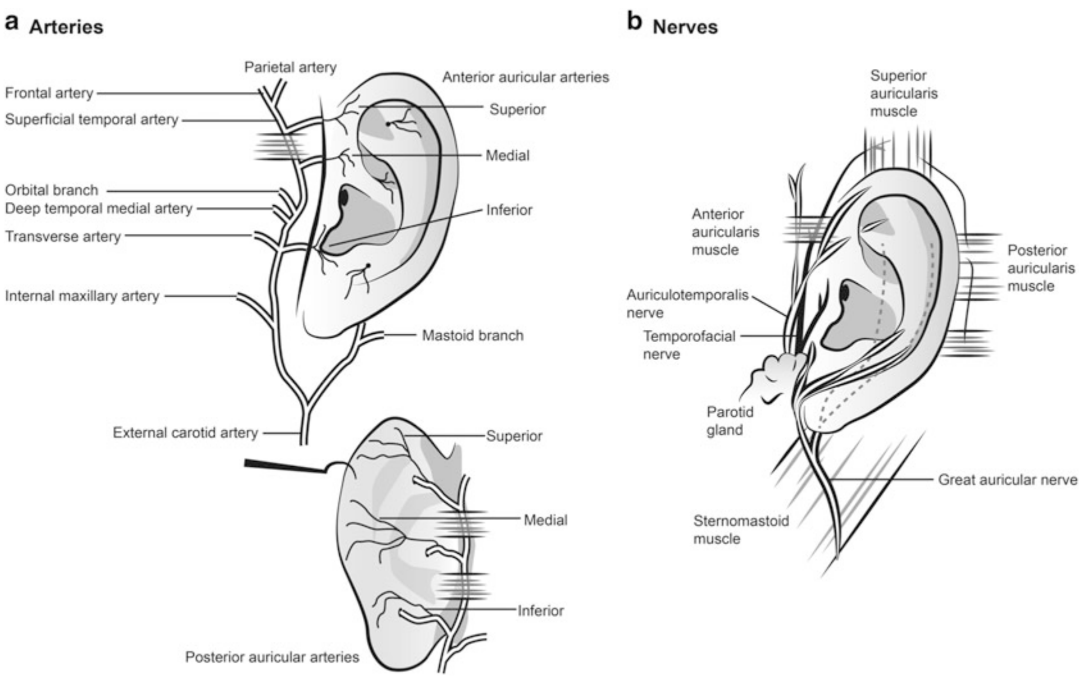

Fig. 16.2 (**a**) Arterial blood supply to the ear. (**b**) Nerve supply to the ear

crease). Motor supply—facial nerve (variable among individuals) (Fig. 16.2b).

Regional anesthesia of the auricle is readily accomplished by instilling anesthetic solution along its base anteriorly and posteriorly. Supplemental anesthesia may be needed at the posterior wall of the external auditory meatus supplied by the auricular branches of the vagus nerve (nerve of Arnold).

Structural support: Auricular cartilage is a single piece of yellow (elastic) fibrocartilage with a complicated relief on the anterior, concave side and a smooth, posterior side. The cartilage thickness is uniform throughout.

Embryologic development of the ear:

- Third week of intrauterine growth: Otic placode is present
- Fifth week of gestation: three hillocks (hillocks 1, 2, and 3) arise on the first branchial (mandibular) arch, and three (hillocks 4, 5, and 6) arise on the second branchial (hyoid) arch on either side of the first branchial cleft. The auricle emanates from the mesoderm of the first and second branchial arches.
  - The following six structures evolve from these hillocks: (1) the tragus, (2) the helical crus, (3) the helix, (4) the antihelix, (5) the antitragus, and (6) the lobule.
- Week 12: the hillocks have fused. The concha derives from the ectoderm of the first branchial groove. There is a transient obstruction of the medial canal by proliferating epithelial cells to form a meatal plug that eventually dissolves, leaving a patent canal.
  - Lack of formation of the antihelix between the 12th and 16th week of embryonic life is a congenital hereditary autosomal recessive malformation that results in a prominent ear.
- Age 3: 85 % of ear development complete
- Age 7–8: nearly fully grown. Ear growth continues into adulthood, but width and distance of the ear from the scalp change little after age 10.

Relationships and Angles

- Concho-mastoid angle is approximately 90° (Fig. 16.3a).
- Scapha-conchal angle is a 90° angle formed as the antihelical fold (Fig. 16.3a).
- Auriculocephalic angle is these two angles in combination with the curvature of the helix which set the auricle adjacent to the scalp at approximately 25–35°.
- The helical rim should be seen just lateral to the most lateral presence of the antihelix from

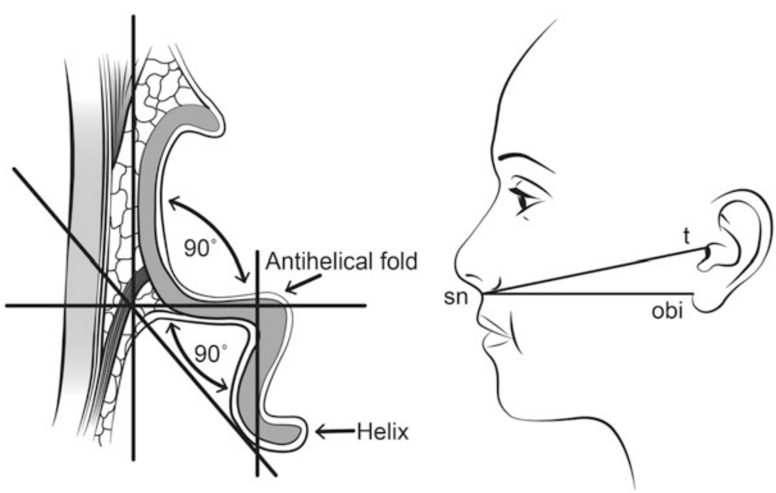

Fig. 16.3 (**a**) Concho-mastoid and scapha-conchal angle, (**b**) Horizontal ear position

the frontal view. The distance measured between the helical rim and the scalp over the mastoid area is slightly less than 2 cm. The distance between the scalp and the uppermost aspect of the helix is approximately 1 cm. Vertical height is approximately 6 cm and horizontal length is 3.3–3.9 cm.

- Horizontal position is measured anthropometrically with the head oriented in the Frankfort horizontal plane and is determined by the distance between the tragion (t) and the subnasale (sn) if the ear canal is preserved or between the otobasion inferius (obi) and the subnasale if the ear canal is atretic.
- Ear inclination can be measured anthropometrically in the sagittal plane with the head positioned in the Frankfort horizontal plane. It is determined by the angle formed by the longitudinal axis of the ear (connecting the highest and lowest points) and the true vertical (Fig. 16.3b). Ideal angle is 24.8° and the angle between the axis of the ear and the bridge of the nose is 14.9°. The glenoid fossa of the mandible lies deep to the preauricular area, and joint problems may manifest as ear pain.

Assessment: Examine the external auditory canal and tympanic membrane with the otoscope and do tuning fork tests to rule out ear pathology, particularly important in patients who complain of hearing changes in association with temporomandibular joint symptoms. An audiogram may be indicated if hearing loss is suspected. Preoperative photography is important and should always be performed, including frontal, full right and left oblique, full right and left lateral, and close-up right and left lateral views.

Deformities

Lop ear: lid-like turning down of the helix characterized by reduced vertical height, reduced fossa triangularis, reduced scapha, and reduced or absent superior crus of the antihelix.

Stahl (satyr/vulcan) ear: pointed ear characterized by an abnormal folding of the skin and cartilage of the pinna, with a pointed upper edge rather than a rounded upper edge.

Shell ears: characterized by underdeveloped helical rims.

Cauliflower ear: deformity characterized by repeated trauma and often a history of auricular hematomas not drained. Results from ischemia and necrosis of the underlying cartilage followed by fibrosis and tissue formation and scarring. Often seen in boxers or wrestlers.

Prominauris: two major deformities account for most abnormalities of protruding ears (individually or in combo): (1) poorly developed antihelical fold, which can involve the superior and anterior crura, and eliminates a definition between the conchal cavity and scapha that results in the lateral projection of the upper portion of the helix, and (2) formation of excessive conchal cartilage, particularly in the posterior conchal wall, causing significant protrusion of the auricle. Other deformities include a protruding earlobe, irregularities along the helix (including an unrolled margin of the helical rim), and an anteromedially displaced insertion of the postauricular muscle.

Microtia

– *Grade 1*: the external ear is small and the auricle retains most of its normal structure, external auditory meatus usually present.
– *Grade 2*: the external ear is moderately anomalous. The auricle can be hook-, S-, or question mark shaped in appearance.
– *Grade 3*: the external is a rudimentary soft tissue structure with no cartilage, the auricle does not have a normal appearance.
– *Grade 4*: anotia (complete lack of the external ear).

Surgical Principles

Optimal outcome is achieved by recognizing the defect and choosing the correct surgical technique.

Surgery is best performed when the patient is older than 6 years old, when the cartilage has reached adequate consistency and maturity. Adults may have less flexibility of the auricular cartilage, as well as some degree of calcification, which will render it brittle and make the operation more difficult.

In unilateral cases it is important to create a new auricle that is as similar to the normal one as possible in both size and auriculomastoid angle (greater than or equal to 12 mm from the surface of the mastoid process to the lateral border of the helix). The various methods include suture only, cartilage-splitting, cartilage-weakening, or a combination.

Davis method: Used for protruding ears caused by hypertrophic posterior wall of the conchal bowl. The height of the conchal wall that will remain is marked (leaving 8 mm of posterior conchal wall height), and the remainder of the conchal bowl to be excised is outlined (should be a "kidney bean" shape). The markings are transferred to the underlying cartilage with methylene blue tattooing. Local anesthesia is used for hydrodissection of the tightly adherent anterior auricular skin along the conchal bowl. The initial amount of skin to be excised in the postauricular crease is drawn in an elliptical fashion, just large enough to remove the predicted excess skin produced with retropositioning. The concha is exposed through the postauricular incision, and the cartilage is incised through the areas tattooed, leaving the anterior skin intact. A subperichondrial plane of dissection is developed and the cartilage removed, leaving the 8 mm of posterior conchal wall. The ear is placed passively onto the mastoid surface, and the new projection is inspected. Further cartilage or postauricular skin can be excised as needed. The underlying muscle and soft tissue are removed to the mastoid fascia. The ear is fixed in position with four mattress transfixion sutures of 3-0 silk, which go through-and-through and are tied over cotton dental rolls for compression. A cotton roll is placed in the ear canal to prevent stenosis. The postauricular incision is closed with absorbable suture, leaving a small opening inferiorly for drainage. The dressing is removed in 2 weeks.

Mustarde method (concho-scaphal suturing): Cartilage-weakening technique used for poorly formed or lacking antihelical fold. Commonly used with the Davis method. The scapha is folded back against the underlying scalp by pressing on the superior helical rim. The crest of the fold is marked, and marks parallel to the crest are made 7 mm apart to avoid creating too narrow of a fold. The lateral marks are tattooed through the skin and cartilage with methylene blue. Local anesthetic is injected along the scaphoid fossa and the anterior auricular skin. The postauricular skin is removed in an identical fashion as in the Davis method above. A small horizontal incision is made in the cartilage at the most inferior aspect of the new antihelical fold, and a Freer elevator is passed to dissect the anterior skin that corresponds to the crest of the new antihelical fold. The body of the new antihelical fold is weakened with forceps or a rasp to facilitate folding and remove inherent memory. Nonabsorbable horizontal mattress sutures (4-0 Mersilene) are placed by making passes through the medial perichondrium, cartilage, and lateral perichondrium. The anterior skin should not be included. Sutures are placed perpendicularly across the antihelical fold so that when tightened, a natural-appearing antihelical fold is created. A compression dressing is placed anteriorly and posteriorly of the scaphoid region and covered with gauze. This is secured with a pressure-type facial dressing.

Furnas method (concha-mastoid suturing): Indicated for reducing excessive conchal cupping to close the gap between the concha and the mastoid prominence (Fig. 16.4). A cotton-tipped applicator is used to press the floor and posterior wall of the concha against the mastoid process, gradually reducing the depth of the

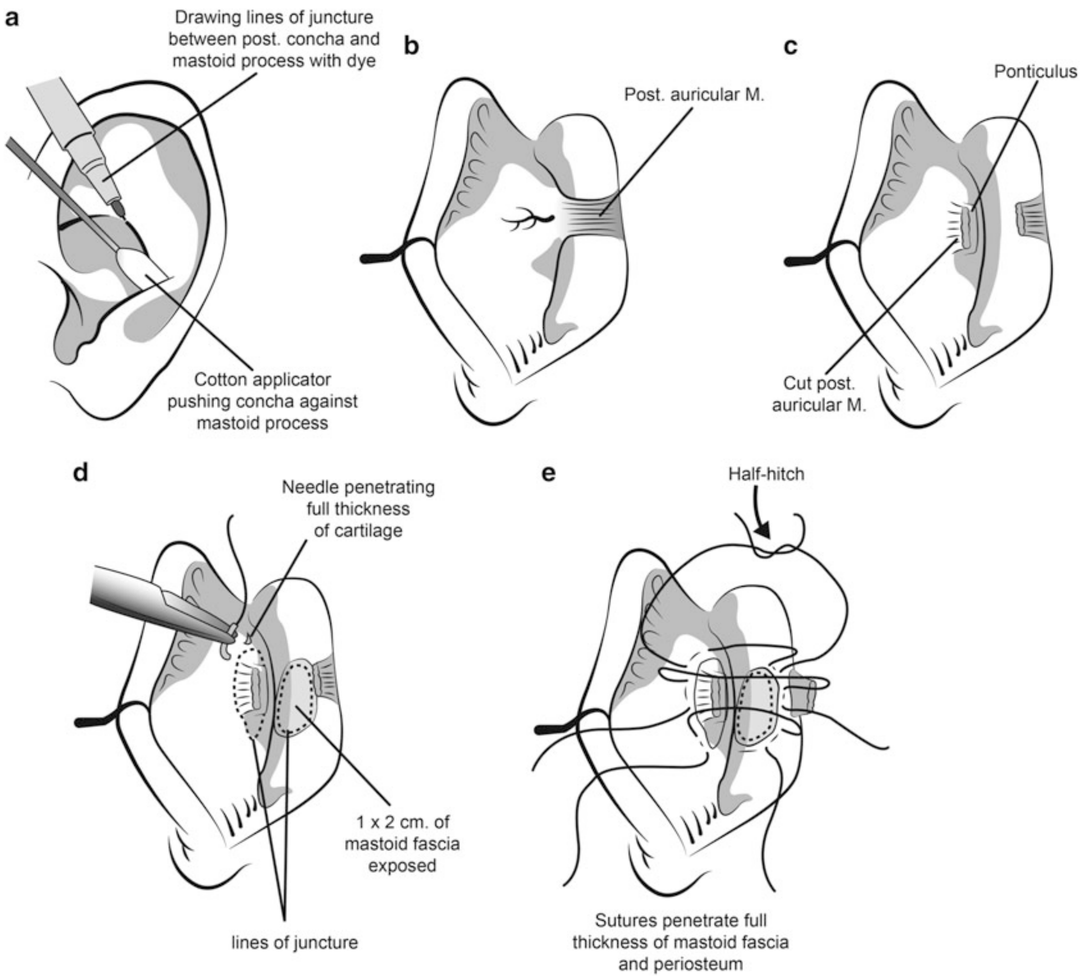

Fig. 16.4 Furnas method to reduce excessive conchal cupping

concha to the point where the ear is no longer prominent. The line of juncture where the concha meets the mastoid process is marked in a line within the conchal cup. Any folds planned for the antihelix are marked. An ellipse of postauricular skin is excised to expose the posterior surface of the auricular cartilage, preserving the small branches of the greater auricular nerve, if possible. A 1 × 2 cm area of deep fascia over the mastoid process is exposed. The ear is manipulated to determine its most desirable position. A horizontal mattress suture (4-0 clear monofilament nylon or Merseline) is passed through the conchal cartilage posterior to the ponticulus, avoiding the skin on the anterior surface. The dye mark on the anterior surface of the concha serves as a guide, but the suture is usually placed slightly beyond this line of juncture. The suture is passed through the mastoid fascia and well into the periosteum of the mastoid process. The suture is tightened with a single half-hitch, noting how the ear is affected. Three or more concha-mastoid sutures are required, and the final knots are not tied until after any corrections of the antihelix. The ear may be dressed with compression as described above. Precautions: Sutures which are inaccurately placed may displace the ear upward or downward (Fig. 16.5). If too far forward then the concha will not be sufficiently corrected. Sutures placed

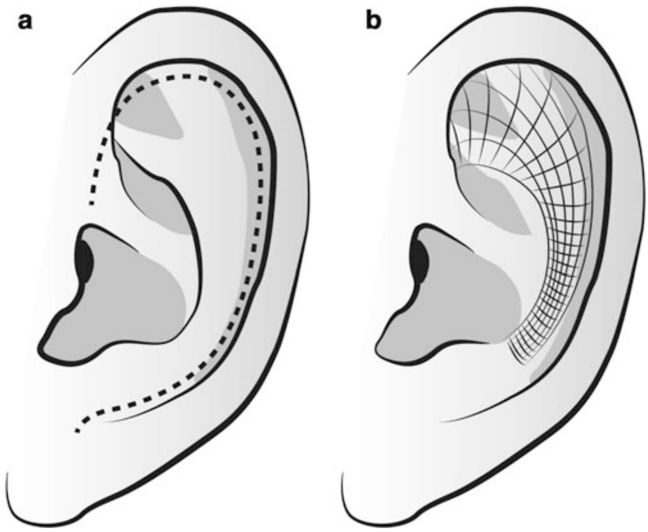

Fig. 16.5 (**a**) Location of cartilaginous incision between the helical rim and antihelix. The skin incision is performed posteriorly, (**b**) Demonstrates the partial-thickness scoring incisions

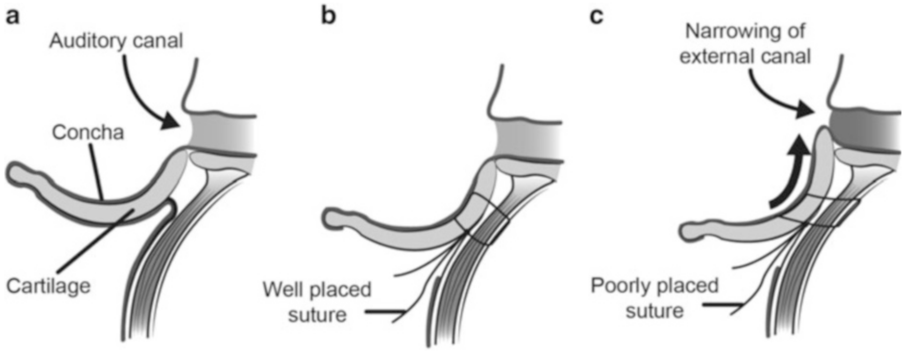

Fig. 16.6 Cross section showing poorly placed sutures causing forward rotation of the concha and reduction in the diameter of the external auditory canal

too far forward on the mastoid or too far back on the concha will decrease the diameter of the auditory canal.

Cartilage-scoring technique for protruding ears: The anterior surface of the cartilage is exposed through a posterior skin incision (Fig. 16.6a). Very little undermining is done along the posterior surface of the cartilage. The antihelical cartilage is completely exposed up to its origin and sectioned. The skin and perichondral elevation on the anterior surface of the antihelix are completed and partial-thickness cartilage incisions are made. The direction of these incisions is important to have a normal-appearing "fan-shape" antihelix that will curve both superiorly and posteriorly (Fig. 16.6b). The incision chosen for the conchal height is of full thickness, and the cartilage is folded sharply on itself at the appropriately chosen conchal height. After partial-thickness incisions of the antihelix and proper alignment of the conchal height with the antihelical fold, the cartilage should stay in the desired position without the need for sutures. To keep the sharp fold of the concha and ensure a smooth cartilage shape in this area where the overlying skin is thin, two 5-0 plain catgut sutures are used to maintain this sharp edge.

The helical rim and anterior skin flap are then returned to their original position and closed with 5-0 plain catgut. The wound is dressed with xeroform posteriorly and gauze anteriorly conforming to the concha, fossa triangularis, and scapha. Fluff gauze and a compression bandage are placed over the ear and left in place for 7–10 days.

Correction of lop-ear deformity: In minor lop ear deformity, simple excision of the overhanging fold of cartilage is all that is required for correction. In moderate and severe deformities, there is reduction in the components of the upper third of the ear and more extensive surgery is needed. A rotation-advancement composite flap can be used along with borrowing of cartilage from the lower two-thirds of the ear since there is a reduction in the size of the upper third of the ear in moderate and severe lop-ear deformities. If this cartilage flap can be placed where the superior crus is needed, then the flap will serve to increase the vertical height of the upper third of the ear (and the ear as a whole), and to create the missing superior crus of the antihelix. In addition to excising the overhanging cartilage, a cartilage flap is rotated from the antihelix upward where the missing superior crus was supposed to be. The excess skin covering the deformed cartilage is sufficient to cover the increased vertical height after adding the cartilage flap.

Correction of protruding earlobes: An extension of the posterior auricular incision is drawn in the shape of a "V" onto the earlobe. Finger pressure on the freshly marked lobe, which compresses it to the mastoid skin, and produces a mirror image imprint that forms a W-shaped portion of skin to be excised. After this portion is excised and hemostasis achieved, closure is accomplished with a 4-0 plain gut suture. The V-shaped incisions are brought together to reduce the protruded state of the lobule. It can also be reduced by excising a square based on the anterior edge at the level of its attachment to the face. A full-thickness excision is performed and the anteroinferior edge of the lobe is de-epithelialized at a distance equal to a side of the square excision. The defect is closed with absorbable suture by rotating the lobe superiorly, apposing the raw edges. A Z-plasty is done on the resultant vertical portion of the scar, and the skin is aligned and closed with monofilament suture.

Prosthetic Auricles

Generally used for congenital, posttraumatic, and postablative deformities. The disadvantages include the need for replacement of the prosthesis every 2–5 years for the life of the patient and skin/implant interface being prone to irritation, which may preclude the patient from wearing the prosthesis. Irritation of the skin/implant interface is more common in children, who may not administer the meticulous hygiene necessary around the transcutaneous abutments.

Indications

- Failed autogenous reconstruction: May have scarring from previous surgical attempts which may preclude further autogenous reconstruction or require transfer to a temporoparietal (TP) flap for framework coverage. The TP flap may have already been used, necessitating either microvascular transfer of the contralateral TP fascia or a prosthesis. In dark-skinned patients prone to scarring, scalp incisions associated with TP flap harvest may represent a significant deterrent to that technique. Patients and families may be hesitant to proceed with a second attempt at autogenous reconstruction after an initial failure.
- Severe soft tissue and/or skeletal hypoplasia: Hemifacial microsomia patients present with tight skin, absence of a superior skin remnant, and a small or almost absent lobule. The cutaneous deficit limits the result that can be obtained. There may be inadequate skin to drape into the folds of a framework. In some patients, the cutaneous deficit is such that the placement of a standard framework will result in ischemia of the overlying tight skin. Skeletal hypoplasia also limits the result. Patients

may have a temporal concavity resulting from hypoplasia of the mandibular ramus and the temporal bone, such that any reconstructed auricle will not project adequately. Some patients have both such that autogenous reconstruction is limited and the degree of facial asymmetry makes auricular reconstruction less of a priority. Currently, it is recommended to augment the soft tissue first to correct the temporal concavity and then proceed with auricular reconstruction on the reconstructed platform.

- Low or unfavorable hairline: If the hairline is low, then compromise can be struck by constructing an auricle that is smaller than the normal side. The superior aspect is not covered with hair. From an aesthetic point of view, it is more important to have the caudal aspect of the auricle (lobule) in a symmetric position relative to the contralateral side rather than the superior aspect, which is more easily camouflaged by hairstyle. Hair over the superior aspect can be treated with electrolysis, laser ablation, and excision/skin graft.
- Posttraumatic or postablative auricular defects: More often adults differ from children in that the skin loss and scarring resulting from the trauma or previous surgery make standard autogenous reconstruction difficult, and the tragus is frequently preserved which makes the aesthetics of the prosthesis more favorable. Presence of tragus allows the anterior border of the prosthesis to be hidden. In general, patients with congenital deformities do not have a tragus, and the anterior margin of the prosthesis, no matter how elegantly constructed, is always visible. Adults tend to have more heterogeneous skin pigmentation and texture, making the prosthesis less visible than in a young child with smooth, homogenous skin color and texture. Adults are less inclined to undergo staged reconstruction, and a prosthetic may be a simpler alternative. Some patients have undergone resection for oncologic indications and treated with radiotherapy, which further complicates or precludes autogenous reconstruction.

Complications

Complications after otoplasty include asymmetry, perichondritis, infections, hematoma, necrosis, and scarring. Infection can involve Pseudomonas, and post op antibiotics should be considered. Routine use of prophylactic antibiotics, however, is not generally recommended. Hypertrophic scarring or keloid formation from the postauricular incision should be prevented by closing the incision without tension. Pathologic scarring usually takes place gradually in the first 2–6 months after surgery, so it is recommended that patients have careful follow-up to identify scarring early. It may be treated with silastic gel and local injections of triamcinolone. Pressure necrosis can occur from an overly tight dressing. Hematoma formation is a risk that is best avoided with careful intraoperative hemostasis and a meticulous compression dressing. An overcorrected middle third results in a "telephone deformity" with a prominent helix and lobule. Delayed or long-term complications include ear deformity, neurosensory deficits, and unfavorable aesthetic results.

Auricular Reconstruction

Auricular reconstruction with autogenous tissue is the method of choice for repair of congenital and acquired ear defects. Parents of children with microtia or other deformities are often anxious to have the ear repaired early; however, it should be delayed until age 6–8 when the rib cartilage is large enough and durable enough for sculpting. Alloplastic frameworks used in the past often fail (silicone, Medpor), but homologous cartilage has shown favorable results. Newer techniques involving tissue engineering and prefabricated cartilaginous molds continue to advance, but sculpted autogenous rib cartilage is still the material of choice for surgical repair.

The procedure is typically staged in order to have ideal conditions for healing and to minimize complications. Measurements for the planned reconstruction are taken from the normal side in unilateral microtia cases in order to create an auricle that is symmetrical. The basic steps in

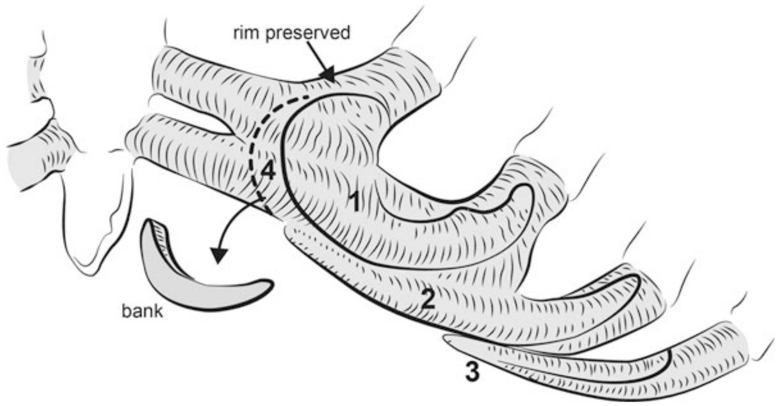

Fig. 16.7 Conchal cartilage ear reconstruction

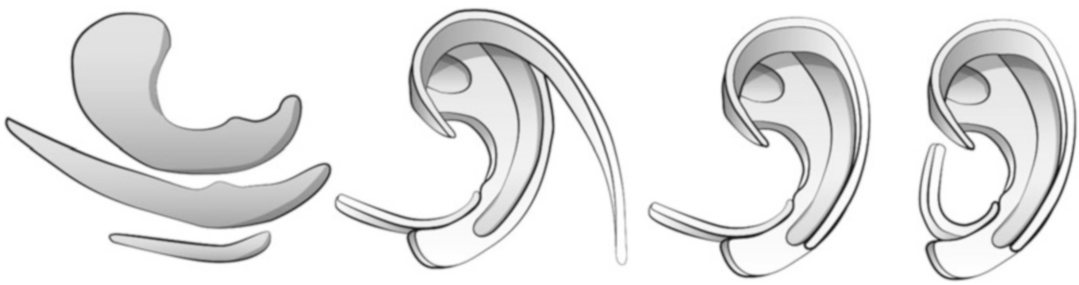

Fig. 16.8 Conchal cartilage carved to resemble normal ear framework

microtia repair require an average of 2–4 stages, including harvesting rib cartilage, fabricating the framework, providing skin coverage, creating a lobule, separating the reconstructed auricle from the head, and constructing a tragus. Stages are typically 6 months apart to allow for reestablishment of blood supply.

Rib cartilage is harvested for only what is necessary to create the framework. Excessive harvest can lead to noticeable chest wall deformity, which can be decreased by preserving a minimal rim of the upper margin of the sixth rib cartilage and maintaining chest wall integrity (Fig. 16.7). The cartilage is handled gently, kept in saline to prevent desiccation, and stripped of muscle and connective tissue while preserving the perichondrium. The cartilage is sculpted with scalpels and chisels in segments to recreate the framework (Fig. 16.8). This is secured with 4-0 and 5-0 clear nylon suture. Modifications are made in adult patients due to the calcified cartilage that often is carved as a single piece since the tissue will not bend without breaking.

A skin pocket is then created at the site of the ear remnant as determined by preoperative measurements. Remnant cartilage is carefully removed and the new framework is implanted at the precise location for the new auricle. Complete hemostasis within the pocket is achieved to prevent hematomas, and suction drains are placed under and behind the framework. The incision is closed with nonabsorbable sutures, which are removed in 1 week. Dressings to conform to the convolutions of the new auricle are placed along with a noncompressive, bulky head dressing. The drains are removed after approximately 5 days when drainage is minimal. Patients are asked to avoid sports or contact activities for 4–6 weeks while the ear and chest are healing. Some authors choose to transpose the earlobe at the first stage, while others prefer to delay this step as part of a secondary procedure. Often a piece of cartilage is banked in the skin pocket or at the rib harvest site to be used for ear projection when the framework is elevated.

The next stage involves lifting the ear and creating a postauricular sulcus. An incision is made nearly circumferentially in the skin lateral to the framework, and the cartilage is elevated off the mastoid periosteum, preserving the connective tissue on the posterior surface. A split-thickness skin graft is harvested from an inconspicuous location and placed in the new postauricular sulcus. The banked cartilage is wedged into the postauricular sulcus to create projection, and this is covered with a tissue flap from either the temporoparietal or occipitalis fascia. The skin graft is secured in place and fastened with a bolster dressing left in place for 1 week.

The final stage is tragus creation, which may be formed from an auricular remnant or created from harvested cartilage of the rib or opposite ear. It can be fastened to the sculpted cartilage framework or implanted into a pocket just anterior to the location of the external auditory meatus through a new incision. Recreating the preauricular sulcus and the tragal eminence is an important aesthetic principle of creating a natural-appearing ear.

Minor refinements may be needed in the future, but overall the ear constructed from autogenous cartilage is able to withstand trauma and retains its shape over the years.

External Auditory Canal Atresia

EAC atresia results from failure of canalization of the epithelial plug portion of the first branchial cleft. Persistence of the tympanic ring results in a bony atresia plate at the level of the tympanic membrane. Ossicular malformations may also exist, and patients typically have a conductive hearing loss or mixed hearing loss. EAC atresia may be seen in association with microtia. Hearing assessment and amplification should be instituted at a young age to facilitate language outcomes.

Realistic goals and expectations should be openly discussed with the patient and family. Surgical intervention on the first ear generally occurs around age 4–5 years with the goal to create a safe (preventing cholesteatoma or otitis media) and hearing ear.

The status of the middle ear is important for good surgical outcome. If there is less than 50 % of the normal contralateral middle ear space, then hearing results are often poor and reconstruction may fail. Attention to the facial nerve anatomy, documentation of function, and intraoperative monitoring are important for planning. A CT scan may help to define the course of the facial nerve prior to surgery.

Surgical technique involves a postauricular incision, widening of the stenotic meatus by removing fibrous tissue, and de-epithelializing the tympanic membrane. The posterior, superior, and inferior bony canal is widened until the first mastoid cells were encountered. The anterior canal is widened in cases where there was an anterior bony overhang. The bony canal is lined with split-thickness skin grafts. Meatoplasty is performed, and split-thickness skin grafts are grafted onto the margins of the meatoplasty to cover the lateral part of the ear canal. Ossicular reconstruction with a prosthesis is performed. The middle ear and ear canal are packed with absorbable packing. The EAC is debrided in 2–4 weeks. Once healing is complete, a postoperative audiogram should be performed. Patients may still require hearing amplification even after successful surgery.

Questions

1. The typical scapha-conchal angle is:
   (a) 15°
   (b) 30°
   (c) 90°
   (d) 120°

2. The sensory nerve supply to the ear comes from all the following EXCEPT:
   (a) Lesser occipital nerve
   (b) Great auricular nerve
   (c) Vagus nerve
   (d) Transverse cervical nerve
3. Describe the different grades of microtia (grades 1–4).
4. Telephone ear deformity can best be described as:
   (a) Overcorrection of the middle third of the ear with a prominent helix and lobule
   (b) Pointed ear characterized by an abnormal folding of the skin and cartilage of the pinna
   (c) Underdevelopment of the helical rim
   (d) Thickening and loss of normal auricular landmarks caused by repetitive trauma
5. The Davis method for correction of auricular deformity is best selected to correct:
   (a) External auditory canal atresia
   (b) Hypertrophic posterior wall of the conchal bowl
   (c) Absence of the antihelical rim
   (d) Microtia
6. The Furnas suture technique is best selected to correct:
   (a) Hypertrophic posterior wall of the conchal bowl
   (b) Absence of the antihelical rim
   (c) Increased auriculocephalic angle
   (d) Hematoma after traumatic injury
7. Describe the steps performed for placement of Mustarde sutures.
8. The parents of a 2-year-old child with a history of unilateral grade 3 microtia present to clinic wanting to discuss options for immediate repair of the defect. They are very distressed about the appearance and are worried about the child's social development. Describe the options for repair and the recommended timing of surgical procedures.
9. Relative indications for prosthetic auricles include all the following EXCEPT:
   (a) Failed autogenous reconstruction
   (b) Severe soft-tissue deficiency
   (c) Low or unfavorable hairline
   (d) Inability to maintain hygiene of the transcutaneous abutment
10. Describe the difference between cartilage-cutting and cartilage-sparing techniques.
11. A patient calls the clinic to report that 2 days after undergoing otoplasty for prominent ears, she is having worsening pain of the operated ear that is severe and uncontrolled with routine postoperative pain medications. A postsurgical compression dressing with a headband was placed and has not been removed. Your advice to the patient is:
    (a) Return to clinic urgently for dressing removal and inspection for a hematoma
    (b) Continue with postoperative pain medications and reassurance that the pain will improve in the upcoming days as the swelling resolves
    (c) Remove the dressing at home and start using antibiotic ear drops for likely otitis externa caused by trauma to the ear canal during the procedure
    (d) Maintain the head dressing since the pain is likely from overly tightened sutures that will loosen with time
12. What methods are employed to reduce the likelihood of hypertrophic scarring and keloids after otoplasty, and what can be done to recognize and treat this complication?
13. Name the branchial arches from which the ear derives and the structures formed from each.
14. Describe the typical stages of auricular reconstruction for microtia repair.
15. Name the standard views utilized in preoperative photography for planning of auricular reconstruction.

Vascular Anomalies

17

Matthew Keller

Vascular anomalies are classified and defined by their clinical course, biologic activity, radiologic, and histopathologic features. The International Society for the Study of Vascular Anomalies Classification of Vascular Anomalies has divided vascular anomalies into two groups, **vascular tumors** and **vascular malformations.** This classification system forms the basis for diagnosis and treatment of vascular anomalies and enables clearer communication between specialists, replacing out-of-date descriptions such as *port-wine stains, stork bites, lymphangiomas, and cystic hygromas*. Vascular tumors typically appear early in life, regress over time, undergo pathologic endothelial proliferation, and involute. Conversely, vascular malformations are present at birth (but not always apparent), grow with the individual, do not regress, and have no endothelial proliferation. Figure 17.1 summarizes the clinical and imaging characteristics, classification, and treatment of the various vascular anomalies which are discussed below in full detail (Tables 17.1 and 17.2).

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Vascular Tumors

Vascular tumors grow due to endothelial hyperplasia. Infantile hemangiomas represent the most common of these tumors, but other vascular tumors can present including congenital hemangiomas, tufted angioma, hemangiopericytoma, pyogenic granuloma, kaposiform hemangioendothelioma (KHE), plexiform neurofibromas, rhabdomyosarcoma, nasal glioma, dermoid cysts, and myofibromas.

Infantile Hemangioma

Overview

Infantile hemangiomas represent both the most common benign pediatric tumor and pediatric head and neck neoplasm, affecting up to 10 % of children. Approximately 60 % of infantile hemangiomas occur in the head and neck. They commonly occur in Caucasians, females (3:1 female:male), and premature infants (23 %). The majority of these tumors are sporadic, but an autosomal dominance pattern can occur. These lesions are apparent at birth or appear within the first 2 weeks of life. One-third of these tumors present as a cutaneous mark (i.e., blanched area of vasoconstriction, telangiectatic macule, ecchymotic spot) which later undergo postnatal proliferation.

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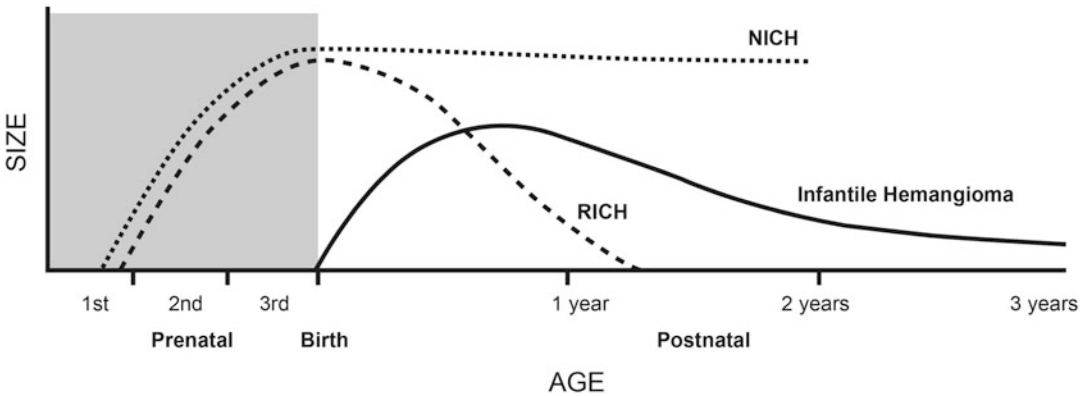

Fig. 17.1 Congenital and infantile hemangiomas: patterns of growth and involution (Mulliken and Enjolras 2004)

Table 17.1 Characteristics of vascular anomalies (Wassef et al. 2015)

Type	Timing	Appearance	MRI characteristics	Therapy
Vascular tumors				
Infantile hemangioma	First weeks of life	*Proliferating* "Strawberry-like"	Well defined, lobulated	Propanolol
	Rapidly growing	Pulsatile	No perilesional edema	Laser therapy
	Regress by 7–10 years	Warm	Flow voids	
		Involuting	Homogenous enhancement	
		Grayish dark red Central ulceration		
Congenital hemangioma	Fully present at birth	Blue-red to purple	*Involuting phase*	
RICH	Involute	Warm Central ulceration	Fatty replacement (high T1 signal)	*RICH*—no treatment
NICH	Do not involute	Lighter colored raised plaques		*NICH*—embolization followed by surgery
Tufted angioma/ kaposiform hemangioendothelioma	Variable	Hypertrichosis		Surgery Laser therapy
Vascular malformations				
Low flow				
Venous malformation	Present at birth (not always evident)	Compressible, blue, soft, nonpulsatile	Infiltrative, lobulated, fluid levels, phleboliths, no flow voids, no contrast enhancement	Compressive garments Sclerotherapy Surgery
Lymphatic malformation	Grow proportionally (do not regress)	Non-compressible, smooth, rubbery	Macrocystic (>2 cm) Microcystic (<2 cm)	Sclerotherapy Surgical debulking
Capillary malformation		Red skin discoloration	Thickened skin	Laser therapy Surgical debulking
High flow				
Arteriovenous malformation		Red pulsatile warm mass with thrill		Embolization

Table 17.2 Indications for treatment of infantile hemangioma

Indications for treatment of infantile hemangioma Acronym: VASCO
(a) Impaired **v**ision or hearing
(b) **A**irway compromise
(c) Impaired **s**wallowing
(d) **C**osmetic effect/ulceration
(e) High **o**utput cardiac failure

Pathology

Infantile hemangiomas arise as abnormal **endothelial cell proliferation** from hemangioma-promoting stem cells. Some studies suggest that these stem cells are "metastatic" maternal placenta cells in high-flow areas to the fetus. The hemangioma endothelial cells positively express glucose transporter protein-1 (**GLUT-1**), unlike the surrounding normal vascular endothelium. This serves as a useful marker when the diagnosis is in question. Clinically, these lesions are designated as **superficial, deep, or combined lesions**. Superficial lesions reside in the papillary dermis, and are typically bright red, non-compressible, well demarcated, and elevated from the surrounding skin. Deep lesions are soft, ill-defined masses of the reticular dermis and subcutaneous tissue with an overlying bluish hue. Combined lesions exhibit both characteristics.

Classification

Infantile hemangiomas most commonly present as **focal** tumors, localized to one cutaneous area. **Segmental** hemangiomas are less common and occur as plaque-like lesions in a geographic distribution over a specific cutaneous region (e.g., CN V "beard distribution"). **Disseminated** lesions (greater than 5) can be associated with visceral hemangiomas; thus those patients need ultrasound screening of the abdomen.

Characteristics

Infantile hemangiomas have a distinct natural history of proliferation followed by involution. The **proliferation phase** is characterized by a rapid growth phase usually occurring within the **first 6 months of life,** which is complete by 1 year. This increase in angiogenesis is the result of upregulation of vascular endothelial growth factor (VEGF), matrix metalloproteinase (MMP)-2, and basic fibroblast growth factor (FGF). These markers of angiogenesis are absent in vascular malformation. The **involution phase** is frequently heralded by a grayish hue in the center of the lesion. Involution is the result of **apoptosis of the endothelial cell**s which results in increased fibrosis and stromal cell formation. This phase has a highly variable and unpredictable time course, lasting anywhere from 2 to 10 years. **Regression is complete in 50 % of children by the age of 5, 70 % of children by the age of 7, and 90 % of children by the age of 9**. Longer involution times are associated with a higher incidence of permanent sequela such as scarring, residual subcutaneous fibrofatty tissue, telangiectasias, or atrophy of the skin.

Complications

The majority of infantile hemangiomas resolve without functional or cosmetic consequences. **Ulceration** is the most commonly noted complication, and can occur in up to 5 % of all lesions. Ulceration typically presents during the period of rapid proliferation, and is prone to develop in areas of friction such as the nape of neck or anogenital area. Ulceration not only produces pain, but also places the patient at increased risk of infection, bleeding, and scarring. When ulceration presents, wound care should be initiated including gentle compression to stop hemorrhage, occlusive dressings to prevent desiccation, topical lidocaine for pain control, and topical emollients such as petroleum gel or silver sulfadiazine.

Functional issues can also arise depending upon the anatomical location of the lesion. **Visual impairment** can become an issue for expanding periorbital hemangiomas. Segmental hemangiomas in the cranial nerve V3 distribution ("beard distribution") have a greater likelihood of a coexistent subglottic airway lesion. Patients with **subglottic hemangiomas** present between the ages of 6 and 12 weeks with progressive stridor and hoarseness. Fifty percent of patients with subglottic hemangioma have an associated cutaneous hemangioma. Classically, subglottic hemangiomas arise from the left posterolateral subglottis. Timely diagnosis and treatment are critical for these patients due to the ability of infantile hemangiomas to rapidly progress in size, which could result in respiratory failure. If suspected, the patient should undergo endoscopy. These lesions should not be biopsied, but the diagnosis should be confirmed with CT and MRI.

PHACES syndrome (posterior fossa malformations, hemangiomas of the cervicofacial region, arterial anomalies, cardiac anomalies, eye anomalies, sternal defects) should be considered in any infant with a large (>5 cm) or segmental hemangioma of the head and neck (Metry et al. 2006). This condition has a marked female predominance (90 %). Dandy-Walker malformation is the most common brain anomaly but a number of other anomalies may be present. Cardiac anomalies are also common and can include coarctation of the aorta and congenital heart defects. Vascular anomalies can include aneurysms, anomalous branching of major cerebral and cervical vasculature, hypoplastic vessels, and stenosis. Eye findings can include optic nerve hypoplasia, microphthalmia, cataracts, and Horner's syndrome. Hearing loss has been reported with PHACES, related to ipsilateral intracranial hemangiomas involving auditory structures. Infants with suspected PHACES should undergo MRI imaging of the head, echocardiogram, ophthalmology examination, and audiometric testing during infancy.

Rarely, a patient presents **with diffuse hemangiomatosis** (>5 cutaneous lesions), visceral hemangiomas, congestive heart failure, hepatosplenomegaly, and anemia. This requires aggressive medical intervention to minimize morbidity and mortality, which can be significant in these patients.

Treatment

Treatment for infantile hemangioma depends on a number of factors including location, size, age of the patient, and growth phase. There is no question that hemangiomas which impair function or those that are life threatening need treatment. Table 17.2 summarizes some common clinical features that can help determine when treatment of infantile hemangioma is indicated in lieu of observation.

Observation

The majority of infantile hemangiomas (60–70 %) involute without cosmetic or functional sequela. Unfortunately, the remaining lesions can cause complications such as airway obstruction, visual obstruction, or tissue distortion and loss. If an observation strategy is selected, the physician must follow the patient until the patient/family is satisfied with the end cosmetic and functional result.

Medical

The trend has shifted towards early medical therapy for the treatment of hemangiomas, especially those which could result in cosmetic disfigurement (i.e., nasal tip; eyelid).

Corticosteroids had been the mainstay medical treatment for hemangiomas prior to the discovery of propranolol. Corticosteroids work by inhibiting angiogenesis through the downregulation of VEGF, MMP-1, IL-6, and other cytokines. They can be administered intralesionally for small, localized lesions or systemically for large or life-threatening hemangiomas. Intralesional injections are typically administered in 6-week dosing intervals throughout the proliferative phase. Corticosteroids have an ~85 % response rate, with changes seen during the first week of therapy. Notably, if steroid usage is discontinued during the proliferative phase, rebound growth can occur in up to 30 % of patients. Therefore, patients should be treated through 10–11 months of age and informed of potential risks including cushingoid facies, irritability, and temporary growth retardation.

Propranolol has significantly changed the management of infantile hemangiomas since its serendipitous discovery in 2008 (Léauté-Labrèze et al. 2015). Propanolol works by inhibiting the VEGF signaling pathway with interrupts angiogenesis, decreases endothelial cell migration, and stimulates **apoptosis**. Effective dosing starts with 0.5–1 mg/kg/day in two or three divided doses which is increased by 0.5 mg/kg/day until a target dose of 2 mg/kg/day is achieved. An EKG must be obtained prior to initiating therapy. It is important to monitor HR/BP for 2 h after initial dose and after every dose increase. Patients should be screened for contraindications such as cardiogenic shock, sinus bradycardia, hypotension, >1st-degree heart block, congestive heart failure, asthma, PHACES (relative contraindication due to higher stroke risk), and diabetes (relative contraindication due to blunting of the hypoglycemic response) (Metry et al. 2006).

Interferon alpha is a second-line treatment for life-threatening hemangiomas or those threatening vital functions (i.e., vision). Interferon inhibits endothelial cell migration and proliferation. Indications for use include patients who failed to respond to corticosteroids, and those with contraindications, side effects, or refusal of corticosteroid therapy. It is also indicated in the setting of **Kasabach-Merritt syndrome**. Kasabach-Merritt is a rare, life-threatening platelet-trapping, consumptive coagulopathy caused by vascular tumor trapping and destruction of platelets. Patients and their caregivers should be aware of the risks associated with treatment, including elevated transaminases, neutropenia, anemia, and **spastic diplegia** which can be permanent. Therefore, these patients should be monitored appropriately while undergoing treatment.

Other therapies include vincristine, topical imiquimod, and becaplermin gel but their use remains limited due to the significant efficacy of propranolol.

Lasers

Lasers remain a popular and effective tool in the treatment of vascular tumors. The yellow light **flashlamp-pumped pulsed dye laser (PDL)** at a 595 nm wavelength is the most common laser used in the treatment of superficial compound hemangiomas. The PDL is also effective for ulcerated hemangiomas, cosmetically sensitive (nasal tip) areas, hemangiomas with functional impact (periorbital), flat hemangiomas, or those with residual vascular pigmentation. Ulcerated hemangiomas respond to PDL with noted improvement in pain, rapid re-epithelialization, and accelerated involution. Treatment is typically performed every 2–4 weeks until involution. Other lasers utilized have included the Nd:YAG and KTP, which have variable success rates and risks. The CO_2 laser can be used for residual subglottic hemangioma or those unresponsive to other treatments.

Surgery

Surgery is performed for a number of reasons including potential cosmetic deformity, obstruction (visual/airway), scarring, residual fibrofatty tissue, and unresponsiveness to medical treatment. Some areas (nose, lip, orbit) of the face have the potential for a severe cosmetic and/or functional deformity if left untreated. For these sensitive sites, the threshold for surgical intervention is therefore lower. Parent desires must be taken into account. Infantile hemangioma is a solid tumor, with distinct surgical planes with minimal feeding vessels (unlike vascular malformations). Excision of facial tumors should be performed in a conservative fashion with a preference for primary closure. Serial excision is an option for large hemangiomas. The overall goal is to minimize resultant scarring.

Congenital Hemangioma

These represent a unique subset of vascular tumors, which are distinct clinical entities from infantile hemangiomas. Unlike infantile hemangiomas, these lesions are fully grown at birth and do not demonstrate rapid neonatal proliferation. These lesions are **GLUT-1 negative**, but otherwise share a number of common features (size, appearance, histology, and radiology) with infantile hemangiomas. These lesions are classified into two categories: **rapidly involuting congenital hemangiomas (RICH)** and **noninvoluting congenital hemangiomas (NICH)**.

Rapidly Involuting (RICH)

These lesions are present to a full degree at birth and **involute** by 6–14 months old. They are GLUT-1 negative and stain positive for Wilms tumor (WT1), a transcription factor activated during angiogenesis. On palpation, lesions are warmer than surrounding skin and a central ulceration may be initially present or develop shortly after birth. Involution starts days to weeks after birth and in a small subset of patients RICH involution is incomplete leaving a vascular plaque with coarse telangiectasias and bluish-white border. Because RICH are self-limiting, treatment is not needed unless there are complications.

Non-involuting (NICH)

These lesions are also present to a full degree at birth but **do not involute**; instead they enlarge proportionally with the child's growth. They are also GLUT-1 negative and stain positive for Wilms tumor (WT1). On exam, they are well-circumscribed round to oval, plaque-like or bossed soft tissue masses with color varying from pink to blue-red or purple. There are two morphologic subtypes: **patch type** and **nodule/plaque type**. Treatment consists of preoperative embolization followed by surgical excision during the preschool age.

Tufted Angioma (TA)

These are uncommon benign vascular tumors that are sometimes present at birth but can also develop later. They present as an infiltrated, firm, dusky red to violaceous plaque or nodule with overlying **hypertrichosis** (a key sign). Histology shows tightly packed capillary **"vascular tufts"** and they are GLUT-1 negative.

Kaposiform Hemangioendothelioma

These lesions are a continuation of a clinical spectrum increasing in disease severity from TA to KHE. Over 50 % of KHE are present before age 1 year, but they have more variable growth and regression patterns. Physical exam demonstrates a raised subcutaneous mass with purpuric bruised appearance. Other findings are mottled red to purple macules/patches/plaques, annular patterns, tenderness, hyperhidrosis, and hypertrichosis. KHE is very aggressive and invades muscle, soft tissue, and bone. Histology shows hypercellular capillaries in reticular dermis, sometimes with dilated lymphatic vessels. Deeper spindle cells are associated with KHE, along with positivity for D2-40 (lymphatic marker) and like TA they are GLUT-1 negative. Visceral involvement is highly associated with Kasabach-Merritt phenomenon (platelet sequestration with severe thrombocytopenia, microangiopathic hemolytic anemia, and consumptive coagulopathy). This phenomenon is most often seen with rapidly enlarging lesions.

Treatment involves drug combinations/chemotherapy, or surgery. Blood products are avoided due to risk of exacerbating Kasabach-Merritt phenomenon. For superficial lesions, the flashlamp pumped pulsed dye laser (585 nm) is most well proven. In the treatment of lesions with subcutaneous components, the Nd:YAG laser is the treatment of choice.

Vascular Malformations

These lesions differ from hemangiomas in that vascular malformations are present at birth, grow with the child (though may enlarge later due to hormonal fluctuations and infections), and do not involute. Their endothelium hypertrophies over time and they do not regress. A sudden increase in size is a concerning feature. Histopathology shows hypertrophied endothelium with normal mitosis (versus hemangiomas which have increased mitosis during the proliferative phase). They are categorized as either "low-flow" or "high-flow" lesions.

(Low-Flow)

Lymphatic Malformation

Formerly referred to as cystic hygromas and lymphangiomas, 90 % of lymphatic malformations (LM) are present at less than 3 years old and 65 % are present at birth. Of all LMs, 80 % are located in the head and neck region. They are frequently associated with venous malformations as the lymphatic and venous systems develop concurrently. Symptoms include a soft, painless, highly compressible mass often with skin discoloration. These lesions can frequently be associated with dysphagia and dyspnea. They may also become painful and more symptomatic with acute upper respiratory tract infections. Imaging of choice is MRI, and LMs are classified into either **macrocystic (≥1 cyst, ≥2 cm)** or **microcystic (<2 cm)**, or **mixed**.

They are staging according to the modified **de Serres** staging system (De Serres et al. 1995):

- I: Unilateral infrahyoid
- II: Unilateral suprahyoid
- III: Unilateral infrahyoid and suprahyoid
- IV: Bilateral suprahyoid
- V: Bilateral infrahyoid and suprahyoid
- VI: Bilateral infrahyoid
- VII: Retropharyngeal
- M: Mediastinal extension

Treatment consists of early conservative excision sparing all vital structures. Expect a 50 % recurrence rate if gross tumor remains. Sclerotherapy is indicated for macrocystic LMs (OK-432, tetracycline, sodium tetradecyl sulfate, alcohol, bleomycin). OK-432 was developed in Japan and is not currently FDA approved. It consists of a streptococcus culture treated and killed with penicillin, which incites a highly effective immune response when injected (delayed hypersensitivity reaction). Other treatment options include laser resurfacing and surgery. The CO_2 laser is used when there is extensive tongue involvement by the LM.

If a large LM is detected on prenatal imaging, EXIT procedure may be required for airway protection. Children with diffuse, interdigitating, microcystic cervicofacial LMs frequently require maxillomandibular reconstruction/osteotomies due to overgrowth of the facial bones. It is worthwhile to include psychiatric care for children with large lesions due to long-term morbidity.

Capillary Malformation (CM)

These lesions roughly follow cutaneous sensory nerve distributions and are commonly referred to as "nevus flammeus." It is important to differentiate CMs from common fading macular stains of infancy, which include "stork bite," "salmon patch (nape of the neck)," or "angel kiss (forehead)." These lesions, in contrast to a true capillary malformation, fade by the age of 1 year and are usually seen in the nuchal region, the eyelid, the glabella, or the lips. Location is the best clue to differentiation of the two entities. Venular malformations (port-wine stains) may cause skin thickening and soft-tissue hypertrophy that can be progressive over the life of the patient. Symptoms include highly blanchable and bright red lesions at birth, which fade to pink in infants, but then slowly enlarge and thicken over life and deepen to dark purple by adulthood. The medial type is lighter at birth. They typically have a unilateral or segmental distribution that respects the midline (see classification below). CMs can be associated with complex malformation syndromes. In particular, lumbrosacral capillary malformations may indicate that spinal cord abnormalities exist and should prompt further investigation. These lesions grow proportional to the child over time and are classified by their location with respect to midline:

- Medial—salmon patch, usually lightens and disappears with time
- Lateral—port-wine stain, does not regress, follows CNV facial distribution. Involvement of lateral thigh and knee indicates Klippel-Trenaunay syndrome (port-wine stain, venous/lymphatic malformation, soft-tissue/bone hypertrophy of an extremity)

Treatment options include the flashlamp PDL (585–600 nm); reported 50–70 % response rate ranging from partial to complete resolution. Other options include sclerotherapy (Sung et al. 2015), major surgical excision (Jacob et al. 1998), and compression therapy (Capraro et al. 2002). Nodular or very large lesions exhibit increased resistance to PDL and may require surgical debulking.

Venous Malformation (VM)

VMs grow slowly in childhood and expand rapidly with hormonal changes (puberty) or after trauma. They get larger with Valsalva or recumbent positioning. Histopathology shows that they are comprised of a very disorganized and random pattern/network of venous channels and the stain negative for Wilms tumor 1 (WT1). There is a familial autosomal dominant subtype that has been mapped to chromosome 9q. MRI is the imaging choice for diagnosis. Complications include congestion, thrombosis and phlebitis, pain, and distal emboli (large lesions). Treatment options include compression garments, surgery for deep lesions, laser for superficial lesions (Nd:YAG), sclerotherapy for small lesions, or as preoperative adjunct for larger lesions. Heparin can be used to reduce the development of thrombosis.

(High-Flow)

Arteriovenous Malformation

Arteriovenous malformations (AVMs) are formed by shunting between arterial and venous systems via anomalous capillary beds resulting in progressive expansion of capillary bed (nidus) with vessel hypertrophy. They may stay small and stable in childhood, and then rapidly grow with puberty or following trauma.

They are staged according to the **Schobinger** system:

- I: quiescent
- II: expansion (bruit, thrill, warm throbbing)
- III: destruction (ulcers, bleeding, bony changes)
- IV: systemic (congestive heart failure, left ventricular hypertrophy)

Symptoms include a warm, **pulsatile** intermittently growing lesion with skin discoloration and bruit. There are various diagnostic imaging options including pulsed Doppler, CTA, and MRA (digital angiography formerly used). Complications involve local tissue destruction and these lesions are prone to hemorrhage. The mainstay of treatment is embolization; some require surgical excision following preoperative embolization.

Vascular Malformation Imaging Recommendations (Dubois and Alison 2010, Legiehn and Heran 2010)

Diagnosis of a soft-tissue vascular anomaly is primarily based on clinical examination. Imaging is usually reserved for therapeutic planning, lesions with unclear diagnosis, or deep-tissue involvement. Ultrasound is a good initial imaging choice. MRI with fat-suppressed T2 and STIR sequences is useful in assessing for the extent of a lesion; fat-suppressed T1 pre- and post-contrast is helpful in differentiating lymphatic from venous malformations. Use of skin marker is highly recommended. Contrast is invaluable for showing whether a mass exhibits enhancement, outlines its vascularity, defines the vascular supply and venous drainage pattern, and shows arteriovenous shunting, all of which are essential data for lesion characterization.

- High-flow lesions: (AVM; infantile hemangioma in proliferation phase)
  Vessels appear as signal voids on spin-echo (SE) sequences and hyperintense foci on gradient-recalled echo (GRE) sequences.
- Low-flow lesions (LM, VM, CM)
  Hallmark is the lack of flow voids on SE or FSE sequences.
- ***Imaging Pitfalls:***
  - Low-signal-intensity structures resulting in pseudoflow voids caused by intralesional septations, intravascular thrombus, or phleboliths—these can be easily identified on contrast-enhanced and GRE sequences.

– Furthermore, dynamic time-resolved contrast-enhanced MRA permits estimation of the contrast arrival time, which is significantly longer in low-flow lesion.

Vascular Anomaly Syndromes

Kasabach-Merritt syndrome—hemangioma, thrombocytopenia, and consumptive coagulopathy. Affects males more than females. 10–30 % mortality if left untreated due to hemorrhage. Do not transfuse platelets unless active hemorrhage or planned surgical procedure.

PHACES syndrome—posterior cranial fossa anomalies, cervicofacial hemangioma, arterial/carotid malformation, cardiac anomaly/aortic coarctation, eye anomalies, sternal pit.

Sturge-Weber syndrome—unilateral port-wine stain in the V1 distribution (ophthalmic division) or V2. Can often extend to the leptomeninges. Can be bilateral and involved upper/lower eyelids. Work-up includes CT (+/-MRI) for intracranial involvement.

Klippel-Trenaunay syndrome—combination of capillary, venous, and lymphatic vascular malformations. Present at birth and often very aggressive. Classic feature is involvement of lateral thigh and knee.

Parkes-Weber syndrome—arteriovenous and capillary malformation in association with skeletal/soft-tissue hypertrophy.

Blue rubber bleb—venous malformation with associated GI lesions heralded by lower GI bleeding.

Maffucci syndrome—multiple hemangiomas associated with enchondromas beginning in adolescence. The skeletal lesions often degenerate into malignant tumors and involve the hands and feet. Pathologic fractures common in long bones.

Servelle-Martorell syndrome—rare congenital angiodysplastic disease with capillary malformations similar to KTS, but associated with progressive limb hypotrophy rather than overgrowth.

Proteus syndrome—extremely rare disorder characterized by overgrowth of body parts. 40 % have cutaneous vascular malformations. Can have parotid monomorphic adenomas.

Bannayan-Riley-Ruvalcaba syndrome—PTEN mutation, skin lipomas, multiple hemangiomas, macrosomia.

Beckwith-Wiedemann syndrome—macroglossia, gigantism (long limbs), ear pits, abdominal wall defects (omphalocele), *nevus flammeus,* neonatal hypoglycemia.

Capillary malformation-arteriovenous malformation syndrome—multiple capillary malformations and AVMs. *RASA1* gene mutation.

Phakomatosis pigmentovascularis—association of capillary malformation (port-wine stain) with extensive melanocytic lesions including dermal melanocytosis (Mongolian spots), nevus spilus, and nevus of Ota. This syndrome is often associated with glaucoma.

Questions

1. Which vascular lesion(s) stain positive for GLUT-1?
2. What does PHACES stand for?
3. You see a 10-day-old infant with a 2 cm erythematous blanchable macule on the bottom of his neck with irregular borders. He is otherwise healthy and there are no other skin lesions. What is the likely prognosis?
   (a) Grows with child over time
   (b) Gradually fades by age 1 year
   (c) Requires further imaging studies to determine the extent of disease
   (d) Will likely become raised and ulcerate prior to slowly fading by early childhood.
4. A 1-year-old has a complex raised vascular lesion on his shoulder that enlarges somewhat when he is agitated. The outer half has started to fade over the past month. Mom reports that it flared up and became very swollen when he was sick a couple of months ago and just subsided back to baseline. He

has a second erythematous macule on his lateral upper calf. Otherwise you see no anatomical abnormalities. What syndrome could this be?
   (a) Parkes-Weber syndrome
   (b) Maffucci syndrome
   (c) Servelle-Martorell syndrome
   (d) Klippel-Trenaunay syndrome
   (e) Beckwith-Wiedemann syndrome
5. How long does the proliferation phase last for infantile hemangiomas?
   (a) 3 months; complete by 6 months
   (b) 6 months; complete by 1 year
   (c) 3 years; complete by 5 years
   (d) 5 years; complete by 7 years
6. Lesion in a 3-month-old with a blanchable macule with central ulceration and overall appearance consistent with a hemangioma. Parents say that it has been getting smaller. By what age can you tell the parents this will almost always regress?
   (a) 14 months
   (b) 5 years
   (c) 7 years
   (d) 9 years
7. A 4-month child from a rural area has a very large, erythematous patch on his shoulder with a patch of hairs in the middle. It has been getting larger. Mom says that he has had a URI lately and you notice he is out of breath while playing with his siblings. What condition should you worry about?
8. What tests do you need to order prior to initiating propanolol therapy? What is the dosing schedule? The nurse wants to know if you need any special monitoring?

Answers

1. Infantile hemangiomas; congenital hemangiomas; tufted angiomas; kaposiform hemangioendotheliomas
2. Posterior fossa malformations, hemangiomas of the cervicofacial region, arterial anomalies, cardiac anomalies, eye anomalies, sternal defects
3. (b)
4. (d)
5. (b)
6. (d)
7. Kasabach-Merritt phenomenon (platelet sequestration with severe thrombocytopenia, microangiopathic hemolytic anemia, and consumptive coagulopathy). See with rapidly enlarging lesions.
8. Dose initially consists of 0.5–1 mg/kg/day in two or three divided doses which is increased by 0.5 mg/kg/day until a target dose of 2 mg/kg/day is achieved. Monitor HR/BP for 2 h after the initial dose and after every dose increase. Patients should be screened for contraindications such as cardiogenic shock, sinus bradycardia, hypotension, >1st-degree heart block, congestive heart failure, asthma, PHACES, and diabetes.

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Part IV

Aesthetic Surgery

Blepharoplasty

18

Benjamin P. Caughlin

Anatomy (Friedland et al. 2010; Goldberg et al. 2005; Papel 1992; Pastorek 1994; Putterman and Urist 1974; Susan et al. 2002; Yousif et al. 1995)

Arterial Supply: Anastomotic branches of internal and external carotid arteries

Medially terminal branches of ophthalmic artery (internal carotid artery branch) and facial, angular, and infraorbital arteries (external carotid artery branches)

Venous Drainage: Facial vein which parallels the course of the arteries and also has anastomoses to the ophthalmic veins, cavernous sinus, and pterygoid plexus

Lymphatic Drainage: Lateral eyelid is drained by channels extending from the periorbita temporally and inferiorly into the ipsilateral parotid and submandibular gland. These lymphatic channels run horizontally and thus vertical incisions can lead to chronic lymphadema

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Motor Nerve Innervation

Orbicularis oculi: Buccal, zygomatic, and frontal branches of facial nerve (CN VII)

Levator palpebrae superioris: Superior division fibers of oculomotor nerve (CN III)

Mueller's Muscle (superior tarsal muscle): Sympathetic nervous system, from superior cervical ganglion, internal carotid plexus, then along oculomotor nerve as it crosses the cavernous sinus—lower lid retractors: inferior division of oculomotor nerve (CN III)

Orbicularis Oculi: Oblique and circular muscle that requires medial canthal and lateral canthal anchoring points to convert the oblique circular contraction into a vertical vector to complete eye closure. Divided into orbital, palpebral, preseptal, and pretarsal components defined by underlying anatomy

Mueller's Muscle: Origin is undersurface of levator, insertion superior tarsal plate

Sensory Nerve Innervation

Upper Eyelid, Brow, and Forehead: Trigeminal nerve through the supraorbital, supratrochlear, and lacrimal branches (CN V-1)

B.J.-F. Wong et al. (eds.), *Facial Plastic and Reconstructive Surgery*,
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Lower Eyelid: Ophthalmic and maxillary division of the trigeminal nerve (CN V-1 and V-2)

Lamella: Outer/superficial: Skin and orbicularis
Inner/Deep: Tarsus and conjunctiva

Upper Eyelid

Superficial to Deep Layers

Skin → orbicularis oculi muscle → suborbicularis oculi fat → orbital septum superior and levator aponeurosis attaching to tarsus cartilage inferior → orbital fat superior and Mueller's muscle inferior → conjunctiva

Orbital Septum: Attaches to the periosteum of the superior orbital rim superiorly. Inferiorly the septum attaches to the levator aponeurosis at approximately 10–15 mm superior to the tarsal border

Superior Fat Compartments: Traditionally two fat compartments of the superior lid, medial and lateral separated by superior oblique muscle. Some texts depict and describe a third compartment deep to the orbital septum located in the lateral third of the upper lid.

The Upper Eyelid Crease

Non-Asian eyelid: Orbital septum fuses with levator aponeurosis superior to tarsal border This in combination with the levator attachment to the skin defines the upper lid crease (Fig. 18.1).

Asian eyelid: Septum fuses to levator aponeurosis below the superior tarsal border. This inferior

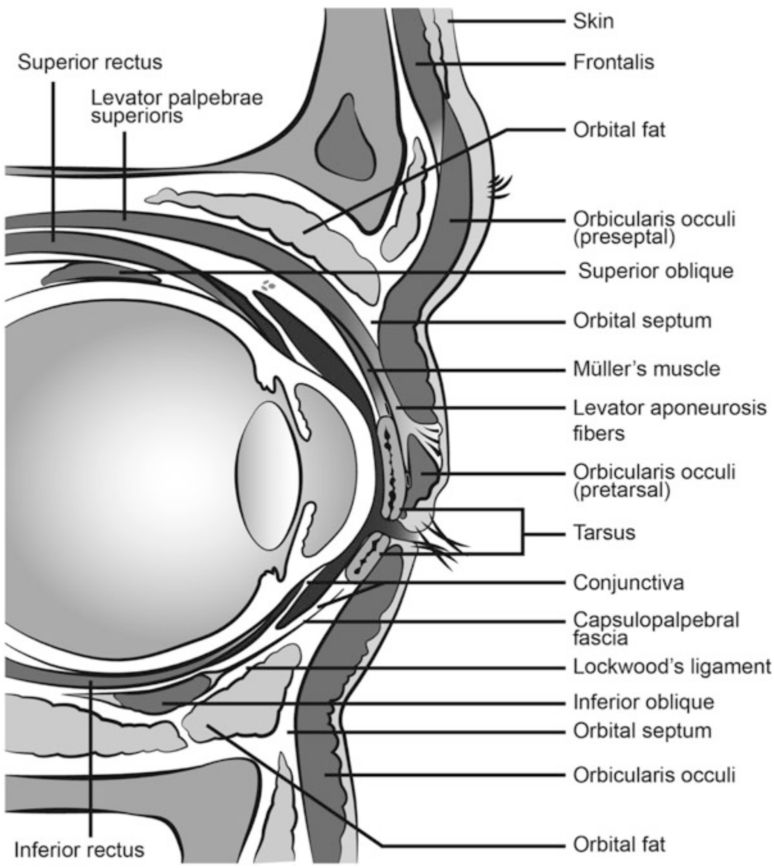

Fig. 18.1 Sagittal view of the orbit and lid anatomy to illustrate soft-tissue layers and fat pad position

extension of the orbital septum prevents aponeurotic fibers of the levator from reaching the subcutaneous tissues of the eyelid and thus preventing a crease. Orbital fat then occupies the space anterior to the tarsus resulting in a fuller appearance to the eyelid. The excess fat herniated anterior to the tarsus can lead to epiblepharon (inward rotation of the lashes towards the globe). A similar phenomenon is observed in the lower eyelid though because of the lack of a prominent lower lid crease this is less pronounced.

Lower Eyelid

Superficial to deep layers: Skin → orbicularis oculi muscle → suborbicularis oculi fat → capsulopalpebral fascial attaching to tarsus superior and orbital septum inferior → inferior retractors superior and orbital fat inferior → conjunctiva

Orbital septum: Attaches to the periosteum of the inferior orbital rim inferiorly and to the capsulopalpebral fascia superiorly approximately 5 mm inferior to the inferior tarsal border. This creates the lower eyelid crease

Inferior fat compartments: Traditionally three fat compartments medial, central, and lateral

Inferior oblique muscle separates the medial and central compartments and the fascial sheath of the inferior oblique muscle extending laterally to separate the central and lateral

Ligaments of Orbital Support (Muzzaffer et al. 2002)

Whitnall's superior transverse ligament: Extends from superiomedial orbital rim across orbit to medial edge of frontal bone—suspends the lacrimal gland, superior oblique tendon, levator muscle

Lockwood's ligament: Formed by conjoining fascia of inferior rectus and inferior oblique. Medial and lateral attachments to orbital rim. Functions as a suspensory sling for the orbit

Lockwood's suspensory ligament suspends the orbit and allows inferior intraorbital fat to remain posterior to the orbital septum. Overtime this ligament weakens and the eye drops or becomes enophthalmic which causes pseudoherniation of fat pushing the orbital septum outward

Arcus marginalis: Collections of connective tissue fibers from Lockwood's ligament which inserts inferolaterally to orbital rim. In conjunction with Lockwood's ligament the attachments contribute significantly to the orbital rim appearance

Orbicularis retaining ligament: Orbicularis oculi attachment to the inferolateral orbital rim. Supports suborbicularis oculi fat from drooping. With age weakens and allows descent of the suborbicularis oculi fat pad

History, Assessment, and Analysis (Becker and Berry 1992; Brennan and Joseph 1979; Halverson et al. 2006; Holt and Holt 1985; Karesh 1994; Lee et al. 1997; Rees 1980; Rohrich et al. 2004)

Relative contraindications to blepharoplasty: Actinic changes, acne rosacea, keloids, herpes zoster, thyroid abnormalities, autoimmune diseases, smoking history, extensive history of dry eye syndrome, acute-angle glaucoma history, prior eye surgery (LASIK or PRK < 18 months)

Skin: Loss of elastic fibers of skin leading to dermatochalasis (redundant and excess skin)

Orbital septum: Weakening of orbital septum leading to pseudoherniation of fat: medially the orbital septum is more thin and this is the main location of pseudoherniation

Suspensory ligaments: Weakens over time and the eye drops or becomes enophthalmic which causes pseudoherniation of the fat pushing the orbital septum outward and demarcating the orbital rim

Orbicularis oculi muscle hypertrophy: Leads to festoons (folds of orbicularis from medial to lateral canthi which can contain fat). From excessive squinting and facial animation, should not be mistaken for fat herniation, plan for orbicularis muscle stripping

Suborbicularis oculi fat: Located between the septum and the orbicularis muscle and descent over time and can contribute to lateral hooding of the upper eyelid and tear trough deformity and hallowing of the orbital rim inferiorly

Lacrimal system: Extensive history into dry eye sensation. Schimer's test or phenol red thread tear test if symptomatic

Lid Margin at Natural Gaze

<u>Upper Eyelid:</u> just inferior to upper limbus margin, no lower than 2 mm in neutral gaze

<u>Lower Eyelid:</u> at or slightly above the inferior limbus with no scleral show

Analysis Specific to the Upper Eyelid

Upper Lid Crease

4 mm above lid margin at medial canthus

6–10 mm above lid margin at mid-pupillary line

5–6 mm above lid margin at lateral canthus

Brow position: In women slightly above the orbital rim and more curved with the peak at the lateral limbus. In men tends to be at orbital rim and straight.

The brow and eyelid relationship: Pivotal in creating a crisp upper lid sulcus inferior to the superior orbital rim, free of redundant skin and protuberant fat pads. Overly deep and hollow upper sulcus equally best avoided. Brow position at or above orbital rim prevents crowded appearance and maintains vertical distance from high point of brow to lid ciliary margin of upper lid with minimal periorbital shadowing.

Brow ptosis: Exaggerates and confounds aging of the upper eyelid complex.

Brow ptosis can lead to suborbicularis fat protrusion giving the appearance of pseudoherniated fat. May also lead to over-resection of skin and lagophthalmos if not recognized prior to brown correction in conjunction with blepharoplasty.

Recognize lateral hooding: Should be a smooth transition of eyelid to lateral temporal skin with no hooding of skin lateral to the orbital rim.

Blepharoptosis

Causes: Levator maldevelopment, myogenic, neurogenic, aponeurotic, mechanical, pseudoptosis

Levator Function: Recognize ptosis by high upper lid crease (>10 mm), from *levator detachment*. This can lead to superior visual field defect and decrease lid merging to corneal reflex distance

Levator Function: Difference in upper lid position from downward to upward gaze >7 mm good; 5–7 mm moderate; 0–5 mm poor

Margin Reflex Distance (MRD-1): The distance from the light reflex on a patient's cornea to the central upper lid margin while in primary gaze; greater than 2.5 mm consider normal

<u>**Analysis Specific to the Lower Eyelid:**</u>, Assess relationship of anterior most projection of globe in relation to malar eminence. If there is negative vector, care should be taken to be conservative with skin and muscle resection. Lateral canthoplasty or lid-tightening procedures should be considered

Eyelid Cheek Complex: Smooth convex profile with no soft-tissue contour irregularities or concavities. Without definition of the inferior orbital rim

Recognize a Double-Convexity Deformity

First convexity: created by a weakened lower eyelid orbital septum

Second convexity: the arcus marginalis (attachment to anterior orbital rim) and the aged descended cheek fat and suborbicularis oculi fat (second convexity).

Medially this forms tear trough deformity and laterally hallowed eye deformity.

Malar fat pad: A triangular soft-tissue structure with the base at the nasolabial fold and the apex pointed superior-laterally to the malar eminence. Age-induced descent of this structure leads to an aged, rounded, and hallowed appearance to the lower eyelid and infraorbital area/rim. When pseudoherniation of orbital fat happens in conjunction with ptosis and loss of soft-tissue volume of the midface the nasojugal groove is deepened and creates the tear trough deformity

Tear trough deformity: Descent of suborbicularis oculi fat and malar fat pad leading to skeletonization of inferior orbital rim

Barton tear trough triad (Barton et al. 2004): (1) herniation of orbital fat, (2) sharp demarcation of the orbit-cheek junction, and (3) retrusion of the lower orbital rim creating a negative vector orbit. The anatomy of the tear trough deformity demonstrates the muscular triangle formed by the orbicularis oculi, levator labii superioris, and levator labii alaeque nasi. Corrected with intraorbital fat mobilization and septal reset to anterior inferior aspect of inferior orbital rim

Lower lid fat displacement or orbicularis festoons "cheek bags" malar area: Patient educated that lower blepharoplasty is not the only treatment here. Appreciate possibility of fat-repositioning procedures to assist with midface changes versus facelift to treat

Lateral canthus: Ideally located 1–2 mm above that of the medial canthus in a line with the inferior edge of the pupil. This allows the tears from the superio-lateral-positioned lacrimal gland to bathe the eye and then run downhill to the lacrimal drainage apparatus, located in the medial canthus. The lateral scleral triangle is larger, wider, and more pointed when compared to the medial scleral triangle. The sharpness of the lateral canthus can be lost and is a complication of blepharoplasty (rounded eye)

Lower lid laxity: Punctal position can cause tear flow issues

Snap test: Grasp lower lid between thumb and index fingers pulled out ~10 mm and should rapidly return to complete globe position: assesses orbicularis and tarsal function to establish ectropion and epiphora risks

Preoperative Photos

Full Face Frontal

Frontal close-up, eyes open, and eyes closed
Left lateral close-up eyes open
Right lateral close-up eyes open
Frontal close-up with upward gazing

Discuss with patient role of adjunct procedures: brow elevation, lateral canthal position adjustment, correction of lower lid laxity, and eyelid skin rejuvenation via resurfacing techniques, ptosis correction, and role in results

Surgical Techniques

Upper Eyelid Approach(Fagien 2002; Pastorek 1995)

Transcutaneous approach for skin and muscle removal:

Patient marked in upright position. Inferior marking just inferior to supratarsal crease

~8–10 mm above lid margin (some do 6 mm). From superior punctum medially to lateral orbital rim laterally. Forceps used and a pinch test performed to delineate redundant skin and superior marking noted at multiple points. A minimum of 10 mm of infrabrow/supratarsal skin should be preserved to allow for complete eye closure and prevent lagophthalmos. Superior marking forms a gentle arc and a small lateral extension beyond the lateral canthus is often required to address lateral hooding. More skin can typically be taken laterally. Laterally a minimum of 5 mm should be left between inferior and superior incisions to prevent webbing. The superior marking is longer laterally than the inferior marking and is tapered to join inferior marking medially. This leaves a lenticular or trapezoid shape. Avoid extension of incision lateral to orbital rim, especially in males if possible (unlikely to use cosmetics for camouflage). The medial edges join ending 6 mm from the angular vein with care taken not to extend past the medial canthus to prevent webbing.

Incision: Through dermis only: Dissection between skin and orbicularis with curved scissors and the premarked skin removed. If orbicularis hypertrophy is present then the predetermined amount of orbicularis muscle is removed. Careful hemostasis obtained. Skin closed with 6.0 permanent suture which is removed 3–5 days after the operation.

Transconjunctival Approach to Upper Lid Medial Fat Pad (Kamer and Mingrone 2000)

Useful for isolated upper lid medial fat herniation. Often utilized as a touch-up procedure after healing if a patient is unhappy with upper lid medial bulge of pseudoherniated fat. The upper lid is everted over a retractor and the septum is approached from the conjunctiva. Only redundant fat is removed. No sutures required. Medial fat can also be approached when performing upper lid skin only or skin/muscle bleph. The globe is gently pushed into the orbit and if medial fat bulges, a stab incision can be made to find the fat and this can be clamped/cauterized.

Lower Eyelid Approaches (De Castro 2004; Garcia and McCollough 2006; Honrado and Pastorek 2004; Pastorek 1994; Perkins et al. 1994; Perkins and Batniji 2005)

Pinch excision of lower lid skin: This is worth mentioning, particularly after a midface lift. Lower lid skin is grasped just below the lash line with forceps and small pinch of skin is demarcated along the length of the lower lid. This is excised with curved scissors and edges can be glued or sutured with fast absorbable suture.

Transcutaneous skin only flap: Incision ~3–4 mm below lash line, at first major rhytid, from inferior punctum medially to lateral canthal angle laterally. Dissection between skin and orbicularis, skin flap laid back down, and only redundant overlapping skin is excised. Used on patients with dermatochalasis and no pseudoherniation of fat or orbicularis hypertrophy.

Transcutaneous skin muscle flap: Incision is the same as above. Dissection between orbicularis and orbital septum. Used on younger patients with robust orbicularis and lack of festoons. Submuscular compartment accessed laterally while taking care to leave pretarsal orbicularis undisturbed (reduce ectropion risk). First, you ask the patient to look up and to open their mouth. This puts tension on the lower lid. Then only the overlapping skin and muscle can be safely removed.

Fat removal: The amount of fat to be removed is determined preoperatively.

Develop plane by dissecting deep to the orbicularis muscle through preseptal fibers creating the muscle flap. Orbital septum entered and fat removed in lateral to medial direction. Small incision made into each fat compartment and with globe pressure only redundant fat removed with clamp and bipolar cautery. Careful hemostasis obtained to prevent hematoma.

Transconjunctival approach: Lower lid.

Benefits: No scar or scar contracture, less risk of ectropion (orbicularis kept intact), septum can be kept intact.

Ideal patient: Young with smooth skin, moderate fat pseudoherniation, with no orbicularis muscle hypertrophy.

Incision: Through conjunctiva (halfway from fornix to lid margin, 1–2 mm below tarsus), incision through inferior retractors. Orbital fat can be approached anterior or posterior to septum depending on where inferior retractors are incised. If plane of dissection is posterior to septum, the fat compartments are approached directly. If dissection is carried out anterior to septum the fat compartments and septum are approached from an anterior direction between the orbicularis muscle and the orbital septum (Fig. 18.1). Orbicularis separated from the orbital septum (superficial to the septum, deep the orbicularis). Septum is incised from an anterior direction and fat is removed as indicated starting with the lateral compartment with caution to control bleeding. Lid allowed to snap back into place, no sutures required.

It is important to consider postoperative or simultaneous chemical peel vs. pinch technique (removing 2–3 mm of only truly redundant skin below the ciliary margin) for those patients with dermatochalasis and superficial rhytides.

Fat Repositioning/Mobilization/Preservation (Baker 1999; Hamra 1995; Persichetti et al. 2004)

Repositioning of orbital fat: septum incised and the pseudoherniated fat is repositioned posterior to the septum. May be performed pre- or post-septally, protruding fat is teased and kept on vascular stalk. This is selectively laid over rim and placed into hollow areas. They are secured with temporary percutaneous sutures which are typically removed day 5 post-op.

Mobilization of orbital fat: septum incised and the orbital fat is mobilized to a new position inferiorly over the orbital rim. Additionally suborbicularis oculi fat (SOOF) can be mobilized to a new position superiorly over the orbital rim.

Ideal patient: orbital fat pseudoherniated anterior to lower eyelid margin. Prominent inferior orbital rim leading to hollowed-out appearance.

Periorbital fat is approached as above via the transcutaneous or transconjunctival approach. Determine if the pseudoherniated fat is to be repositioned back into the intraorbital area deep to the orbital septum or mobilized with the inferior most aspect of the septum and brought over the orbital rim to camouflage the orbital rim.

Fat mobilization: If orbital fat and septum are to be mobilized inferiorly, the septum is entered at the *arcus marginalis* (localized rim of thickening where the eyelid's orbital septum attaches to the orbital bone). With slight globe pressure the now herniated fat protrudes and this as well as the inferior most aspect of the orbital septum are sutured inferiorly to the periosteum of the anterior orbital rim medially (septal reset). Then the SOOF laterally can be re-secured to a similar location at the anterior orbital rim. For isolated tear trough deformity often solely elevation of SOOF is adequate.

For a prominent nasojugular groove (tear trough deformity), the fat must be mobilized and brought to a new position. Dissection is carried between orbicularis oculi and orbital septum (while keeping pretarsal orbicularis intact to decrease ectropion risk) and carried down **supra**periostealy to 15 mm below inferior orbital rim margin. Zygomaticofacial nerve and infraorbital nerves identified and four 5.0 nylon sutures placed to secure the SOOF and superior malar fat pad to the rim periosteum, thus filling the nasojugular groove.

Special Techniques

Skin/Muscle Suspension for Lower Lid Bleph

Ideal patient: redundant skin, prominent orbicularis muscle swag, with significant fat pseudoherniation.

Incision: made 2.5 mm inferior to ciliary margin, skin flap developed 3 mm inferiorly while care is taken to preserve pretarsal portion of the orbicularis muscle to prevent scleral show and ectropion.

Develop plane by dissecting deep to the orbicularis muscle through preseptal fibers creating the muscle flap. Orbital septum entered and fat removed in lateral to medial direction. Patient asked to look up and open mouth and skin and muscle that overlaps superior to subciliary incision is removed. Lateral muscle suspension suture is placed with a buried knot between orbital periosteum and lateral orbicularis muscle. The suture should go all the way to the dermis of the skin at the inferior limb of lateral canthus to support the lower lid.

Prophylactic Lateral Canthal Anchoring (Glat et al. 1997; Jacobs 2003; McCord et al. 2003): Prevents postoperative lower lid malposition, scleral show, ensures eyelid closure, improves and maintains proper eye shape.

Factors affecting post-blepharoplasty eyelid malposition: Hypotonicity, malar hypoplasia, shallow orbit, thyroid ophthalmopathy, unilateral myopia, orbicularis sling, actinic changes of lower lid, and revision blepharoplasty.

Ideal patient: Those with preoperative lower lid scleral show flaccidity of lower lid. Lid distraction test performed. Lower lid pulled ~5 mm away from globe; if little or slow snap back then canthoplasty recommended. If a firm snap back then solely canthopexy will likely suffice.

Canthopexy: Anchoring without cantholysis

Double-armed 4.0 permanent suture used to grasp the upper and lower lid tendons followed by the double-armed suture being passed through the periosteum at least 4 mm inside the lateral orbital rim inline with the inferior edge of the pupil. The suture is tied externally lateral to the orbital rim ~4 mm from the rim's edge.

Canthoplasty: Cantholysis, lid shortening, and re-anchoring.

Lysis of lower lid tendon performed at canthal angle. Small amount of lid margin trimmed for shortening which is determined by testing the canthus against orbital rim with forceps. Same suture as above though is additionally passed through the inferior edge of the tarsal plate and brought out through the lateral tendon of the upper lid. The suture is anchored same as with canthopexy.

Orbital Septal Tightening Techniques with Fat Preservation (Hamra 2004; Prado et al. 2006)

Ideal patient: Pseudoherniation of fat due to weakened orbital septum.

The orbital septum is exposed (not entered) by blunt muscle elevation and retraction. Gentle pressure on the globe delineates the amount of pseudoherniation and bulging. For electrocautery a grid spray of 30 units is applied with Colorado tip cautery to the intact septum. For CO_2 laser set at 7 W with 2 mm spot in scanner mode to the intact septum. Energy is applied over entire septum until shrinkage obtained and a symmetric smooth contour is appreciated with gentle pressure on the globe.

Supratarsal Crease Creation/Asian Blepharoplasty (Doxanas and Anderson 1984; Fernandez 1993; McCurdy 2005)

As delineated in the anatomy section it is the lack of a dermal attachment of the levator aponeurosis because of the lower fusion of the septum with the levator that blunts the upper lid crease in the Asian patient. This low fusion also leads to preaponeurotic fat that occupies the space anterior to the tarsus leaving a fuller appearance to the upper eyelid. Depending on the patient's goals, this fat may need to be repositioned or removed which can debulk the eyelid fullness and allow for a sharpened upper lid crease. Removal of this redundant fat can also be used to treat epiblepharon which causes inward deviation of the lashes towards the globe. The supratarsal crease can then be created by securing the levator aponeurosis to the dermis at the superior tarsal border.

Technique: Incision planned 6–10 mm above lid margin at predetermined position of desired crease. Skin pinch performed and the location of the superior incisions determines the amount of skin to be removed as in standard blepharoplasty. Skin removed superficial to orbicularis followed by a thin strip of orbicularis removal along inferior incision to allow for a deepened crease. The lower flap is then undermined ~2 mm inferiorly to expose dermis for future fixation to levator. Orbital septum identified and entered followed by removal or repositioning of predetermined fat to create the deepened sulcus. The levator aponeurosis and superior tarsus are exposed. The lid crease is created by fixation of the dermis from the undermined inferior incision flap to the levator fibers. A minimum of three sutures, midline, lateral limbus, medial limbus, are required.

Blepharoptosis Repair (Shields and Putterman 2003)

Frontalis Sling

Ideal patient: Congenital ptosis, external ophthalmoplegia, third-nerve paralysis, and myasthenia gravis, with less than 4 mm levator function.

Technique: Harvest autogenous fascia lata, deep temporal fascia, or use synthetic material.

Standard blepharoplasty incision ~8–10 mm above eyelid margin as well as two small stab incisions above the eyebrow, and a third forehead incision centered between the brow incisions placed 5 mm higher than the other incisions. Fascia or grafting material fixed to anterior aspect of upper third of tarsus at midline and two points correlating with each medial and lateral limbus. The graft is passed through incisions and pulled up from forehead incision until eyelid margin is at the superior limbus. The ends of the fascial strips are secured to the frontalis muscle after anchoring with 6-0 chromic suture.

Levator Resection

Ideal patient: Congenital, myogenic, and aponeurotic ptosis with levator function of 4 mm or greater.

Technique: Standard blepharoplasty incision, bluntly dissection through orbicularis pretarsal fibers inferior to orbital septum until lower border of levator aponeurosis is exposed. Enter septum and retract fat to expose the levator muscle aponeurosis deep the septum. Separate levator and Mueller's muscle at upper edge of tarsus using fine scissors. Resect desired amount of levator muscle and fix it to the anterior-superior third of the tarsus with 6-0 absorbable sutures. Eyelid pulled downward to confirm height.

Mueller Muscle-Conjunctival Resection

Ideal patient: Ptosis of any etiology that corrects with instillation of topical phenylephrine.

Technique: Evert the eyelid over a retractor. Predetermined the amount of resected muscle/conjunctiva by a caliper (8.5–9 mm of Muller's muscle resection produces similar results to phenylephrine application). Toothed forceps used to pull conjunctiva and Muller's muscle from the levator. Resection performed and mucosa closed in running fashion.

Surgical Techniques to Repair Ectropion (Hirmand et al. 2002)

Assess which technique will return the lower lid complex to a more natural position manipulating tissues to see which maneuver (or combinations of maneuvers) will return lower lid to a more natural position.

Lateral canthal tendon tightening (Hirmand et al. 2002) (to treat lateral canthal tendon laxity): If preoperative reposition of lateral canthus results in good aesthetics and function then repositioning of lower lid complex may be all that is required. Accomplished by canthopexy vs. canthoplasty as described above.

Insertion of a spacer graft (to treat scarring between septum and deeper capsulopalpebral fascia): A spacer graft separates the capsulopalpebral fascia from the orbital septum and allows vertical elevation of the central lower eyelid margin to correct scleral show and retrodisplaced orbital fat. Graft material: hard palate mucosal graft, alloplastic grafts, or nasal septal graft placed and secured between the two layers of scared tissues.

Cheek fat pad elevation: To treat ectropion that results from descent of the malar fat pad.

Subperiosteal midface elevation (if combination of above with lack of adequate lower eyelid skin because of previous operation): This can allow enough skin movement to possibly prevent free grafting. This technique is used to reposition the lower eyelid and all the midface structures back to anatomic position.

Complications (Adamson and Constantinides 1995; Glavas 2005; McGraw and Adamson 1991; Patipa et al. 1996; Patipa 2000; Thornton 1994; Wilkins and Byrd 1985)

Retrobulbar Hematoma

Cause: Inadequate hemostasis often due to retraction of vessel into orbit

Symptoms:

- Decreased acuity, amaurosis fugax, scintillating scotomas
- Diminished EOM movements
- Loss of pupillary response
- Scleral hematoma

Treatment: remove dressings, ophthalmology consult

Stat OR set up: while

20 % mannitol (2 g/kg IV 12 g over 3 min the rest over 30 min)

Diamox 500 mg IV

95 % O_2/5 % CO_2 which dilates drainage vessels

Solumedrol 100 mg IV

Betoptic (BETAXOLOL HCL) glaucoma med: one drop immediately then BID

Surgical intervention: lateral canthotomy, release Lockwood's, Whitnall's, and arcuate ligaments

Lagophthalmos

Cause: likely from over-resection of skin. If long lived can lead to corneal injury

Treatment: options include massage followed by more aggressive full-thickness skin graft from contralateral eyelid, postauricular area, or supraclavicular area to reinstate adequate height to eyelid

Webbing of Medial Upper Eyelid Incision

Cause: Extension of medial incision past medial canthus

Treatment: massage versus surgical correction with Z, W, or V to Y plasty as indicated

Conjunctivitis/Chemosis

Cause: likely from excessive cautery and disruption of orbital and eyelid lymphatics

Treatment: ice application for first 48 h postoperatively, conservative treatment recommended, can take 2–5 months to resolve. Can require tarsorrhaphy suture or patching in severe cases

Oversculpting/Hallowed Appearance

Cause: over-resection of orbital fat

Treatment: best prevented by preoperative assessment and conservative fat removal. Surgically treated by injectables and/or fat mobilization/repositioning

Diplopia

Cause: most commonly from injury to inferior oblique muscle as it separates the medial and central fat pads of the lower eyelid, scarring or stricture. Muscle should be identified and injury prevented during fat manipulation

Treatment: 6 months of observation and ophthalmology consult required if persistent

Infections

Cause: unsterile techniques

Treatment: rare due to high vascularity, use antibiotic ointment to prevent and prompt recognition and treatment with antibiotics

Suture Granuloma/Pyogenic Granuloma

Cause: increased incidence with transconjunctival approach to lower eyelid

Treatment: topical corticosteroid and then surgical removal if persistent

Tearing/Epiphora

Cause: consequence of lagophthalmos, lid margin integrity malposition, lacrimal gland disruption, canaliculi disruption.

Treatment: assess lacrimal system and lid function treat appropriately

Lateral Canthal Rounding

Cause: results from malposition of lateral canthus and disruption of anchor function. Increased incidence with transcutaneous approach of lower eyelid resulting in scarring and retraction

Treatment: canthopexy, canthoplasty, and/or lateral canthal anchoring

Entropion

Cause: likely from posterior lamellar retraction, scaring, lateral canthal tendon laxity, and midface decent

Treatment: conservative management: taping of eyelid, massage, and observation.

Surgical intervention: canthoplication versus combined lateral tarsal strip with grafting and or wedge resection depending on severity. The contribution from the malar fat pad descent can be corrected by repositioning of this structure and can assist to restore infraorbital and lower lid position

Questions

1. Which statement is false:
   - (a) In the Caucasian eyelid the orbital septum of the upper lid attaches to the levator aponeurosis ~10 mm above the superior tarsal margin
   - (b) In the lower lid the orbital septum attaches to the capsulopalpebral fascia ~5 mm below the lower tarsal margin
   - (c) *Mueller's muscle attaches to the orbital septum posterior to the levator aponeurosis* **(attaches to the tarsus)**
   - (d) The inferior orbital septum attaches to the periosteum of the inferior orbital rim inferiorly and to the capsulopalpebral fascia superiorly
2. What muscles form the tear trough?
   The anatomy of the tear trough deformity demonstrates the muscular triangle formed

by the orbicularis oculi, levator labii superioris, and levator labii alaeque nasi.

3. In the Asian eyelid what structure prevents aponeurotic fibers of the levator from reaching the subcutaneous tissues of the eyelid, thus preventing a crease?
   (a) *Orbital septum*
   (b) Levator aponeurosis
   (c) Preaponeurotic fat
   (d) Thick skin
4. Capsulopalpebral fascia is a fibrous extension of what structure?
   (a) The periosteum of inferior orbit
   (b) *Inferior rectus muscle*
   (c) Inferior oblique muscle
   (d) Orbital septum
   (e) Perichondrium of inferior tarsus
5. Using a fat-preserving technique, the best way to treat a tear trough deformity is:
   (a) Inferiorly reposition the pseudoherniated fat over the orbital rim
   (b) Superiorly reposition the suborbicularis oculi fat over the orbital rim
   (c) Lower lid skin only blepharoplasty
   (d) Medial canthopexy
   (e) *Both A and B*
6. Retroorbital hematoma is treated by surgical exploration but on the way to the OR what percentage of mannitol should be started
   (a) 1 % mannitol
   (b) 2 % mannitol
   (c) 5 % mannitol
   (d) *20 % mannitol*
7. Which of the following is NOT an indication for lateral canthoplasty?
   (a) Lateral canthal dystopia
   (b) *Vertical lid laxity correct answer horizontal lid laxity*
   (c) Ectropion from cicatrix, atony, or paralysis
   (d) Lid retraction
8. If the lower eyelid retractors become detached from the lower edge of the tarsal plate it results in . . .?
   (a) *Entropion*
   (b) Ectropion
   (c) Diplopia
   (d) Pseudoherniation of the orbital fat
9. In the lateral suspension technique using the transcutaneous skin muscle flap the lateral suspension knot of the suture is placed:
   (a) Between the skin and lateral orbicularis muscle
   (b) *Between the periosteum and the lateral orbicularis muscle at the lateral canthus*
   (c) Between the periosteum and the lateral orbicularis muscle at the mid-inferior orbital rim
   (d) Deep the periosteum at the lateral canthus
10. Which statement is **true?**
   (a) Using electrocautery to reduce the orbital fat volume requires opening of the orbital septum
   (b) Using CO_2 laser to reduce the orbital fat volume requires opening of the orbital septum
   (c) *When reducing pseudo fat herniation during blepharoplasty with CO_2 laser and/or electrocautery the orbital septum is not opened/entered*
11. Which muscle is most commonly injured during blepharoplasty that leads to diplopia?
   (a) Superior rectus
   (b) Superior oblique
   (c) Inferior rectus
   (d) *Inferior oblique*
12. Descent of the malar fat pad leads to all of the following **except?**
   (a) Rounding of the lower eyelid
   (b) Retracted appearance to the lower eyelid
   (c) Hallowed appearance to the infraorbital area
   (d) *Shallowed nasolabial fold (based at NLF and apex at malar eminence) so this leads to a deepening of the nasolabial fold*
13. Select the **false** statement:
   (a) Canthopexy is anchoring the lateral canthal superior and inferior tendon to the inside of the orbital rim without lysis of the tendon
   (b) Canthoplasty is anchoring the superior and inferior canthal tendons after lysis

of the lateral canthal tendon and removal of a portion of the lateral lower lid

(c) *The anchoring stitch for lateral canthal anchoring is placed at the height of the superior limbus (should be at inferior pupillary height)*

(d) The ideal lateral scleral triangle is larger, wider, and more pointed than the medial scleral triangle

14. When working up blepharoptosis the normal margin reflex distance for the upper eyelid (MDR-1) is:

(a) Less than 10 mm

(b) *Greater than 2.5 mm*

(c) 0–5 mm

(d) 15 mm or greater

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Browplasty

19

Virginia P. Teti

The facial plastic surgeon must appreciate the contribution of the brow position and its role in periorbital aging and the contribution to upper eyelid skin redundancy. The brow should be repositioned before any intervention is undertaken to address the upper eyelid. After proper repositioning of the brow, the upper eyelid redundancy may be remedied entirely or the amount of upper eyelid skin required for removal may be reduced.

Anatomy

- Subunits: The forehead represents the upper third of the face and may be divided into subunits based on the vertical fifths of the face: the central forehead, lateral forehead, and brows. The anatomic boundaries include the trichion or anterior hairline superiorly, the supraorbital rim and nasion inferiorly, and the temporal line laterally.
- Vascularity: Branches of the external and internal carotid provide vascularity to the forehead. Namely, the superficial temporal artery and subsequent zygomaticotemporal branches provide blood supply to the lateral forehead. Centrally, the internal carotid via the ophthalmic artery provides the supratrochlear and supraorbital branches, located approximately 1.7 cm and 2.7 cm from the midline, respectively.
- Innervation:
  - Sensory: All branches of the trigeminal nerve provide sensation to the forehead. Central forehead sensation is supplied by the ophthalmic (V1) division of the trigeminal nerve via the supraorbital and supratrochlear nerves. Laterally, the lacrimal branch of V1, the zygomaticofacial branch of V2, and the auriculotemporal branch of V3 provide sensation.
  - Motor: The temporal branch of the facial nerve provides all motor innervation. The temporal branch exits the parotid and courses superiorly from a point 1.5 cm below the external auditory canal, crossing the zygoma approximately 2.5 cm anterior to the auditory canal and traverses superomedially toward to the frontalis muscle, approximately 2 cm lateral to the lateral orbital rim. The temporal or frontal branch of the facial nerve traverses within the temporoparietal fascia, prior to innervating the frontalis muscle from below. Endoscopically, the zygomaticotemporal vein, otherwise known as the

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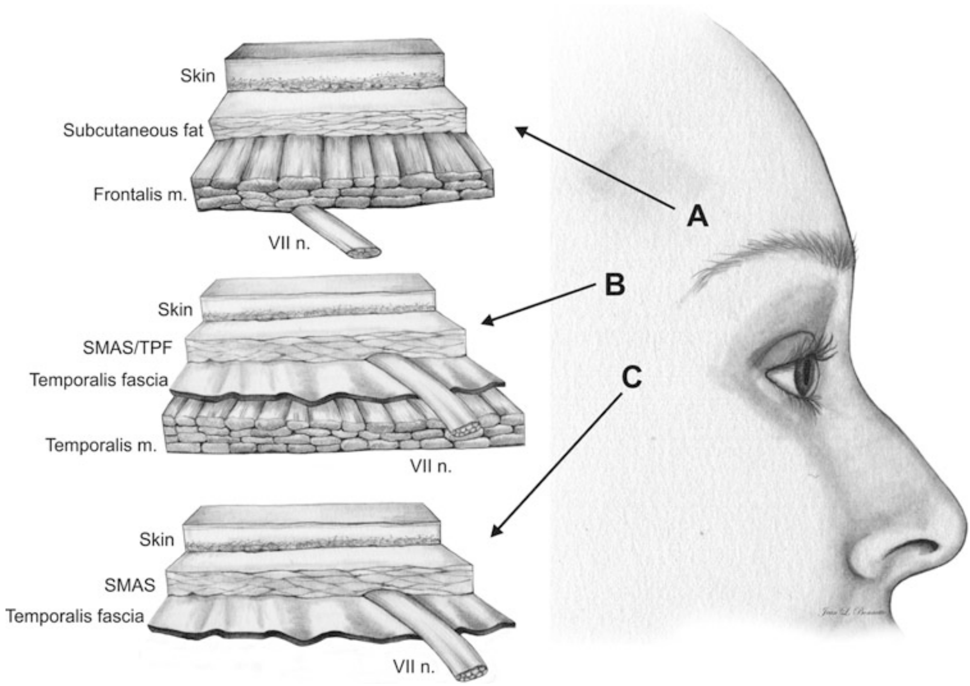

Fig. 19.1 Pathway of the frontal branch of the facial nerve. Note the frontal branch of the facial nerve traverses beneath the frontalis muscle in the forehead (*area* **a**); yet in the temple, the nerve is intimately associated with the temporoparietal fascial layer (*area* **b**) and within close proximity to the overlying skin while traversing over the zygomatic arch (*area* **c**)

"sentinel" vein, may serve as a landmark of the temporal branch of the facial nerve; the nerve typically runs immediately superficial to this vessel and must be protected if cautery is required.

- Layers: The forehead layers are extensions of the scalp. The mnemonic SCALP reminds us of the surgical layers of the scalp from superficial to deep, namely skin, subcutaneous tissue, aponeurosis of the galea and frontalis muscle, loose connective tissue, and the pericranium. Laterally, the galeal layer is continuous with the temporoparietal fascial layer, which is continuous with the superficial musculoaponeurotic system (SMAS) inferiorly.
- Muscles: The predominant muscle of the forehead is the anterior belly of the occipitofrontalis muscle. The vertical orientation of the frontalis muscle creates the transversely oriented relaxed skin tension lines (RSTL) of the forehead. The primary brow elevator is the frontalis muscle. Brow depressors include the paired corrugator supercilii, procerus, and orbicularis oculi muscles. The corrugator supercilii muscles form the glabellar vertical rhytids and the procerus muscle forms the transverse glabellar rhytids. Lateral rhytids at the lateral canthus, otherwise known as crow's feet, appear secondary to orbicularis oculi contraction (Fig. 19.1).

Aesthetics of the Orbital Complex and Brow Positioning

The ideal brow shape and position vary depending on gender, age, culture, and current aesthetic trends (Fig. 19.2).

- Women:
  - The medial brow begins at a vertical line drawn through the medial canthus extending to the alar-facial junction.

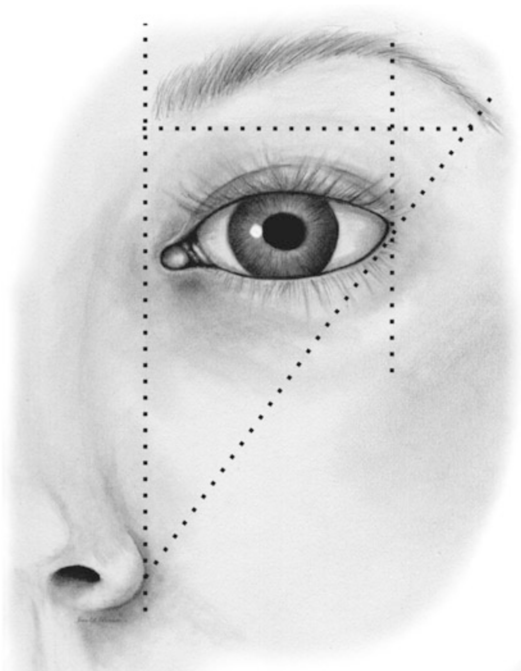

Fig. 19.2 The ideal female brow. Note the apex of the brow is tangent to the lateral canthus

 - The brow is club shaped medially and gradually tapers while resting above the supraorbital rim.
 - The apex of the brow typically arches above the lateral limbus; yet recent trends have supported a more laterally based apex tangent to the lateral canthus.
 - The lateral brow ends along an oblique line drawn through the alar-facial junction and lateral canthus while resting on the same horizontal plan as the medial brow.
 - The average height of the female brow from eyebrow to hairline is typically between 5 and 6 cm. Forehead heights greater than 7 cm may be aesthetically improved with forehead shortening maneuvers.
- Men:
 - The male brow shape should assume a more transverse orientation and rest along the orbital rim.
 - The male brow is thicker and flatter than the female brow and should taper slightly while traversing from medial to lateral.
 - An isolated elevation of the medial brow creates an unnatural, surprised look while an arched shape to the brow creates a "feminized" appearance.

Preoperative Analysis: Anatomic Considerations

Individuals with ptotic eyebrows often involuntarily attempt to elevate the brow via contraction of the frontalis muscle. The surgeon must encourage patients to close their eyes and allow the forehead to relax. Only then may the surgeon accurately assess the actual position of the brow and the degree of upper eyelid dermatochalasis. Overaggressive resection of brow or upper eyelid skin may result in further brow ptosis, short upper eyelid syndrome, and lagophthalmos.

When determining which brow-lifting procedure to perform, one must consider specific factors of the patient:

- Location of frontal and temporal hairline
- Quality of hair—alopecia, thinning, or abundant.
- Forehead height relative to facial proportions.
- Eyebrow aesthetics—shape, symmetry, quality, position, and mobility
- Degree of dermatochalasis of the upper eyelids, lateral canthal hooding, medial fat pseudoherniation
- Presence of eyelid ptosis or eyelid lagophthalmos
- History of dry eyes, prior eye surgery or blepharoplasty, thyroid disorders

Static and dynamic rhytids must be assessed preoperatively. Older patients typically have more subcutaneous atrophy and hence rhytids appear more pronounced due to actions of the muscle being transmitted directly to the skin.

Fair and thin-skinned patients usually heal with more favorable scars than individuals with darker or sebaceous skin. Older patients often demonstrate thinner scars secondary to decreased skin elasticity.

Nearly all patients have some aspect of facial asymmetry. Passive and active asymmetries of the brow must be noted preoperatively. Dynamic eyebrow asymmetries should not be addressed. Surgeons must take caution if attempting to correct a static brow asymmetry, as these subtle changes may alter the patient's unique facial characteristics.

Forehead bony contour should be noted. Women with frontal bossing or prominent supraorbital rims may appear masculinized. Bone reduction or alloplastic augmentation techniques may be considered.

In general, the brow elevation procedure is performed first before an upper lid blepharoplasty, if indicated. Often, after correction of the brow position, the amount of upper lid eyelid redundancy is significantly reduced, allowing the surgeon to accurately assess the need for blepharoplasty, thereby limiting the risk of lagophthalmos.

Similar to other facial plastic surgery procedures, accurate preoperative and postoperative measurements and photographic documentation are essential for introspective critique and medicolegal security. Typical views include the frontal full face, lateral, oblique, and frontal views with brows at rest, raised, and frowning.

Selection of Browplasty Techniques

A variety of procedures and incisions exist designed to improve the brow position from which the facial plastic surgeon must select based on individual anatomic and aesthetic considerations.

- A chemical brow lift is a nonsurgical therapeutic option used to elevate the temporal brow by using Botox (Allergan, Irvine, CA) to selectively denervate the temporal brow depressors, the lateral orbicularis muscle. Unopposed elevation by the frontalis muscle leads to brow elevation, typically providing 3–4 mm in vertical height ((Fig. 19.3).

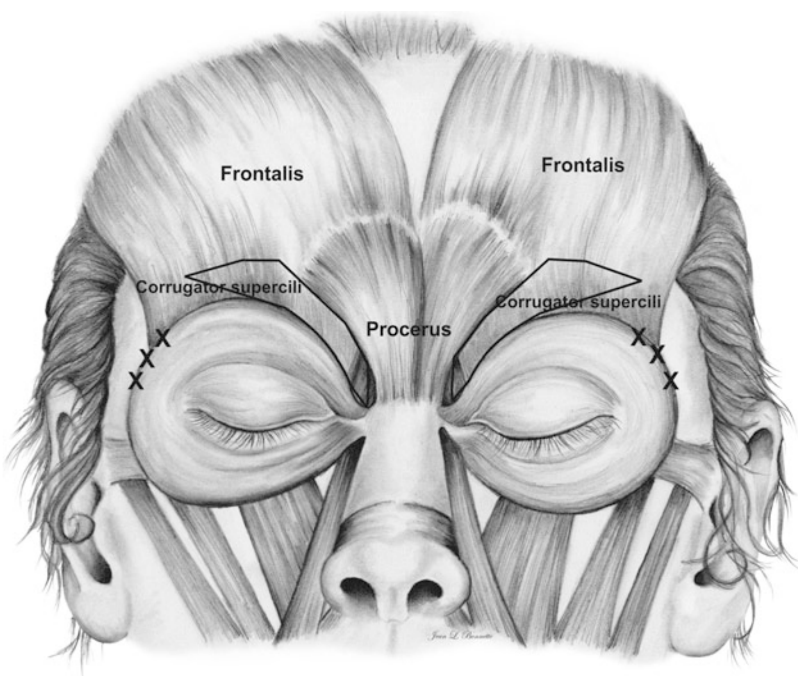

Fig. 19.3 Muscular anatomy of the brow and forehead. *X* indicates the lateral orbicularis oculi muscle and site for injection of Botox to elevate the temporal brow

Surgical Techniques

In general, the techniques for surgical rejuvenation of the upper face may be considered within three categories: the coronal lift and modifications, the direct brow lift and modifications, and the endoscopic brow lift. The indications, advantages, and disadvantages are listed in the chart along with details of the surgical techniques described below (Table 19.1).

Coronal forehead lift:

- The coronal lift remains a reliable method to address a forehead with short vertical height with significant brow ptosis and forehead rhytids. Exposure of the forehead musculature allows for precise myoplasty, if desired.
- Patients must be counseled on visible scarring and possible alopecia, scalp hypesthesia, and posterior displacement of the hairline.
  - Technique: The surgical curvilinear incision is placed approximately 4–6 cm posterior to the hairline and designed in a beveled fashion to minimize follicle injury.
  - A subgaleal dissection is performed until 1–2 cm above the supraorbital rim. Laterally, blunt dissection proceeds above the superficial layer of the deep temporal fascia. The flap is dissected over the supraorbital rim to release the arcus marginalis in a subperiosteal plane.
  - Myoplasty of the corrugator and procerus muscles may be performed bluntly with care to avoid the supratrochlear artery and nerve traversing around and through the corrugator. The frontalis muscle is identified in the flap and unipolar cautery may be used to incise the muscle and galea immediately deep to the horizontal forehead crease, with care to remain medial to the midpupillary line to avoid injury to the temporal branch of the facial nerve. Lastly, excision of frontalis or procerus muscle is commonly avoided to prevent contour irregularities.
  - The flap is advanced superiorly and posteriorly with an appropriate amount of redundant skin excision parallel to the hair follicles. The incision is closed in layers and a suction drain may be used for 24 h.

Table 19.1 Surgical indications and considerations for brow lifting

Procedure	Indications	Advantages	Considerations and disadvantages
Browpexy	Mild brow ptosis	Performed via upper lid blepharoplasty	Possible brow asymmetry, possible, prolonged eyelid edema
Direct brow lift	Correct brow asymmetry, unilateral brow ptosis, pale-nonsebaceous skin	Most accurate brow elevation, preserves forehead sensation, favorable scar camouflage in patience with nonsebaceous skin	Visible scare, sharply defined suprabrow, only treats the brow with limited glabella exposure
Midforehead lift	Correct brow asymmetry, patients with thick horizontal forehead rhytids and androgenic baldness	Precise brow elevation, useful in patients with horizontal forehead creases, preserves the hairline	Visible scar, avoid in oily, thick skin
Endoscopic brow lift	Less invasive brow and forehead lift	Excellent scar camouflage, preserves hairline	Less precise manipulation of brow position, possible soft tissue irregularities due to brow fixation techniques
Trichophytic forehead lift	High forehead	Reduces vertical height of high forehead, preserves hairline	Visible scar, prolonged hypesthesia of scalp hairline alopecia
Coronal forehead lift	Forehead and brow lift, low forehead	No visible scars, increases vertical height of low forehead	Elevates the hairline, vertically lengthens the upper third of the face, visible scar, less precise manipulation of brow position

- Disadvantages of this technique include the elevation of the anterior hairline, temporary or permanent hypesthesia or paresthesia posterior to the incision and the risk for hematoma formation.
- Due to the distance between the incision and the brow, the coronal lift and its modifications are not routinely used to correct precise brow asymmetries.

Trichophytic forehead lift:

- The pretrichial forehead lift can offer a means of shortening the vertical height of the forehead in patients with a high hairline. The procedure offers the benefit of reducing the redundant forehead skin without raising the anterior hairline (Fig. 19.4).
  - Technique: The incision is designed in an irregular fashion approximately two or three hair follicles behind the anterior hairline. The incision is beveled parallel to hair follicle shaft to allow ingrowth of hair and designed at the junction of the cephalad forehead and anterior hairline to optimize scar camouflage. The pretrichial incision is extended laterally in the temporal region posterior to the hairline.
  - The flap is elevated in a similar fashion to the coronal lift with similar options to perform myoplasty, if desired.
- Disadvantages include the visible scar despite meticulous closure and the broader area of anesthesia posterior to the incision.

Temporal lift:

- This lift is designed to address the lateral one-third of the brow and indicated primarily for female patients with appropriate medial brow position and isolated lateral brow ptosis. This procedure offers excellent results, yet

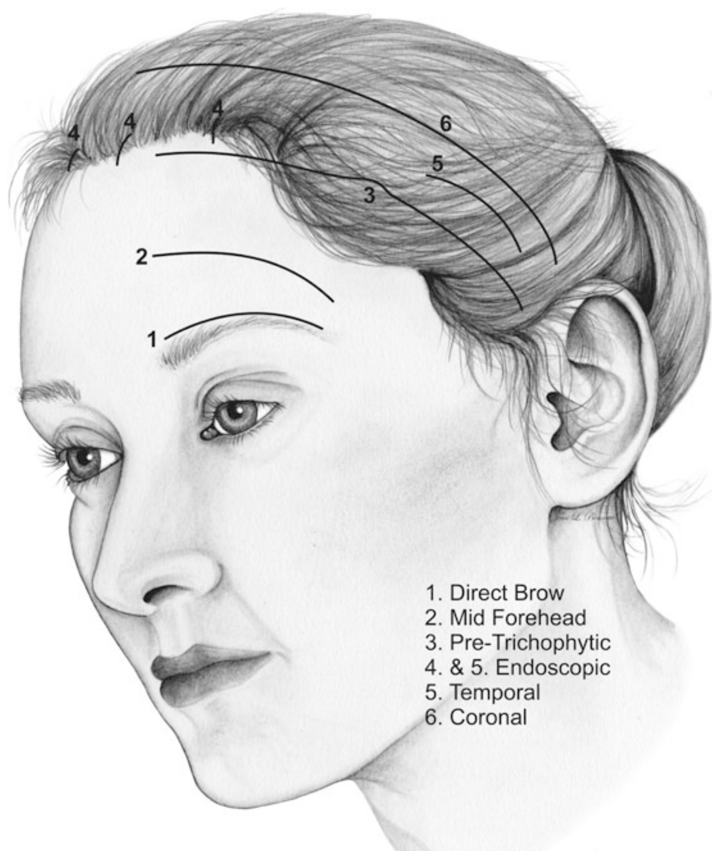

Fig. 19.4 Proposed incision placement for brow lift procedures in oblique view: *1*. Direct brow. *2*. Midforehead. *3*. Pre-trichophytic. *4,5*. Endoscopic port sites and temporal incision. *5*. Temporal lift. *6*. Coronal

requires complete release of the temporal line, lysis of all brow ligaments, and release of the periosteal ligaments along the orbital rim.

  - Technique: The incision is typically 2 cm posterior to the temporal hairline and dissection proceeds along the superficial layer of the deep temporal fascia. The dissection extends inferiorly to identify the lateral orbital rim with release of the arcus marginalis, conjoint tendon, and temporal line to enable lateral brow mobility. Use of the endoscope is commonly practiced to improve visualization of the zygomaticotemporal (sentinel) vein and adequate release of the arcus marginalis. Finally, lateral suspension is directed superiorly and posteriorly and secured with suture secured from the deep temporal fascia to the temporoparietal fascia. The scalp is closed in layers.

Midforehead brow lift:

- The midforehead brow lift may be considered in males with deep horizontal rhytids and a receding anterior hairline.
  - Technique: An elliptical incision is designed around the rhytid with two-thirds of the ellipse above the incision and one-third below. Two different horizontal rhytids are selected to stagger the incisions; however, some surgeons prefer one continuous incision across the brow, often requiring an intentional irregularization to improve scar camouflage.
  - The overlying skin and subcutaneous tissue is excised until the frontalis muscle is exposed. Dissection proceeds in the subcutaneous plane until the orbicularis oculi muscle or supraorbital rim is exposed.
  - Horizontal mattress sutures are placed inferiorly through the orbicularis oculi muscle and attached superiorly to the periosteum. A layered skin closure then follows.

Direct brow lift:

- The direct brow is commonly indicated to modify an asymmetric or ptotic brow. Technically, this method requires minimal undermining with relative low risk of damage to the supratrochlear and supraorbital neurovascular bundles. The control of the brow positioning is direct, yet requires precise placement of permanent suspension sutures to the superior periosteum. Due to the proximity of the incision to the brow, this technique allows precise changes in the brow position and may be useful in cases of unilateral facial paralysis to correct the ptotic brow.
  - Technique: An ellipse of skin is resected from the suprabrow area to elevate the brow approximately 4–8 mm above the opposite eyebrow. The inferior border of the skin ellipse is incised along the superior margin of the eyebrow parallel to the axis of the hair shafts, with great care to avoid injury to the hair follicles of the brow. The incision is beveled to maximize scar eversion. Horizontal suspension sutures are placed between the sub-brow dermis and the forehead periosteum approximately 1 cm above the desired point of eyebrow elevation. The skin incision is closed in a layered fashion.
  - Alternatively, the ellipse of skin incision may be designed in a prominent midforehead rhytid in an attempt to camouflage the incision, utilizing the same surgical technique as described above.

Browpexy:

- This procedure is typically indicated in women with mild-to-moderate brow ptosis.
  - Technique: A standard blepharoplasty excision of skin and orbicularis muscle is performed followed by dissection superiorly toward the brow in a submuscular orbicularis plane or in a subperiosteal plane, extending above the superior orbital rim. Permanent suture is then passed transcutaneously at the level of the infrabrow hairs into the sub-brow space and then passed through the periosteum above the supraorbital rim. It is then secured through the sub-eyebrow tissue at

the level of the original transcutaneous sutures. With tightening of the suture, the eyebrow will be elevated. Precise placement and tension of each suture may allow modification of the eyebrow position based on the degree of elevation desired. The blepharoplasty procedure is then completed.

- Risk of this procedure involves potential injury to the supraorbital neurovascular bundle resulting in bleeding or forehead anesthesia. Additionally, due to the meticulous suspension suture placement, dimpling of the thinner eyelid skin, overcorrection with lagophthalmos, and inadequate correction of brow ptosis have been described.

Endoscopic brow lift:

- The indications for the endoscopic brow lift are similar to the coronal lift with the advantage of direct endoscopic visualization, magnification, and perhaps improved identification of the supraorbital and supratrochlear neurovascular bundles. Advantages include the use of smaller incisions made possible with the use of the endoscope, decreased incidence of sensory neuropathy and alopecia, and less bleeding compared to the coronal lift. Key principles of endoscopic brow lift include subperiosteal dissection and adequate and complete release of the arcus marginalis.
  - Technique: Typical incision placement includes a midline sagittal, and bilateral paramedian incisions tangent to the midbrow (or at the location of the desired brow apex between the lateral canthus and lateral limbus) that are typically 2 cm in length and located 1–2 cm posterior to the anterior hairline. Additionally, two temporal incisions are marked in an elliptical fashion obliquely oriented from the alar-facial junction, through the lateral canthus, and parallel to and approximately 1–1.5 cm posterior to the hairline. These locations may vary depending on surgeon preference.

Dissection: The central scalp and paramedian incisions are elevated anteriorly and posteriorly in a subperiosteal plane, typically in a blunt fashion, and dissections proceed to a level 1–2 cm above the supraorbital rim, as the neurovascular bundle and/or branches can emanate from a true foramen above the supraorbital rim in approximately 10 % of cases. The endoscope is then introduced to allow improved visualization of the supratrochlear and supraorbital neurovascular bundles while releasing the arcus marginalis over the orbital rim and onto the nasion. Laterally, the temporal incisions are dissected similarly to the lateral brow lift as described above. Of note, the sentinel vein lies in close proximity to the temporal branch of the facial nerve. If bleeding arises from this vessel, cautery should be applied with great care at the deep aspect of the vessel to avoid overlying nerve injury. The temporal line is divided from lateral to medial to connect the two planes. Transverse releasing incisions are made through the periosteum along the supraorbital margin to allow appropriate brow mobility and release.

Fixation: Multiple fixation techniques have been described in the literature including no fixation, skin staples and taping, microscrew placement in the paramedian incision and fixation with skin staples posterior to the microscrew, suspension sutures with microscrew fixation, sutures secured through cortical bone tunnels, sutures secured to miniplates, and absorbable screws and cortical anchors (Endotine Coapt system, Palo Alto, CA). Sclafani et al. reported that a minimum of 6 weeks is required for adhesion between the cranium and overlying periosteum. Additionally, Thomas et al. demonstrated in the rabbit model that in 8 weeks the biomechanical strength of the dissected subperiosteal versus subgaleal flaps were similar to matched, undissected controls.

– The temporal incisions are closed as described in the temporal lift and staples are utilized to close the midline and paramedian anterior scalp incisions.

Complications

Endoscopic	Open
Paresthesia/dysesthesia (6.2 %)	Alopecia (8.5 %)
Asymmetry (3.6 %)	Unacceptable scarring (1.4–3.6 %)
Alopecia (3.0 %)	Paresthesia/dysesthesia (0.3–5.4 %)

- Substantial heterogeneity exists in the reporting of paresthesia in the literature (specifically, nerve distribution, severity, and duration of paresthesia). Paresthesia/dysesthesia most frequently occurs with anterior hairline, midforehead, and endoscopic techniques. Coronal lift in the subperiosteal plane is associated with the highest risk of injury to the frontal branch of the facial nerve (6.4 %) while motor injury is less likely to occur in the subgaleal plane.
- The anterior hairline approach in the subcutaneous plane demonstrated the overall highest probability of alopecia.
- Infection or abscess formation is unlikely to occur in any of the techniques studied (0.2–0.4 % incidence).

Questions

Browplasty Review Questions:

1. Which of the following techniques will shorten the vertical height of the forehead?
   (a) Midforehead lift
   (b) Direct brow lift
   (c) Endoscopic brow lift
   (d) Pretrichial lift
2. While performing a midforehead lift, indicate the proper plane of dissection?
   (a) Subcutaneous
   (b) Subfrontalis
   (c) Subgaleal
   (d) Subperiosteal
3. A patient is concerned over her “angry” appearance and presents with prominent vertical furrows between her brow. You offer treatment with botulinum toxin A. Where should you inject this product and how many units would you advise?
   (a) 20 units, bilateral corrugator supercilii muscles
   (b) 4 units, bilateral lateral orbicularis oculi muscle
   (c) 10 units, procerus muscle
   (d) 20 units, frontalis muscle
4. A younger patient presents to your office with mild-to-moderate lateral hooding of her upper eyelids secondary to lateral brow ptosis. She is reluctant to undergo surgical correction of her brows. To improve her condition, you offer her:
   (a) Reassurance. Gently tell the patient that no intervention is warranted.
   (b) Botulinum toxin A—to forehead, 20 units
   (c) Botulinum toxin A—to procerus, corrugator supercilii m, 20 units
   (d) Botulinum toxin A—to lateral orbicularis oculi m, 10 units
5. A 63-year-old female presents to your office with moderate brow ptosis and a high hairline. Which procedure would change her hairline most significantly?
   (a) Trichophytic lift
   (b) Coronal lift
   (c) Endoscopic temporal lift
   (d) Direct brow lift
6. While performing a temporal brow lift, indicate the proper plane of dissection?
   (a) Subcutaneous
   (b) Temporoparietal fascia

(c) Superficial layer of the deep temporal fascia
(d) Subperiosteal

7. Which of the following techniques will allow the most accurate eyebrow lift with the greatest elevation per millimeter of tissue excised?
   (a) Direct eyebrow lift
   (b) Midforehead lift
   (c) Temporal lift
   (d) Endoscopic lift

Answers: 1. (d), 2. (a), 3. (a), 4. (d), 5. (b), 6. (c), 7. (a)

Additional Resources

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Cheiloplasty

20

Yuan Liu, Jared Inman, and Farhad Ardeshirpour

Anatomy

Limits

- Upper: nasal base.
- Lower: mental crease.
- Lateral: melolabial and labiomandibular creases.

Tissue Layers (Fig. 20.1)

- Lip skin: contains hair, sebaceous glands, eccrine glands.
- Orbicularis oris muscle: sphincteric arrangement with decussation at commissures, where lip elevator, depressor, and buccinator muscles join (modiolus).
- Mucosa: relatively few salivary glands compared to rest of oral cavity.

Arterial supply: *superior/inferior labial artery* (courses horizontally in submucosal plane, posterior to orbicularis oris, at about level of anterior vermillion line; medially, upper division may rise slightly; both may have tortuous path through muscle)

External carotid → facial artery→ labial artery

Venous outflow: not well defined. Typically venae comitantes.

- *Superior/inferior labial vein→facial vein→internal jugular* (**or** joins anterior branch of *retromandibular vein* to form *common facial vein*, which drains into *internal jugular)*. Upper lip may have deep venous system separate from arterial.

Innervation: upper lip: *infraorbital nerve→maxillary branch of trigeminal nerve (V2)*. Lower lip: *mental nerve* (emerges from mental foramen usually apical to 2nd premolar or between apices of lower premolars)→*inferior alveolar nerve→mandibular branch of trigeminal nerve (V3).*

Relaxed skin lines: course radially, perpendicular to underlying orbicularis oris muscle.

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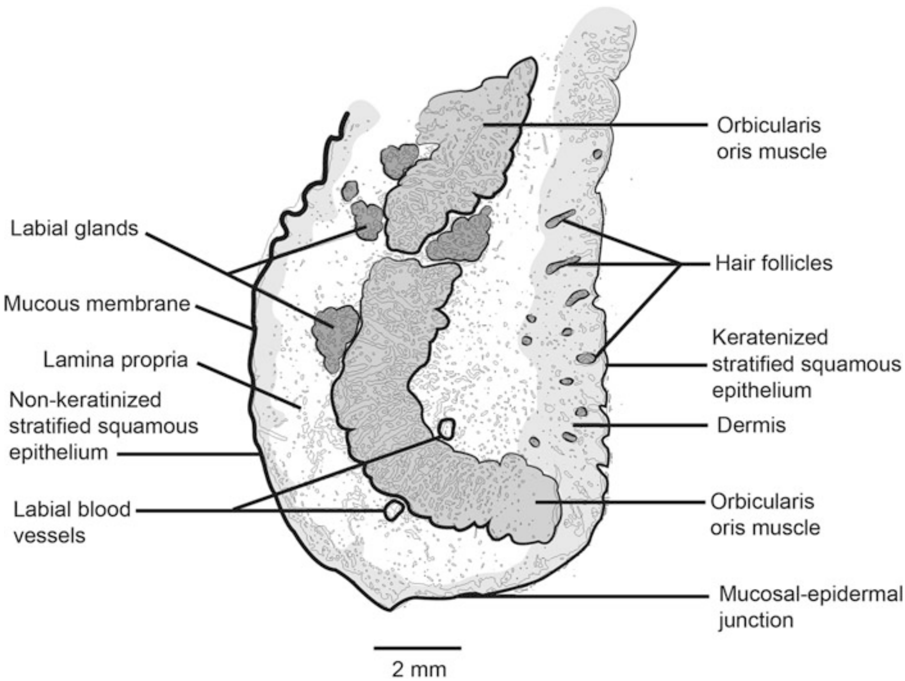

Fig. 20.1 Layers of the lip and structures contained in each layer

Vermillion

- *External demarcation*: anterior vermillion (or mucocutaneous) line at transition to lip skin.
- *Internal demarcation:* posterior vermillion (or wet) line, which separates dry and wet vermillion, and is the innermost line of contact with lips closed.
- Red color due to lack of keratinization and underlying capillary plexus.
- Mostly devoid of hair follicles, sweat glands, and sebaceous glands.

Philtrum: embryologically derived vertical ridges of no functional, but aesthetic significance.

Cupid's bow: two high points of upper lip anterior vermillion line with V-shaped depression in between (Fig. 20.2).

White roll/line: raised line of skin at transition from anterior vermillion line to lip skin. Possibly functions as excess skin to allow complex movements of lip.

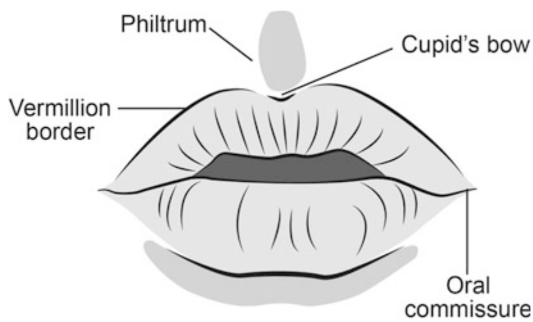

Fig. 20.2 Borders of the lip

Embryology

Upper lip: paired maxillary swellings fuse with paired medial nasal swellings. Gives rise to philtral ridges and Cupid's bow.

Lower lip: paired mandibular swellings fuse together. Less elastic than upper lip due to fewer fusion planes.

Analysis and Physical Exam

No ideal standard of beauty, and varies for different people and perspectives. However, there are some proportions and features which may contribute to attractiveness.

Frontal View

– Distance between menton and subnasale = 1/3 distance from menton to hairline.
– Distance between menton and subnasale = distance from subnasale to glabella.
– Upper lip height = lower lip height = 1/3 distance from subnasale to menton (Fig. 20.3).

Lateral View

– Upper lip should fall 4 mm, and lower lip 2 mm, behind line tangent to pogonion and nasal tip inferior break (Fig. 20.4)
– Or, upper lip should lie 3.5 mm, and lower lip 2.2 mm, anterior to line from subnasale to pogonion.

Aging

– Lip size increases in puberty due to muscular and glandular hypertrophy, then gradually decreases thereafter.
– White roll flattens.
– Blunting of Cupid's bow.
– Decreased vermillion show.
– Loss of projection.
– Downturning of commissures.
– Rhytids develop in vermillion and lip skin.

Exam: should consist of all factors mentioned in aging, along with dental occlusion, philtrum definition, dental show, condition of epithelium, chin position, and size of chin in proportion to lips. Must evaluate teeth to assess cause of lip over or under-projection.

Volume: the lower lip has about 50 % greater volume than upper lip.

Smoking changes: increase risk in deep rhytids perpendicular to vermillion border, discoloration, and increase risk of oral cavity malignancy.

Sun damage changes: red, scaly lesions may appear called actinic cheilitis which are premalignant lesions.

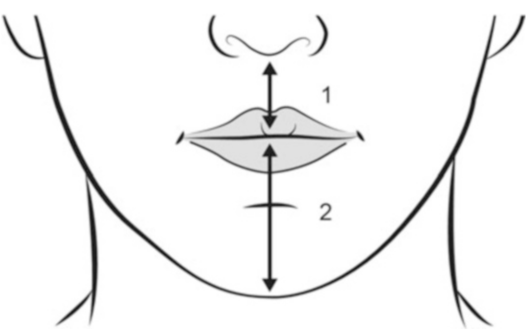

Fig. 20.3 Ratio of upper lip to lower lip. The distance from the subnasale to the junction of upper and lower lips is about half of the distance from the junction to the menton

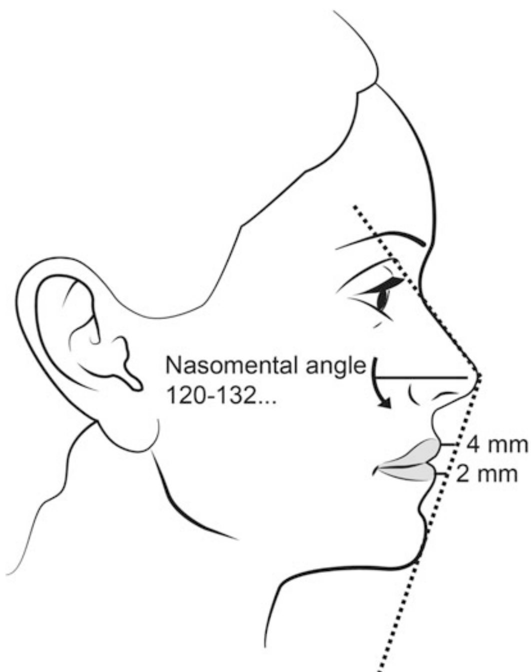

Fig. 20.4 Amount of upper and lower lip protrusion. The upper lip falls about 4 mm, and the lower lip 2 mm, behind the line drawn from the nasal tip to the pogonion

Rhytid Treatments

Development of rhytids is accelerated by sun exposure, cigarette smoking, and frequent puckering (e.g., smoking, straws).

Botulinum toxin A (Botox): injected immediately beneath skin in the middle of rhytids. Helps more with hyper-dynamic rather than static rhytids. Also creates lip eversion and fullness. Narrow therapeutic window: functional motor impairment versus cosmetic relaxation (Semchyshyn and Sengelmann 2003).

Fillers: See below for details. May be combined with Botox for longer lasting results.

Resurfacing: dermabrasion, chemical peels (e.g., phenol-based solutions), CO_2 laser (for deep rhytids). CO_2 is ideal laser as it creates a deep injury with subsequent remodelling, but prolonged erythema requiring use of heavy makeup.

Augmentation Cheiloplasty

Involves either increase in vertical height of lip or projection of lip. Augmentation can be achieved with a number of different methods including autologous material, injectable fillers, tissue advancement, alloplastic implants, and surgery. For lengthening, material is placed submucosally in the inferior edge of upper or superior edge of lower lip. For more projection, material is placed in the same plane anteriorly. Lip augmentation should be uniform, with emphasis on accentuating the central lip. Excessive lateral augmentation results in an unnatural look and should be avoided.

Autologous Materials

- *Fat*: unpredictable resorption rate, generally 20–50 %. Has become more reliable with newer harvest and injection techniques but fat persistence in the lips remains lower than fat augmentation elsewhere in the face. Liposuction risks (Botti and Villedieu 1995)
- *Dermis-fat*: donor fat excised instead of liposuctioned. Much more predictable results that fat injection. Smooth, long-lasting, versatile (Niechajev 2000)
- *Fascia* (e.g., temporalis fascia): gives thin, minimal augmentation (Recupero and McCollough 2010)
- *SMAS*: variable survival, up to 5 years (Leaf and Firouz 2002, Recupero and McCollough 2010)
- *Tendon* (e.g., palmaris longus tendon): long lasting. Maintains lip mobility (Trussler et al. 2008)

Fillers: injected just below dermis.

Injectable fillers have gained popularity for lip augmentation. Although the majority of fillers used are off-label by the FDA, their availability and reliability have made these products a first-line treatment option for patients needing volume enhancement. Although a number of injectable fillers are on the market, hyaluronic acid fillers remain the preferred product of choice.

Hyaluronic acid (Juvéderm, Restylane, Perlane): preferred material for augmentation.

- *Bovine* (Zyplast, Zyderm) *or porcine collagen* (Permacol, Evolence)*:* generally nonreactive. Newer versions decreased risk of hypersensitivity. Lasts 2–6 months. Now largely historical and no longer available in the USA (historical)
- *Hyaluronic acid* (Juvéderm, Restylane, Perlane, Belotero Balance): preferred material for augmentation. Malleable. Can be injected along philtrum, white roll, rhytids, and vermillion. Generally nonreactive, but carrier components may elicit allergic reaction. Lasts 6–12 months. Commonly used, well tolerated, high satisfaction rate. Reversible with hyaluronidase injection (Philipp-Dormston et al. 2014, Glogau et al. 2012). Belotero Balance is an HA used commonly

for fine perioral rhytids. It does not produce a Tyndall effect.

– *Polyacrylamide gel* (Royamid, Aquamid): high rate of granuloma formation and infectious complications. Permanent (Buck et al. 2009). Non-FDA approved
– *Calcium hydroxyapatite* (Radiesse): firm, lumpy. Can cause nodules and stiffness, which limits its usefulness in lip. Lasts 1–2 years. Not recommended for lip augmentation
– *Polymethylmethacrylate* (Bellafill formerly Artefil): polymethylmethacrylate particles stimulate neocollagenesis. Palpable. Permanent. Can cause granulomas or chronic infection. Not recommended for lip augmentation (Salles et al. 2008, Bagal et al. 2007, Solomon et al. 2012)
– *Silicone* (BioPlastique, Silikon 1000): placed using microdroplet technique due to tendency to lump. Permanent. Long-term risk of foreign-body reaction. Can migrate. Unpopular (Buck et al. 2009)
– Aesthetic complication*s*- *"trout pout," "duck lip," "chimp lip"*—all due to overinjection of agent

Implants: placed in submucosal tunnel using tendon passer through commissures. Scarring on vermillion possible from implant incisions.

– *Acellular human dermal matrix* (AlloDerm, Cymetra): estimate size with dry instead of rehydrated state of AlloDerm due to compression in vivo. Injectable form shorter lasting than implantable sheets. Lasting 6–12 months versus partial permanent integration
– *Expanded polytetrafluoroethylene* (dPTFE, Gore-Tex, SoftForm): does not resorb, but develops capsule fibrosis that may tighten or increase firmness of lip. Patients can feel material in lip. Extrusion possible, especially in upper lip due to motion. Permanent. Not favored in most practices due to higher complication rate comparatively
– *Silicone implants*—easily placed, reversible

V-Y advancement**:** technique involves recruitment of oral mucosal to achieve augmentation. Incision made down to orbicularis oris. Place apex of V inward. Multiple Vs (W-plasty) can be used in series to advance wider area of tissue. May have less predictable results. Useful for patients with very thin lips. Scarring not significant. Complications include potential "fish mouth" deformity, lowering of upper lip, and minimal loss of animation (Aiache 1991). Prolonged edema and swelling. Transient loss of sensation, and this may take some time to resolve. Very bold and distinctive appearance postoperative (Fig. 20.5).

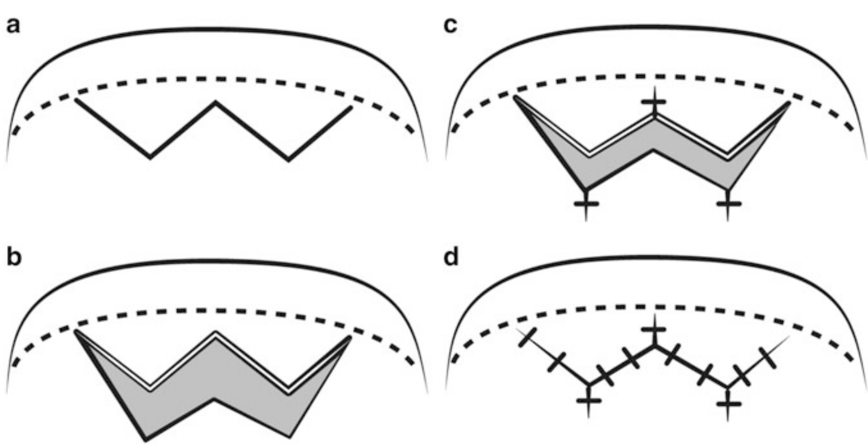

Fig. 20.5 W-plasty. Consists of 2 V-to-Y advancements to increase the height of the lip by sacrificing width

Reduction Cheiloplasty

Vermillion advancement: excision of ellipses of cutaneous skin next to vermillion. Skin excised down to fascia right above muscle but not through fascia. No undermining of edges. Can be used to better define Cupid's bow. Will maintain white roll.

Nasal base resection: seagull-shaped incision following contour of nasal base, may extend into nasal sill. Excise in subcutaneous plane. Good for long upper lip and well-defined Cupid's bow.

Vermillion reduction: resect equal amount of tissue on either side of wet line. May excise muscle along with mucosa. Preserve lower lip height at level of lower incisors (Niamtu 2010)

"Bikini lip reduction": excision of "bikini top"-shaped area (infinity loop) from upper lip and triangular area (with point down) from the lower lip. Designed to maintain upper to lower lip volume proportion (Fig. 20.6)

Complications

- Bleeding.
- Infection: consider antiviral for history of herpes simplex.
- Incision dehiscence: after surgery, rest lips for 2 weeks. May feel tightness with smiling for 6–8 weeks. Avoid smoking.
- Paresthesia: may last up to 6 months.
- Asymmetry: may be treated with steroids if caused by localized edema.
- Accentuation of pre-op defects: identify these pre-op.
- Implant extrusion: remove exposed portion. Large extrusions may require complete removal. Steroid injections may be used for tightness from scar tissue formation in extrusion pocket.
- Minor defects: can be corrected with permanent cosmetics or dermal pigmentation.

Questions

1. Where and in what orientation does the main arterial blood supply for the lips travel?
   (a) Under the skin surface superficial to the orbicularis oris muscle, coming in horizontally from the commissures
   (b) Within the orbicularis oris muscle, coming in horizontally from the commissures
   (c) Deep to the orbicularis oris muscle, under the mucosa, coming in horizontally from the commissures
   (d) Deep to the orbicularis oris muscle, under the mucosa, coming in vertically from the nares and chin
2. True or false: the lip vermillion is abundant in minor salivary glands
3. True or false: the relaxed skin lines around the lips are parallel to the anterior vermillion border
4. What is the ideal relationship between the height of the upper lip, the height of the

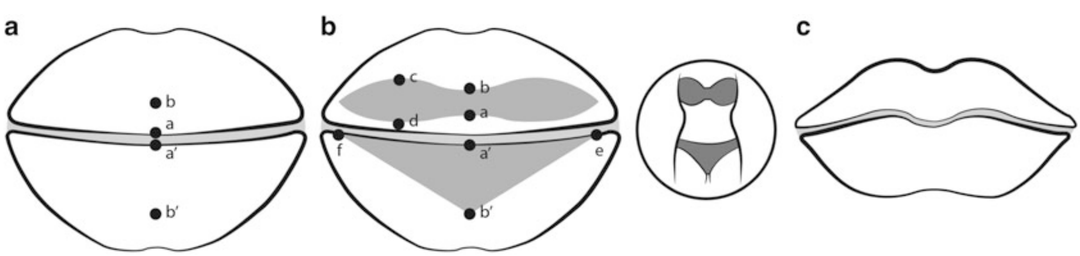

Fig. 20.6 "Bikini" lip reduction design

lower lip, and the distance between the nasal base and the menton?

5. Where should the upper and lower lip reside along the horizontal position (a line drawn tangent to the subnasale and the pogonion)?
6. How do the lips change with age?
7. What effect does Botox have when injected into the lips?
   (a) No cosmetic effect
   (b) Reduces rhytids
   (c) Increases lip fullness and eversion
   (d) b and c above
8. What is the advantage of using autologous materials versus exogenous fillers and implants for lip augmentation?
9. What do calcium hydroxyapatite, silicone, and polymethylmethacrylate have in common as lip fillers?
   (a) Short to moderate duration of effect
   (b) Easily reversible if desired
   (c) Pliable and natural feeling
   (d) Can cause granuloma formation
10. What is an advantage of expanded polytetrafluoroethylene (ePTFE) over acellular human dermal matrix as a lip augmentation implant?
   (a) Lower risk of extrusion
   (b) More softer and more natural feel
   (c) Longer duration of effect
   (d) Lower risk of scarring and fibrosis

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Chemical Peels 21

David M. Lieberman

Indications for Chemical Peeling

(a) Photodamage
(b) Rhytides
(c) Actinic changes
(d) Dyschromia
(e) Acne scars

Photoaging

– UVA and UVB generated free radicals
– Leads to DNA changes and upregulation of metalloproteinases
– Downstream effects include breakdown of collagen and solar elastosis

With chemical peels, it is always a balance of benefit and risk

– The deeper the peel, the more significant the result *and* the higher the risk and downtime
– Candid discussion with the patient about this balance is essential

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Skin Analysis

Cross-sectional anatomy of the skin:
Epidermis:

- Four distinct cell types:
  – Keratinocytes
  – Melanocytes
  – Langerhans cells (dendritic cell found in prickle cell layer, contain cytoplasmic organelles called Birbeck granules, likely mediate immunologic response by acting as antigen-presenting cell)
  – Merkel cells (basal cell layer, neuroendocrine cells)
- Five layers:
  – Basal cell layer (stratum germinativum)
  – Prickle cell layer (stratum spinosum)
  – Granular cell layer (stratum granulosum)
  – Cornified layer (stratum corneum) **anucleated layer*

Rete ridges: projections of bottom of epidermis, help to anchor epidermis into the dermis

Dermis:

- Papillary dermis: loose collagen, blood vessels, fibrocytes (synthesize collagenase), surrounds adnexal structures
- Reticular dermis: thicker, compact collagen

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Pilosebaceous Unit

- Contains: hair, hair follicle, sebaceous gland, sensory end organ, arrector pili muscle
  - Sebaceous component predominant in areas like the nose
  - Hair component predominant on the scalp or bearded areas

Patient Selection and Analysis

Fitzpatrick Classification (Table 21.1)

- Originally created to classify patients prior to a study on the effects of oral methoxsalen photochemotherapy (PUVA) on psoriasis (Fitzpatrick 1988)
- Classification initially based on a person's tendency to burn versus tan (melanogenesis)
  - Based on response to minimum erythema doses (MEDs)
    - MED: 60 min of noon summer sun exposure
- Also divided according to baseline skin pigmentation
- **Valuable when stratifying risk of performing chemical peels**
  - Risk Level:
    - Type I or II: lower risk for hypopigmentation or post-inflammatory hyperpigmentation
    - Type III or IV: higher risk of dyschromia (abnormal pigmentation) after a peel
      (a) Pre- and posttreatment with bleaching agents, tretinoic acid, and sunscreen necessary

Glogau Photoaging Scale (Table 21.2) (Glogau and Matarasso 1995)

- Photoaging type I: not suitable for deep peels
- Photoaging type IV: not suitable for superficial peels
- Challenge is selecting peels for types II and III

Superficial Chemical Peel

- Removal of either statum corneum (light superficial peel) only or entire epidermis (superficial peel)
- Typically done in a series of treatments to achieve best outcome
- Does not improve dermal issues such as deeper rhytides

Table 21.1 Fitzpatrick

skin type	Skin color	Tanning response
Type I	White, freckled	Always burn, never tan
Type II	White	Usually burn, tans with difficulty
Type III	White, olive	Sometimes mild burn, tan average
Type IV	Brown	Rarely burn, tan with ease
Type V	Dark brown	Very rarely burn, tan very easily
Type VI	Black	No burn, tan very easily

Table 21.2 Glogau

Group	Age (years)	Findings
I: Mild	28–35	Minimal wrinkles; no keratosis; minimal acne scarring; little makeup
II: Moderate	35–50	Early wrinkling with motion; early keratosis; mild scarring; some makeup
III: Advanced	50–65	Wrinkling at rest; actinic keratosis; telangiectasis; moderate scarring; always wears makeup
IV: Severe	60–80	Severe wrinkling; actinic keratosis and skin cancers; severe acne scarring; makeup cakes on

Table 21.3 The Jessner's formula

Resorcinol	14 g
Salicylic acid	14 g
Lactic acid	14 mL
Ethanol	100 mL

TCA 10–20 %

- Light frost, exfoliation of superficial ½ of epidermis
  - Preparation: wash and degrease skin
  - Endpoint: level I frost (erythema and streaky white frost)
  - Redness and peeling for 1–3 days
  - Moisturizer and sunscreen posttreatment
  - Typically used for early wrinkle treatment, mild photodamage

Jessner's solution (Table 21.3)

- 14 % lactic acid, 14 % resorcinol, and 14 % salicylic acid
- Keratolytic agent: removes stratum corneum and destroys portions of the epidermis
- Thought to break intercellular bridges between keratinocytes (effective in preparation for a medium-depth peel)
- Often used for acne treatment on every other week schedule

Alpha-hydroxy acid

- Common agents: glycolic acid 40–70 %, lactic acid, salicylic acid
- Occurs naturally in food (glycolic acid—sugarcane, lactic acid—sour milk)
- Popularized as a home-use agent
- Theory: cause desquamation due to diminished corneocyte cohesion above the granular layer in the epidermis (Clark 1999)
- *Glycolic acid: must be rinsed off with water or neutralized with 5 % sodium bicarbonate after 2–4 min*
- Typically used for wrinkle treatment and reduction of benign keratosis

30 % Salicylic acid peels

- Higher strength (30 %) indicated for early-to-moderate photodamaged skin
- Half face control study: 30 % salicylic vs. 70 % unbuffered glycolic acid (Kligman and Kligman 1998)
  - 30 % Salicylic acid does not contain resorcinol (found in Jessner's) eliminating risk of cardiotoxicity and has proven efficacy
- Typically only 2–3 peels needed in sequence
- *Self-limiting peel*. No neutralization needed as penetration stops once the vehicle (hydroethanolic) volatilizes
- Typical downtime 1–4 days

Medium-Depth Peel

- Destruction of the epidermis with inflammation/damage **extending into the papillary dermis and upper reticular dermis**
- Typically single treatment (i.e., not done in series)
- *Traditional agent: 50 % TCA. No longer used due to risk profile of TCA treatment in strengths >50 %, including increased risk of scarring*
- **Agents: 35 % TCA solution. Start with Jessner's vs. 70 % glycolic acid vs. solid CO_2 to improve TCA penetration**
- Common Treatment Protocols:
  - Jessner's solution to break up epidermal barrier, then 35 % TCA for deeper treatment (Monheit 1989)
  - Indications: mild-to-moderate photoaging, dyschromias, melasma, lentigines, epidermal growths, rhytides, actinic keratosis
  - Typically use mild sedation or deeper anesthesia
  - Pretreatment:
    - Retinoic acid to accelerate epidermal regeneration
    - Topical bleaching agent for high risk of postinflammatory hyperpigmentation (PIH)

- Protocol:
  - Skin is washed and degreased (essential to optimize even and complete peel penetration)
  - TCA dose is determined by amount of solution used (dampness of the gauze or cotton tip applicator and number of passes)
  - Peel endpoint: *Level II frosting* (white coat with erythema showing through) or *level III frosting* (solid white frost without visible erythema—indicates dermal penetration)
  - More sensitive areas (eyelid skin) or areas more prone to scarring (bony prominences such as the zygomatic arch and inferior border of the mandible) should be treated up to a level II frost only
  - Eyelid skin: treat to within 2–3 mm of the lid margin, cotton tip applicator should be damp without excess solution, dry tears as they form since they can wick peel solution into eye through capillary action (if chemical gets into eye flush with mineral oil)
  - Postoperative treatment varies by center. Considerations include 0.25 % acetic acid compresses, emollient, gentle cleansers; antiviral treatment starts 24 h before the peel and continues until epidermal regeneration is complete (approximately 7 days)
  - Peeling occurs over 4–7 days. Pink appearance can last 2–4 weeks

Deep Peel

- Inflammation **extending through the papillary dermis into the reticular dermis**
- Results in new collagen formation
- Candid discussion with patient about risks and downtime before proceeding

Table 21.4 Baker-Gordon phenol peel

3 mL USP liquid phenol 88 %
2 mL tap water
8 drops liquid soap (Septisol)
3 drops croton oil

- Indications: moderate-to-severe photodamaged skin

Baker-Gordon Deep Chemical Peel B (Table 21.4)

- Described in 1961
- Gold standard for deep chemical peels
- Formula needs to be mixed close to the time of application
- Conscious sedation or general anesthesia required. Local blocks recommended.
  - Occluded: application of a waterproof zinc oxide tape applied to each subunit after application
    - Increases penetration into the midreticular dermis
    - Risks include hyper- and hypopigmenation, a glossy and hypopigmented appearance to the skin (“alabaster skin”) and scarring
  - Unoccluded: penetration not as deep, therefore reducing the efficacy and risk profile
- Full-strength phenol causes immediate coagulation of keratin proteins, thereby blocking further penetration
  - Phenol alone does not peel when less than 35 % and peels only lightly up to 88 %
  - Phenol: cardiotoxic (see below), hepatotoxic, nephrotoxic
- In the Baker-Gordon formula the 88 % **phenol** is diluted to 50–55 % resulting in *keratolysis* as well as *keratocoagulation* and increasing penetration
- Soap surfactant (**Hibiclens or Septisol**) reduces skin tension and allows more even penetration
- **Croton oil**: vesicant epidermolytic agent that enhances phenol absorption
  - *Thought to be the primary agent responsible for the peel*

Table 21.5 Hetter formula tables

Medium-light peel formula	4 cc phenol 88 % 6 cc water 16 drops Septisol 1 drop croton oil	33 % phenol 0.35 % croton oil
Very light peel formula *Used for eyelids and neck*	3 cc of above mixture plus: 2 cc phenol 88 % 5 cc water	27.5 % phenol 0.105 % croton oil
Medium-heavy peel formula *Not for lids, temples, preauricular, or neck*	4 cc phenol 88 % 6 cc water 16 drops Septisol 2 drops croton oil	33 % phenol 0.7 % croton oil
Heavy peel formula *Not for lids, temples, preauricular, or neck*	4 cc phenol 88 % 6 cc water 16 drops Septisol 3 drops croton oil	33 % phenol 1.1 % croton oil
Heaviest peel formula *Used for perioral rhytides or heavy, desiccated, pale skin*	3 cc phenol 88 % 2 cc water 8 drops Septisol 3 drops croton oil	50 % phenol 2.1 % croton oil

- Pain occurs for 20 s following application and returns 20 min later. Can last 6–8 h.
- Biosynthetic dressing (Vigilon or Flexzan) for first 24 h

Histology study following Baker-Gordon phenol peel (Kligman et al. 1985)

- Facial skin specimens taken after facelifts performed years after the initial peel (1.5–20 years later)
- Dermal changes:
  - New 2–3 mm dermal strip seen with thin, compact parallel collagen bundles arranged horizontally
  - Abundance of elastin fibers
  - Less ground substance compared to unpeeled skin
  - Absence of telangiectasias
  - Normal number of melanocytes still present (creates hypopigmentation not depigmentation)
- Epidermal Changes:
  - Return of polarity
  - Improved order of layers
  - Fewer cytologic irregularities (actinic keratosis, lentigos)
  - More uniform basement membrane

Gregory Hetter (Table 21.5) (Hetter 2000)

- Modified the Baker-Gordon formula based on different phenol and croton oil concentrations to obtain robust results and decrease risks
  - 0.25–0.5 % croton oil: heals within 7 days
  - 0.6–1.0 % croton oil: heals within 9–10 days
  - >1 % croton oil: healing time longer than 10 days and some risk of hypopigmentation
  - >2 % croton oil: consistent hypopigmentation and delayed healing

    Standard concentrations: 25 % phenol, 1.05 % croton oil

    Croton oil is added with a dropper. Standard drop size *0.04 mL*

    (a) **Hetter formula tables**
    - ***Croton oil is the primary ingredient responsible for the peel (contains cytotoxic resin)***
    - **Depth of peel increased by increased croton oil concentration, taped occlusion, multiple applications of croton oil**
    - Phenol concentration has nothing to do with depth of injury

Wound Healing

- <u>Four Stages of Wound Healing:</u>
  - Inflammatory Phase
    - Vasodilation, cytokine response, complement cascade
    - Immediate dusky erythema
    - Lasts approximately 12 h
    - Coagulation: seen as epidermis separates
      - (a) Treat with debriding soaks, compresses and occlusive emollients
      - (b) Consider 0.25 % acetic acid soaks to prophylaxis against bacterial infection including Pseudomonas
  - Proliferative Phase
    - Angiogenesis
    - Re-epithelialization: begins 1–3 days after peeling
      - (a) Lasts approximately 10 days
      - (b) Epidermal migration from wound margins and adnexal epithelium
      - (c) Collagen synthesis
  - Maturation Phase
    - Continues for 3–4 months
    - Collagen maturation—bundles reorient into mature formation
    - Neovascular dermis regresses (30 days for superficial peel, 60 days for medium depth peels, 90 days for deep peels)

Cardiac Arrhythmias in Phenol Face Peeling (Botta et al 1988)

- Arrhythmias correlated with procedure duration and surface area treated (dosage)
  - 80 % excreted by the kidney
- Tachycardia -> premature contractions -> ventricular tachycardia OR AFib
  - Protocol to limit toxicity:
    - Preoperative hydration (~1 L)
    - Intraoperative hydration (~1 L)
    - Staging the treatment to limit systemic phenol levels (allow for 15 min between application of each subunit)
    - Continuous cardiac monitoring
    - Oxygen supplementation
    - Aborting procedure for signs of EKG abnormalities (PVC, PAC)
    - Consider forced diuresis with furosemide 20 mg 10 min prior to procedure
    - Consider prophylactic lidocaine hydrochloride 75 mg IV prior to procedure to protect myocardium and decrease chance of phenol-induced arrhythmias
    - Preoperative cardiac clearance if appropriate
      - (a) Other side effects of phenol: stimulation and then depression of the CNS, decrease in BP and UOP
- **Water** dilution of the solution can ***increase*** **absorption**. Flushing or removing the solution should be done with *mineral oil*

Prolonged Postpeel Erythema *PPPE* (Maloney et al. 1998)

- Characterized by erythema, pruritus, burning, stinging, irregular skin texture
- Likely the result of an inflammatory reaction
- Can begin as early as 2 weeks post-peel
- Study: retrospective review of 236 nonoccluded Baker-Gordon peels
  - 11 % developed PPPE
  - Only factor that correlated with developing PPPE was a history of tape allergy
  - Of the 27 patients: 15 resolved within 7 weeks, 25 within 4 months, final 2 by 1 year
  - <u>Intrinsic risk factors</u>: sensitivity to peeling agent, preexisting condition (rosacea, SLE, eczema, atopy), contact dermatitis
  - <u>Extrinsic risk factors</u>: sensitized by pretreatment (retin-A, glycolic acid), aggressive peel technique or preparation, infection
- *Potential complications: post-inflammatory hyperpigmentation, textural changes, scarring*
  - *Treatment sequence:* avoidance of irritants -> emollients -> topical steroids -> acetic acid soaks -> systemic steroids -> dermatology consult
- If scarring evident: add intralesional steroids, silicone sheeting, dye-pulsed laser

Specific Conditions/Concerns

- Post-radiation-treated skin: higher risk of post-peel breakdown if skin is not healthy. Evaluate quality of skin and presence of hair (suggests sufficient health to support pilosebaceous units for regeneration of epidermis)
- Herpes simplex: pretreatment history increases risk of posttreatment recurrence. Treatment with antiviral agents is necessary.
  - Acyclovir/valacyclovir: inhibit viral replication within the epidermal cell. Therefore therapy should be continued until full re-epitheliazation (7–10 days for medium depth, 14 days for deep peel, Monheit 1989)
- Melasma: large symmetric macules on the cheeks, forehead, upper lip, nose, and chin
  - Etiology: genetic predisposition, exposure to UV radiation, pregnancy, oral contraceptives, thyroid dysfunction, cosmetics, phototoxic and antiseizure drugs (Clark 1999)
  - Pre- and post-treat with hydroquinone 4–8 %, retinoic acid, and sunscreen

Relevant Medications

- Hydroquinone: **blocks tyrosinase from developing melanin precursors and therefore reduces new pigment formation**
  - Reduces new pigment as the epidermis regenerates
- Azelaic acid and kojic acid: non-hydroquinone bleaching agents. azelaic used if acne is an issue
- Topical Vitamin C (Ascorbic Acid)
  - Promotes collagen synthesis and has antioxidant capabilities

Topical Tretinoin

- Changes with photoaging: epidermal dysplasia, cytologic atypia, loss of polarity of keratinocytes, dermal damage with elastosis, loss of collagen, increase in glycosaminoglycans (GAGs)
- **Tretinoin mechanism of action: binding to nuclear receptors exposing DNA-binding sites, thereby changing gene expression (decreasing MMPs such as collagenase, gelatinase, and stromatolysis)** (Fisher et al. 1996)
- Weiss et al. 1988—Double-blind vehicle-controlled study
  - Tretinoin versus vehicle: forearm and face
  - Global improvement in tretinoin group: fine wrinkles, coarse wrinkles, tactile roughness, facial lentigines, solar freckling
    - 100 % showed improvement by 12 weeks
    - Main adverse reaction—dermatitis. Typically subsided with time, reduced frequency of application, topical steroids
  - Biopsy results: tretinoin-treated areas showed increase in epidermal thickness, increase in granular layer thickness, increase in mitotic figures, improved stratum corneum organization (more compact and homogenous appearance), reduced melanocytic hypertrophy and hyperplasia, reduced epidermal atypia.
    - Dermal increase in collagen may take longer treatment period (>1 year)
- Kang et al. 1997—Topical Tretinoin and Photoaging
  - Tactile smoothening shortly after starting tretinoin due to compaction of stratum corneum and increased hyaluronic acid with associated water retention
    - This epidermal change is transient—therefore long-term wrinkle reduction is due to dermal changes

  - Topical tretinoin increases collagen in the high dermis
    - Dermis contains 85 % type I collagen, 10 % type III collagen
    - Decrease of mature collagen in photoaged skin (a cause of wrinkling) and restoration seen with retinoic acid
    - UV radiation upregulates breakdown of collagen (collagenase) causing reduction of collagen and wrinkle formation
    - **When human skin is treated with tretinoin, UV-B-induced binding to DNA to upregulate collagen breakdown is reduced by 70 % (Fisher et al. 1996)**

Complications of Chemical Peeling

Intraoperative: incorrect peel medication, solution misplacement during application

- Ensure the solution has not expired
- Saline, bicarbonate, and mineral oil should be immediately available

Postoperative:

- Infection: best prevention is appropriate use of soaks and debridement of necrotic material
  - Streptococcus, Staphylococcus, *Escherichia coli*, Pseudomonas
    - Bacterial infection signs: delayed wound healing, ulcerations, necrotic material accumulation, purulence, odor
  - Herpes simplex: due to reactivation of HSV
    - Increases risk of postoperative scarring
    - Patients with pretreatment history of HSV should be treated appropriately
      (a) Acyclovir 400 mg TID starting 24 h before the peel and continuing for 7–14 days
      (b) Valtrex 1000 mg BID starting 24 h before the peel and continuing for 7–14 days
      (c) Acyclovir topical ointment to supplement oral treatment during active infection
  - Fungal infection
    - Acetic acid soaks
    - Antifungal treatment (oral, topical)

Additional Resources

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Questions

1. The benefit of using Jessner's solution prior to 35 % TCA in a medium-depth chemical peel is:
   (a) Jessner's works as a surfactant that reduces skin tension and allows more even penetration
   (b) Jessner's reduces the chance of prolonged post-peel erythema (PPPE)
   (c) **Jessner's works as a keratolytic agent to remove the stratum corneum and destroys portions of the epidermis**
   (d) Jessner's works as a keratocoagulant to remove the stratum corneum and destroys portions of the epidermis
2. An appropriate sequence for a medium-depth chemical peel could be:
   (a) **Prepare skin with retin-A and hydroquinone -> antiviral treatment -> peel procedure -> emollients -> steroid cream**
   (b) Antiviral treatment -> prepare skin with retin-A and hydroquinone -> peel procedure -> emollients -> steroid cream
   (c) Prepare skin with steroid cream and emollients -> antiviral treatment -> peel procedure -> start retin-A and hydroquinone

   (d) Prepare skin with retin-A and steroid cream -> antiviral treatment -> peel procedure -> emollients -> steroid cream
3. In a deep peel, depth of the peel is increased by:
   (a) Higher concentration of phenol
   (b) Lower concentration of phenol
   (c) **Higher concentration of croton oil**
   (d) Leaving the skin surface unoccluded
   (e) Starting with a Jessner's peel before the deep peel
4. The following is NOT a result of a Baker-Gordon peel
   (a) New strips of collagen in the dermis arranged in compact parallel bundles
   (b) Less ground substance (matrix, mucopolysaccharides)
   (c) Fewer cytologic irregularities in the epidermis
   (d) **Fewer melanocytes in cases of hypopigmentation**
5. The following is NOT a means to reduce phenol cardiotoxicity:
   (a) Preoperative hydration
   (b) **Shortening the duration of peel**
   (c) Oxygen supplementation
   (d) Forced diuresis with furosemide 20 mg 10 min prior to procedure
   (e) Prophylactic lidocaine hydrochloride 75 mg IV prior to procedure
6. Know the mechanism of action of the following three medications:
   (a) Acyclovir/valacyclovir—inhibit viral replication within the epidermal cell
   (b) Hydroquinone: blocks tyrosinase from developing melanin precursors
   (c) Tretinoin: binds to nuclear receptors exposing DNA-binding sites, thereby changing gene expression (decreasing MMPs such as collagenase, gelatinase, and stromatolysis)
7. During a Baker-Gordon peel signs of cardiotoxicity become evident. A reasonable first step would be to:
   (a) Flush the peeled skin with distilled water
   (b) **Flush the peeled skin with mineral oil**
   (c) Neutralize the peel with 5 % sodium bicarbonate and then flush with water
   (d) Start ACLS protocol
8. Be able to walk someone through the following patient presentations:
   (a) Mediterranean woman with early aging changes interested in a peel
   Skin preparation and training with retin-A and hydroquinone, choose a superficial peel, know the peel contents and treatment sequence
   (b) Caucasian woman in her 40s with Glogau II/II changes interested in a peel
   Skin preparation and training with retin-A and hydroquinone, medium-depth peel contents and sequence, post-peel care.
   (c) Caucasian woman in her 60s with Glogau IV changes interested in a peel
   Be able to discuss the risks and benefits of a deep peel, skin preparation and training with retin-A and hydroquinone, discuss Baker-Gordon peel versus Hetter modification, intraoperative precautions, post-peel care.
   (d) Patient presents 4 weeks after a deep peel with significant redness in an isolated area
   Discuss the differential of post-peel complications including PPPE, normal healing, bacterial/viral/fungal infection, scarring. Discuss treatment options for each complication.

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Fillers, Botulinum Toxin, Mid-Facial Implants, Tissue Expansion

22

Nate Jowett

Anatomy

Soft Tissue Envelope of the Face

- The muscles of facial expression (Table 22.1), together with the temporoparietal fascia, form the superficial musculoaponeurotic system (SMAS)
- Motor innervation provided solely by facial nerve; muscles are innervated from their undersurface except the following deep muscles: levator anguli oris, buccinator, mentalis
- Fasciocutaneous retaining ligaments connect SMAS to overlying dermis throughout the face
  - Strong over the forehead, eyelids, nose, lips, and chin
  - Intermediate strength over medial cheek and neck
  - Loose over lateral cheek and temple
- Osteocutaneous retaining ligaments (very strong) exist between the dermis and periosteum overlying the zygoma and body of the mandible

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Facial Aesthetic Units and Subunits

- Forehead—Midline (1), lateral/temporal (2), brow (2)
- Eye—Lower lid (1), upper lid (1), medial canthus (1), lateral canthus (1)
- Nose—Root (1), dorsum (1), sidewall (2), tip (1), columella (1), soft triangle (2), ala (2)
- Cheek—Infraorbital (1), buccal (1), zygomatic (1), lateral (1)
- Lips—Upper lateral lip (2), philtrum (1), lower lip (1)
- Chin
- Other muscles of expression supplied by facial nerve: anterior/superior/posterior auricular muscles (move auricle in respective directions), occipitalis (moves scalp backward)

Blood Supply

- External carotid artery
  - Facial artery → submental, angular, and inferior and superior labial branches
  - Internal maxillary artery → inferior orbital, anterior and deep temporal, and mental branch of inferior alveolar branches
  - Superficial temporal artery → transverse facial, frontal, middle temporal, and anterior auricular branches

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Table 22.1 Major muscles of facial expression

Muscle	Origin	Insertion	Action/Effect	Associated Rhytides	Associated Expressions
Frontalis (Fn)	• Galea aponeurotica near coronal suture	• Frontal bone (superciliary ridge) and skin of brow • Interdigitates with CS (deep), Pr and OOc (superficial)	• Elevates eyebrows and forehead skin	• Horizontal forehead	• Surprise, interest, excitement • Sadness
Corrugator supercilii (CS)	• Frontal bone (medial superciliary ridge)	• Skin of medial brow (passes between pars orbitalis and pars palpebralis of OOc)	• Pulls eyebrows medially (major) and inferiorly (minor)	• Vertical glabellar	• Contempt, disgust, anger, pain
Procerus (Pr)	• Fascia overlying upper lateral cartilages and nasal bone	• Skin between eyebrows • Interdigitates with Fn (deep)	• Pulls medial brows inferiorly (major) and medially (minor)	• Transverse radix nasi • Nasal bridge	• Pain, anger, aggression
Nasalis [compressor naris (CN), dilator naris (DN), depressor septi (DS)]	• CN: Maxilla, superolateral to incisive fossa • DN: Maxilla, superior to incisive fossa, medial to CN • DS: Maxilla, incisive fossa	• CN: Opposing muscle and procerus aponeurosis • DN: Lower alar cartilage • DS: Base of caudal septum	• CN: Narrows nostrils, depresses nasal cartilages • DN: Dilates nares • DS: Narrows nostril, pulls ala inferiorly	• DS: horizontal philtral	• DN: Anger, aggression
Orbicularis oculi (OOc) –Pars orbitalis	• Nasal and superomedial orbital portions of frontal bone, inferomedial orbital portions of maxilla • Medial palpebral ligament	• Lateral palpebral raphe (not lateral canthal tendon) • Skin of brow • Superior aspect interdigitates with Fn and CS (deep)	• Forced eye closure, brow depression	• Lateral canthal (crow's feet) (major)	• Happiness (Duchenne smile)
OOc—Pars palpebralis preseptalis	• Superficial head: MCT • Deep head: Fascia overlying lacrimal sac	• Lateral palpebral raphe (not lateral canthal tendon)	• Gentle eye closure (sleeping, blinking), lacrimal sac pump	• Lateral canthal (minor)	• Happiness (Duchenne smile)
OOc—Pars palpebralis pretarsalis	• Superficial head: MCT • Deep head: Posterior lacrimal crest and fascia overlying lacrimal sac	• Lateral canthal tendon (~7 mm from lateral orbital tubercle and ~7–10 mm below zygomaticofrontal suture)			

Buccinator (Bn)	• Pterygomandibular raphe, alveolar processes of maxilla and mandible	• Modiolus	• Pulls angle of mouth posteriorly (whistling, smirk, suckling, mastication)	• Lateral oral commissure	• Annoyance, contempt, disapproval, sarcasm
Levator labii superioris alaeque nasi (LLSAN)	• Superior aspect of frontal process of maxilla at level of medial canthal tendon	• Lower lateral cartilage • Skin of superomedial NLF, ala, and Cupid's bow • Skin, vermillion and OOr fibers of medial upper hemi-lip	• Elevates upper lip, nasal ala, skin of nasal sidewall, NLF, and cheek, with indirect upward displacement of lower lid (snarl, nostril flaring)	• NLF (superomedial) • Nasal sidewall • Lid/cheek junction	• Anger, disgust, contempt, aversion
Levator labii superioris (LLS)	• Inferior orbital rim (zygomatic and maxillary bones), just superior to infraorbital foramen	• Skin of NLF (lateral to nasal ala) and Cupid's bow • Skin, vermillion, and OOr fibers of central upper hemi-lip	• Elevates central upper hemi-lip, NLF (superolaterally), and cheek with indirect upward displacement of lower lid (sneer, smile)	• NLF (lateral to nasal ala) • Lid/cheek junction	• Disgust, contempt, aversion
Zygomaticus minor (Zm)	• Temporal process of zygoma, just posterior to zygomaticomaxillary suture	• Skin of NLF (middle aspect) and malar fat pad • Skin, vermillion, and OOr fibers of central upper hemi-lip	• Deepens and retracts middle aspect of NLF • Everts and draws upper lip posteriorly and superiorly (crying)	• NLF (middle aspect)	• Sadness
Levator anguli oris (LAO)	• Canine fossa of maxilla, inferior to infraorbital foramen	• Modiolus	• Pulls angle of mouth directly upward (uncomfortable smile)	• NLF (middle aspect) (indirect)	• Discomfort, embarrassment
Zygomaticus major (ZM)	• Temporal process of zygoma, just inferior to zygomaticotemporal suture	• Modiolus • Occasional interdigitation with DAO and Rs and insertions into skin of lower NLF	• Draws angle of mouth superiorly, posteriorly, and laterally (smile, laugh)	• NLF (lower aspect)	• Happiness, joy
Risorius (Rs) (variable expression)	• Parotidomasseteric fascia	• Modiolus	• Draws angle of mouth posteriorly and laterally (smug smile)	• NLF (lower-lateralmost aspect)	• Contempt, smugness, happiness
Orbicularis oris (OOr)	• Modiolus • Alveolar processes of maxilla and mandible	• Decussation in midline with contralateral side • Skin of philtral columns and vermillion	• Deep fibers: appose lips to teeth • Superficial fibers: closure and protrusion (pucker, purse)	• Vertical perioral (lipstick)	• Pouting, anger

(continued)

Table 22.1 (continued)

Muscle	Origin	Insertion	Action/Effect	Associated Rhytides	Associated Expressions
Depressor anguli oris (DAO)	• Oblique line of mandible, inferior to mental foramen	• Modiolus • Skin of labiomandibular crease	• Curves angle of mouth inferiorly, lengthening and deepening lower NLF (frown)	• Marionette lines	• Sadness, grief, aversion, disgust
Depressor labii inferioris (DLI)	• Oblique line of mandible, inferior and medial to mental foramen	• Skin, vermillion, and OOr fibers of central lower hemi-lip	• Draws lower lip inferiorly and laterally, partially everts	• Horizontal labiomandibular	• Anger, aversion, irony
Mentalis (Mn)	• Vertical line adjacent to midline on mental protuberance of mandible, inferior to level of teeth roots and mental foramen	• Skin of the chin • Medial fibers interdigitate with paired muscle (when absent, results in cleft of the chin)	• Raises soft-tissue prominence of chin, indirectly elevating and everting the lower and upper lips (pouting)	• Labiomental sulcus, chin dimples	• Sadness, grief, anger, doubt, disdain
Platysma (Pt) [pars modiolaris (PMo), pars labialis (PL), pars mandibularis (PMn)]	• Superficial fascia overlying pectoral and deltoid muscles	• PMo: Modiolus • PL: Skin, vermillion, and OOr fibers of central lower hemi-lip • PMn: Mandible, below oblique line	• Widens neck, deepens suprasternal notch • PMo: Pulls angle of mouth inferiorly and laterally • PL: Pulls central lower hemi-lip inferiorly and laterally, partially everts • PMn: Pulls jaw inferiorly	• Longitudinal neck bands • Horizontal neck rhytides	• Fear, horror, aversion, pain, anger, disgust, sadness

- Internal carotid artery
  - Ophthalmic artery → dorsal nasal, supraorbital, supratrochlear, medial palpebral branches
  - Lacrimal branch of ophthalmic artery → lacrimal, zygomaticofacial, lateral palpebral branches
- Rich external–internal carotid anastomoses throughout the face give rise to a risk of retrograde embolic spread of filler to retinal and CNS vascular supply

Skin Innervation

- Ophthalmic branches (V1): Supratrochlear (medial brow/forehead/scalp), supraorbital (central hemi-brow/forehead/scalp), palpebral branch of lacrimal (lateral upper lid), infratrochlear (medial upper lid, nasal dorsum, conjunctiva, caruncle), external nasal branch of anterior ethmoidal (nasal tip)
- Maxillary branches (V2): Infraorbital (medial lower lid/cheek, upper lip), zygomaticofacial (lateral lower lid), zygomaticotemporal (medial zygoma, hairless temple)
- Mandibular branches (V3): Mental (mentum and lower lip), buccal (lateral cheek), auriculotemporal (lateral zygoma/scalp, hair-bearing temple, superior helix, and concha)
- VII: Sensory auricular branch (posterior wall of external auditory meatus)
- X: Auricular branch or "Arnold's nerve" (external auditory meatus)
- Cervical plexus (C2): Greater occipital nerve (posterior scalp to vertex), lesser occipital nerve (post-auricular)
- Cervical plexus (C2, C3) : Great auricular nerve (lobule and peri-lobule skin, inferior helix and concha, posterior auricle), transverse cervical nerve (anterior neck)
- Cervical plexus (C3, C4): Medial/middle/lateral supraclavicular nerves (sternal notch, supraclavicular regions, skin of upper chest and shoulders)

Regional Variation in Skin Thickness (Full Thickness)

3–3.5 mm:	Nasal tip, chin, forehead, cheek
2–3 mm:	Lower eyelid, lips, philtrum, submentum
1.5–2 mm:	Neck, nasal dorsum
1–1.5 mm:	Upper eyelid, posterior concha

The Aging Face

Signs and Symptoms

- Skin: Thinning of epidermis, fragility, loss of turgor, decreased elasticity, increased laxity, rhytides, folds, ptosis, hyperpigmentation
- Other: Fat atrophy and ptosis, temporal wasting, bone resorption

Intrinsic Factors: Chronologic Aging

- Accumulation of cellular damage from reactive oxygen species (ROS) generation through mitochondrial oxidative metabolism over time → increased matrix metalloproteinase (MMP) expression → dermal extracellular matrix (ECM) breakdown with loss of skin elasticity → accumulated damage from imperfect repair
- Replicative senescence of epidermal keratinocytes → decreased rate of epidermal turnover → thinning of epidermis → fragile skin
- Replicative senescence of dermal fibroblasts → thinning of basement membrane, flattening of rete pegs, decreased ECM turnover → thinning of dermis → skin laxity, wrinkling
- Marked decrease in epidermal glycosaminoglycans (GAGs), especially hyaluronic acid (HA) → loss of skin moisture (HA binds and retains water)
- Decrease in dermal GAG content (esp. HA) → loss of dermal turgidity, laxity, wrinkling

- Weakening of retaining ligaments over time potentiated by gravity → ptosis
- Volume loss of facial adipose tissue, muscle, and bone (partial resorption of maxilla and mandible leading to decreased soft-tissue projection) all occur with age

Extrinsic Factors

- Photoaging is the superposition of ultraviolet radiation (UVR) damage on intrinsic aging
- UVA (penetrates deeply, ~30 % reaches deep dermis) → ROS generation → up-regulation of MMP and down-regulation of procollagen expression → dermal ECM breakdown with loss of skin elasticity → accumulated damage from imperfect repair
- UVB (absorbed superficially, results in sunburn, only 10 % reaches superficial dermis) → neutrophil influx and release of neutrophil elastase together with up-regulation of elastin promoter in upper dermal fibroblasts → breakdown of ECM with accumulation of disorganized (dysfunctional) elastin and associated proteoglycans in ECM of superficial dermis (solar elastosis)
- UVB → TP53 mutation and p16 deletion in keratinocytes → unregulated growth → actinic keratoses and carcinomas
- Solar elastosis is more pronounced between wrinkles (likely from relative shielding of wrinkle base from UV exposure) leading to deepening of wrinkles
- UVR also alters HA homeostasis, compounding intrinsic loss of HA
- Erythema ab igne (EAI)—Clinical hyperpigmentation and solar elastosis in skin exposed to chronic heat/infrared radiation
  - Mechanism: Thought to result from neutrophil influx, release of neutrophil-derived proteolytic enzymes, and subsequent fibroblast-mediated imperfect repair
- Other accelerants of skin aging: smoking, alcohol, chronic disease, and poor nutrition

Age-Related Pigmentation Changes

- Melanocyte counts decrease by ~8–20 % per decade (sun-exposed and sun-protected areas)
- Density of melanocytes remains ~2× higher in sun-exposed areas
- Paradoxical increase in hyperpigmentation with age due to UVR-induced up-regulation of tyrosine kinase activity in surviving melanocytes and UVR-induced abnormal pigment retention by keratinocytes (solar lentigines)

Repetitive Use of Facial Muscles Over Time

- SMAS connected to dermis via fasciocutaneous retaining ligaments throughout the face
- Repeated/habitual contraction of underlying SMAS produces and determines orientation of folds, wrinkles, and relaxed skin tension lines (RSTLs) (except lids due to rigid tarsal plates)
  - Mechanism: Muscle shortens without corresponding shortening of overlying skin → temporary wrinkle at right angles to vector of muscle contraction → skin adaptation and increasing laxity over time leads to presence of wrinkles/folds at rest

Mechanisms Underlying Major Facial Folds

- Nasolabial fold: Elevator muscles of the lip send muscular projections to the dermis along path of NLF. Dynamically present in youth; present at rest with age.
- Labiomandibular (melomental/marionette line and jowl lines): Weakening of the fasciocutaneous ligaments along the anterior border of the masseter over time results in ptosis of the premasseteric space

- Gravity pulls the contents medially and inferiorly resulting in marionette lines
- Jowl lines are the continuation of the marionette lines inferior to the strong mandibular osteocutaneous retaining ligament (same mechanism)
- Appear only with age
- DAO also believed to contribute to Marionette lines

Botulinum Toxin

- Exotoxin produced by *Clostridium botulinum* (Gram-positive, motile, anaerobic rod)
- Nine known toxin types (A,B,C_1,C_2,D,E,F,G, H)—A,B,E,F,H are neurotoxic in humans
- A and B are commercially available for clinical use (Table 22.2)
- Mechanism: Enters distal neuron through receptor-mediated endocytosis, cleaves SNAP-25 (type A) or VAMP (type B), preventing docking and fusion of synaptic vesicles to presynaptic membrane (necessary for acetylcholine release into the neuromuscular junction)
- Onset: Peak effect seen at 7–14 days (type B having a slightly faster onset than type A)
- Duration of effect: Striated muscle paralysis lasts 3–4 months (type A lasts slightly longer than type B), autonomic blockade lasts 6–9 months
- Recovery of function
  - Growth factor secretion from denervated muscle results in active axonal sprouting
  - Original nerve terminals recover function by production of new SNAP-25/VAMP

Table 22.2 Current FDA-approved botulinum toxins

Type	Brand	FDA-approved cosmetic uses	Dose ratio (to Botox®)	Notes
OnabotulinumtoxinA	BOTOX®	Glabellar lines Lateral canthal lines	1:1	• Original and most commonly used commercial toxin • Freeze dried powder (50 or 100 units per vial) • Storage: −5°C or 2–8 °C, 2 years (24 h once reconstituted)
AbobotulinumtoxinA	Dysport®, Reloxin®	Glabellar lines	1:2–1:4	• Possible higher diffusion (greater spread of effect) vs. BOTOX® • Freeze dried powder (300 or 500 units per vial) • Storage: 2–8 °C, 2 years (4 h once reconstituted)
IncobotulinumtoxinA	Xeomin®	Glabellar lines	1:1–1:1.3	• Possible reduced risk of antibody formation as compared to BOTOX® • Freeze dried powder (50 or 100 units per vial) • Storage: −20 to −10°C or 2–8 °C, 3 years (24 h once reconstituted)
RimabotulinumtoxinB	MYOBLOC® (NeuroBloc®)	None	1:50–1:100	• Faster onset, shorter duration of action (vs. Type A) • Greater area of diffusion, more painful injection (acidic pH) • Higher protein content, more frequent antibody formation • Available in 2500, 5000, or 10,000 U liquid vials • Storage: 2–8 °C, 21 month (4 h once diluted)

- Cosmetic indications
  - FDA approved: Glabellar (4 U into each of 5 sites in total) and lateral canthal lines (4 U into each of 3 sites per side)
  - Off-label: Forehead rhytids, brow elevation (lateral OOr injection), palpebral fissure widening, vertical perioral and Marionette lines, NLFs, "gummy" smile, platysmal bands, hyper prominent masseter muscle, synkinesis
- Loco-regional complications: Paralytic lagophthalmos and exposure keratopathy (excessive OOr weakening), lid ptosis (migration of toxin to lid elevators), facial ptosis (e.g., brow), facial asymmetry, dry eye (lacrimal gland inhibition)
- Systemic complications (rare): Spread of toxin outside injection area causing dysphagia or respiratory paralysis and possibly death, hours or weeks later (FDA black box warning 2009)
- Contraindications: Known hypersensitivity, egg allergy, active infection at injection site
- Relative contraindications: Neuromuscular disease, pregnancy and lactation (effects unknown), concurrent use of aminoglycosides or muscle relaxants (potentiates effect)
- Antibodies and subsequent resistance may develop with repeated injections over time (delay repeat injection as much as possible), type switching (A to B) is sometimes necessary

Injectable Volumizing Fillers

Indications

- Fine lines—superficial papillary dermis injection
- Moderate to severe lines and wrinkles—mid and deep dermis injection
- Facial augmentation (e.g., orbital rim, tear trough, temple, mandible, malar/submalar, chin)—subcutaneous, supra- and preperiosteal injection

Ideal Filler

- Biocompatible, hypoallergenic, noninflammatory, nonmigratory, non-carcinogenic, nontoxic, resistant to infection, consistent and predictable response, natural feel, inexpensive, long-lasting, retains shape over time, short and painless injection, requires no recovery time, long shelf life, easily stored (no refrigeration)

Classification and Properties (Tables 22.3 and 22.4)

- Biologic—Tissue-derived (Auto-, allo-, or xenograft) or cell culture-derived
  - Collagen, micronized connective tissue, hyaluronic acid (HA), autologous tissue
  - Collagen and HA preparations differ in concentration (higher concentration for mid-deep dermis) and degree of cross-linking (delays degradation)
  - HA preparations also differ in particle size (larger particles → more augmentation) and carrier gel characteristics (gel viscosity, presence of lidocaine)
  - Elastic modulus (G') of filler/carrier combination (measurement of hardness) is a prime determinant of appropriate placement

    High G' products should be placed in deeper lines (e.g., NLF and marionette lines).

    Low G' products should be used in areas requiring a soft agent (e.g., body of lip, tear trough)
- Synthetic—Chemically synthesised biocompatible compounds
  - Bioabsorbable (calcium hydroxylapatite, polylactic acid, methylcellulose)
  - Permanent (PMMA: polymethyl methacrylate)
  - Although still often mentioned in many textbooks as an option, injection of liquid silicone anywhere in the body is not FDA approved, and is considered unethical by

Table 22.3 FDA-approved biologic injectable fillers and fat

Source	Brands	Uses and duration	Notes
Collagen			
Bovine	Zyderm® Zyplast®	• Fine-mod lines, folds, scars • ~2–4 months	• *Requires skin testing 6 and 2 weeks prior to first injection* • Storage: Refrigerator, 3 years • 96 %/4% Type I/III
Recombinant human	CosmoDerm® CosmoPlast®		• Storage: Refrigerator, 3 years • 93/7% Type I/III
Micronized connective tissue			
Human cadaveric dermis	Cymetra®	• Depressed scars • ~3–12 months	• Thick paste, difficult to inject • Avoid periocular, forehead, glabellar injection (risk of emboli) • Avoid if allergic to polysorbate 20 or specified antibiotics • Storage: Room temperature, 18 months
Human cadaveric fascia	Fascian®	• Previously used for mod-severe wrinkles	• Inflammation and nodules result from dermal injection • *Off-market, no longer available*
Hyaluronic acid			
Rooster coon	Hylaform	• Mod-severe wrinkles/folds • ~6 months	• Higher incidence of skin reaction vs. bacterial source • Superficial injections can result in bluish tint (Tyndall effect), especially perioral and orbital rim • Storage: Room temperature, 2 years • Effect reversible with hyaluronidase injection (big advantage)
Bacterial cultures of equine streptococci	Restylane/Perlane® Juvéderm® Boltero® Captique® Hydrelle/Elevess® Puragen®	• Fine lines (Captique®) • Mod-severe wrinkles/folds • Facial augmentation (Juvéderm Voluma) • ~6 months (up to 24 months)	• No risk of nodule formation, all areas of face may be injected • Superficial injections can result in bluish tint (Tyndall effect), especially perioral and orbital rim • Storage: Room temperature, 2 years • Effect reversible with hyaluronidase injection (big advantage)
Autologous tissue			
Fat	N/A	• Facial augmentation • Years	• Unpredictable result, ~30–50 % initial resorption rate, often uneven resulting in lumpiness • ***High risk of embolic sequelae, especially with periocular and forehead injections
Fibroblasts	LaViv®	• Mod-severe NLF • At least 6 months	• Requires punch biopsy harvest (behind ear), 4–6 weeks culture time, then 3 treatment sessions at 3–6 week intervals • *Inject into superficial papillary dermis* • Avoid if allergic to gentamicin, amphotericin, DMSA, bovine serum

most experts due to high risk of complications (silicone granulomas, induration, nodules, fibrosis, ulceration, migration)

- Contraindications: Documented hypersensitivity to active compound or carrier components, active infection at site of injection, bleeding disorders,

Technique and Plane of Injection

- Needle gauge selection dependent on filler viscosity (30 G for low viscosity agents, 27 G for thicker agents)
- Serial puncture: Superficial dermis (fine lines) and mid-papillary dermis (moderate wrinkles)

Table 22.4 FDA-approved synthetic injectable fillers

Compound	Brands	Uses and duration	Notes
Calcium hydroxlapatite	Radiesse®	• Mod-severe wrinkles/folds • Facial augmentation (off-label) • Nasal contour defects (off-label) • ~6–12 months (up to 18 months)	• Avoid superficial and avoid lip injection (risk of nodules) • Non-osteogenic microspheres enzymatically degraded over time to Ca^{2+} and PO_4^{-3}, acts as scaffold for fibroblast deposition of new collagen • Storage: Room temperature, 2 years
Poly-L-lactic acid (PLLA)	Sculptra®	• Severe folds/ wrinkles • Facial augmentation (esp. for concavities) • Lipoatrophy in HIV patients • ~2 years	• Avoid superficial, nose, lip injections (risk of nodules) • Inject into deep dermis (at dermal/SQ interface) using cross-hatch technique; SQ, preperiosteal injection also feasible • Delayed onset of effect, typically requires 3–5 injections • Storage: Room temperature, 2 years (72 h reconstituted)
Polymethyl methacrylate (PMMA) and bovine collagen	Bellafill® (previously Artefill® Artecoll®)	• Mod-severe NLF and acne scars • Facial augmentation (off-label) • Permanent	• *Requires allergy skin test* • Avoid superficial, nose, lip injections (risk of nodules) • PMMA microspheres are contained within bovine collagen, trigger fibroblast deposition of new collagen • Storage: Refrigerator, 12 months

- Linear Threading: Subcutaneous or deep dermis injection requiring a linear path (e.g., lip augmentation, deep wrinkles such as nasolabial folds)
- Fan: Subcutaneous requiring a large area (e.g., malar/submalar augmentation)
- Cross-Hatching: Recommended for PLLA (Sculptra®) injections (deep dermis, preperiosteal space injection)

Complications of Injectable Fillers

- Minor/moderate—Edema, erythema, ecchymosis, asymmetry, hypersensitivity reaction, granuloma, nodule formation, infection
- Major—Thrombotic events
  – Mechanism: Anterograde or retrograde embolic spread of filler through inadvertent intravascular injection or high-pressure transudation
  – Local—Vascular compromise leading to soft tissue necrosis
  – Regional—Central retinal artery occlusion (CRAO), cavernous sinus thrombosis, cerebral ischemic events, death
  – Presentation of CRAO: Sudden loss of vision, retinal whitening, cherry-red spot in central macula
- Risk reduction—Use of blunt tip needles, large cannulas, epinephrine at injection site, low pressure injections, multiple passes, small volumes on each pass (avoid large boluses), inject on withdrawal, use of ice immediately after filler injection, careful observation following injection, crash-cart and ready protocol for management of embolic/thrombotic events
- Management of filler-related embolic/thrombotic events—stop injection, call for help/ transport to appropriate care facility, hyaluronidase injection (regardless of filler used), 2 % topical nitroglycerin paste onto injection site, massage, warm compress, glucocorticoid (oral or IV), enoxaparin and aspirin (if not contraindicated), sildenafil and hyperbaric oxygen, and prophylactic antibiotic and antiviral therapy

Table 22.5 Polymers used in semisolid and solid facial implants

Material	Advantages	Disadvantages
Silicone	• Induces strong capsule without tissue ingrowth • Nontoxic, nonallergenic	• Strong inflammatory reaction • Unstable placement and/or inadequate soft-tissue coverage results in ongoing inflammation +/− seroma • If placed too superficially, may result in capsular contraction and implant deformity, or extrusion
Porous polyethylene	• Minimal inflammatory reaction • Porosity permits extensive fibrous tissue ingrowth which prevents migration	• Difficult to sculpt • Fibrous ingrowth makes removal difficult
Expanded Polytetrafluoroethylene (ePTFE, GoreTex®)	• Minimal capsule formation and tissue ingrowth (best for soft-tissue augmentation) • Easily removed if necessary	• Soft (unsuitable for bony augmentation)
Polymethyl methacrylate (PMMA)	• Can be custom-made intraoperatively (supplied as powdered mixture, which hardens in 10 min by an exothermic reaction—must use irrigation to cool)	• Very rigid and hard, difficult to shape • Thermal injury due to exothermic reaction
Mesh polymers (Dacron®, Mersilene®, Marlex®, Supramid®)	• Extremely pliable, easy to shape • Promotes significant fibrous tissue ingrowth	• Extremely difficult to remove

Mid-Facial Implants

Indication

- Augmentation of bony or soft-tissue deficiencies of malar eminence, submalar region, premaxilla, mandible, or nose (discussed in other chapters)
- Causes: Congenital, syndromic, traumatic, HIV-related, or age-related volume loss

Ideal Implant

- In addition to factors listed for ideal facial fillers, easily shaped without compromising implant integrity, able to permanently retain its form, tapered margins that blend into adjacent bony areas, sterilizable without degradation

Materials

- All induce capsule formation to varying degrees (stabilized implant)
- Significant tissue ingrowth stabilizes implant but complicates removal/switching
- Risk of extrusion decreases with increasing depth of placement
- Polymers (Table 22.5)
- Calcium ceramics
  – Calcium hydroxylapatite (mixed with blood and microfibrillar collagen) moldable paste (disadvantages: brittle, low tensile strength, difficult to fix in position)
  – Calcium phosphate (Norian CRS Bone Cement®, BoneSource®, Mimix®) moldable putty, hardens in 5–10 min
  – Nova Bone® (45 % sodium oxide, 45 % silica dioxide, 5 % calcium, 5 % phosphate) is an osteoconductive material
- Biologic materials (auto-, homo-, or xenografts): Bone, cartilage, fat; dermis may be used but are limited by donor site morbidity and resorption
- Injectable fillers are increasingly being used for facial volume augmentation

Preoperative Analysis—Midface

- Assess bony malar structure and adequacy of submalar soft-tissue volume
  – Type I: Primary malar hypoplasia with adequate submalar soft tissue

Treat with malar shell implant that projects cheek laterally
- Type II: Normal malar skeleton, submalar soft-tissue deficiency
  Treat with submalar implant that projects anteriorly (and/or rhytidectomy)
- Type III: Bony malar hypoplasia and submalar soft-tissue deficiency
  Treat with combined malar and submalar implants

Surgical Technique

- Approaches: Intraoral (most common), subciliary (via lower blepharoplasty), transconjunctival, rhytidectomy, zygomatico-temporal, transcoronal
- Outlines areas requiring augmentation with the patient awake and sitting up
- Intraoral approach
  - Incision in gingivobuccal sulcus—use a wide elevator directed superolaterally along bone up to malar prominence, oblique elevation of soft tissue off maxillary buttress, and malar eminence
  - Submalar space created by elevating soft tissues above masseter below malar eminence
  - Identify infraorbital nerve if infraorbital implant is planned
- Implant should fit easily into pocket
- Secure implant using screws, internal or temporary transcutaneous sutures
- Avoid dead space behind implant; ensure margins blend into adjacent areas, with no palpable step-offs

Soft-Tissue Expansion

Indications (Table 22.6)

- When adequate tissue adjacent to large cutaneous defect is unavailable
  - Falls between regional flap and free tissue transfer on reconstructive ladder
- Works best with a bony support underlying the balloon (scalp and forehead are ideal)

Internal Tissue Expanders (Balloon)

- Shapes: Round, rectangular, crescent
- Sizes: 100–2000 cc
  - General guideline is to choose a base size that is 2–2.5× the width of the defect over flat areas and 2.5–3× the width of the defect over curved areas
- Types of filling valves:
  - External remote—Port outside of patient, avoids percutaneous injections (better for children), risk of infection and tube obstruction

Table 22.6 Uses, advantages, disadvantages, complications of head and neck tissue expansion

Uses	Advantages	Disadvantages	Complications
• Common: Staged repair of scalp defects, hair replacement, auricular reconstruction • Other: Cheek and neck • Distant free-flap donor sites (prior to flap harvest to allow for primary closure)	• Sensate tissue • Excellent color and texture match for surrounding tissue • Avoids free flaps • Allows for hair-bearing skin	• High risk of complications (inexperienced 25–40 %, experienced 3–7 %) • Time and expense: 2 operations and 4–8 weeks of expansion, up to 20 injections • Cosmetically unsightly (during expansion) • Discomfort/pain with expansion • Requires repeated visits, patient compliance, patient motivation	• Hematoma/seroma • Infection, extrusion • Mechanical failure (leakage, rupture, valve or tubing obstruction) • Skin necrosis • Nerve injury • Vascular compromise • Muscle atrophy • Fat atrophy • Bone resorption • Insufficient expansion • Flap failure (following expansion)

  - Integrated—Less dissection required, risk of implant rupture
  - Internal remote—Port connected to balloon by silicone tubing tunneled subcutaneously away from expander; requires more dissection, risk of valve overturn, migration, and tube obstruction

External Tissue Expanders

- Limited tissue expansion may also be achieved using external devices as simple as externally applied adhesive tape to induce skin stretch and subsequent biologic creep (success has been reported in the preoperative expansion of radial forearm skin to obtain primary closure of a subsequent radial forearm free-flap donor site)

Mechanism and Tissue Response to Expansion (Table 22.7)

- Soft tissue tolerates controlled and gradual expansion better than rapid expansion
- Tissue expanded flaps may be considered a type of delayed flap, as they demonstrate enhancements in vasculature commonly seen with delay phenomenon
- Mechanisms
  - Mechanical creep: Displacement of interstitial fluid and ground substance, with realignment of collagen fibers and fragmentation of elastin. The underlying process behind stress relaxation of tissue (decrease in the recoil force of skin when held under stretch)
  - Biological creep: Cell proliferation and up-regulated ECM synthesis occurring in

Table 22.7 Tissue response to long-term expansion

Epidermis	Dermis	Fat	Vascular plexus	Other tissues
• Surface area increases without thinning of overlying epidermis • Increased mitotic activity within expanded skin • Epidermal height is maintained and/or enhanced, stratified organization preserved, basal layer thickened • Hyperpigmentation occurs secondary to melanocyte up-regulation of melanin expression • Return to normal histologic appearance typically occurs within 1–2 years following expansion	• Thinning occurs (30–50 %), the degree of which is related to the rate of expansion • Up-regulation of fibroblast-mediated collagen synthesis • Altered 3-dimensional arrangement of ECM with fragmentation of elastic fibers • Number of hair follicles remains fixed, density decreases in expanded skin	• Most intolerant of expansion • Thinning of adipose tissue (up to 50 %) occurs with flattening and fibrous degeneration of adipocytes • Some reversal of fat loss may occur following completion of expansion, but majority is permanent	• Tissue expansion up-regulates VEGF expression and subsequent angiogenesis • Expanded skin flaps are more vascularized (in both number and caliber of vessels), are more resistant to infection, and have a higher survival rate than non-expanded skin • Rate of survival of random-expanded tissue flaps is similar to that obtained for random delayed flaps	• Muscle: Poor tolerance for expansion (thinning, atrophy, necrosis, weakness) • Nerve: Tolerate gradual expansion (up to 30 %); however, some loss of function is expected • Bone: Resorption is rare, calvarial bone resorption has been described, special care should be taken in pediatric patients

response to stretch that functions to restore resting tension of the stretched tissue toward baseline, necessitating an increase in surface area.
- Rapid intraoperative tissue expansion (ITE): Mechanical creep + enhanced undermining and recruitment of surrounding tissues
- Long-term tissue expansion: Biologic and mechanical creep

Implant Surgery

- Placement plane
  - Scalp: Between galea and pericranium
  - Forehead: Between frontalis and pericranium
  - Face: Sub-SMAS is possible, supra-SMAS is likely safer (lessen risk of facial nerve branch transection/direct nerve compression)
  - Neck: Care with neck placement (avoid pressure over carotid sinus)
- Wide undermining is required, balloon must lie flat without buckling
- Select appropriate location for remote port, sutures edges (if possible) to prevent overturn
- Slight filling of balloon at time of insertion is warranted to obliterate dead space and aid in hemostasis, but must avoid tension on wound edges on closure
- Permanent suture use for all layers of closure (implant placement surgery) to lessen risk of wound dehiscence with subsequent expansion

Inflation

- Begins 2 weeks after placement
- Use sterile saline and sterile technique; a small (23-gauge) needle is best
- Inject saline until overlying skin becomes firm, within the tolerance of patient comfort
- Do not blanch skin; if blanching occurs, withdraw saline until color restored
- Patient can expect discomfort for 12–48 h following each injection
- Number of injections, volume per injection, and length of expansion vary with patient, implant size, and location (5–7 days between injections, 4–8 weeks for expansion is typical)
- Endpoints—implant reaches capacity or skin expansion adequate for desired flap

Explant Surgery

- Brief over-inflation of balloon immediately prior to removal is useful for flap closure (provides additional tissue-surface area through mechanical creep and disrupts the capsule)
- A dense fibrous capsule forms around expander balloon (lined by macrophages, surrounded by fibroblasts, highly vascular)
  - Contributes to contracture, shrinkage, thickening, and decreased pliability of flap after balloon removal (some experts advise against expansion of forehead tissue for nasal reconstruction for this reason)
  - Capsule may be cautiously excised at time of implant removal

Questions

1. Name two osteocutaneous ligaments of the face
   Ans: zygomatic and mandibular
2. Which of the following muscles is innervated from its superficial surface?
   (a) Levator labii superioris
   (b) Levator anguli oris
   (c) Orbicularis oris
   (d) Depressor labii inferioris
   (e) Depressor anguli oris
   Ans: (b)
3. Which of the following is not a brow depressor?
   (a) Corrugator supercilii
   (b) Procerus
   (c) Nasalis
   (d) Orbicularis oculi
   Ans: (c)

4. Which of the following does not form the modiolus?
   (a) Zygomaticus minor
   (b) Zygomaticus major
   (c) Levator anguli oris
   (d) Buccinator
   (e) Risorius
   (f) Depressor anguli oris
   Ans: (a)
5. Discuss the anatomy of the nasolabial fold
   Ans: The lip elevators (LLSAN, LLS, zygomaticus minor, sometimes zygomaticus major) send muscle fibers that attach directly to the dermis along the path of the NLF. Although present and necessary for dynamic expression in young and old, the fold deepens and is present at rest with age.
6. Discuss the origin of marionette lines and jowling
   Ans: Marionettes and jowl lines appear only with age. Weakening of the fasciocutaneous ligaments along the anterior border of the masseter with age leads to ptosis of the premasseteric space. The ptosis ends (gets "hung-up") at the strong mandibular osteocutaneous ligament. Additionally, marionette lines are also believed to result from repetitive DAO action over time
7. Of the following regions, which has the thinnest covering of skin?
   (a) Upper lid
   (b) Lower lid
   (c) Nasal dorsum
   (d) Nasal tip
   (e) Neck
   Ans: (a)
8. Discuss intrinsic and extrinsic factors and mechanisms believed to result in changes to the skin seen with age.
   Ans: Intrinsic: Accumulation of cellular damage from reactive oxygen species (ROS) generation through mitochondrial oxidative metabolism over time, replicative senescence of epidermal keratinocytes and dermal fibroblasts, decreases in GAGs (esp HA), weakening of retaining ligaments, volume loss
   Extrinsic: Photoaging (UVA affects primarily dermis, UVB affects primarily epidermis, solar elastosis), nutrition, alcohol, smoking, chronic disease
9. Discuss the mechanism of botulinum toxin.
   Ans: Enters distal neuron through receptor-mediated endocytosis, cleaves SNAP-25 (type A) or VAMP (type B), preventing docking and fusion of synaptic vesicles to presynaptic membrane (necessary for acetylcholine release into the neuromuscular junction)
10. Which of the following is not an FDA-approved usage of BOTOX®?
    (a) strabismus and blepharospasm
    (b) primary axillary hyperhidrosis
    (c) glabellar lines
    (d) lateral canthal lines
    (e) perioral lines
    Ans: (e)
11. Name 8 properties of an ideal volumizing filler.
    Ans. Biocompatible, hypoallergenic, noninflammatory, nonmigratory, non-carcinogenic, nontoxic, resistant to infection, consistent and predictable response, natural feel, inexpensive, long-lasting, retains shape over time, short and painless injection, requires no recovery time, long shelf life, easily stored (no refrigeration)
12. The duration of effect of injectable calcium hydroxlyapatite (Radiesse®) for moderate to severe wrinkles is:
    (a) 2–4 months
    (b) 4–6 months
    (c) 6–12 months
    (d) permanent
    Ans: (c)
13. Which of the following (in isolation) is inappropriate for facial augmentation?

(a) Collagen
(b) Hyaluronic acid
(c) Calcium hydroxlapatite
(d) PLLA
(e) PMMA

Ans: (a)

14. Which of the following facial implants results in the least tissue ingrowth?
    (a) Porous polyethylene
    (b) ePTFE
    (c) Dacron®
    (d) Mersilene®

    Ans: (b)

15. Discuss mechanical vs. biologic creep

    Ans: Mechanical creep: Displacement of interstitial fluid and ground substance, with realignment of collagen fibers and fragmentation of elastin. The underlying process behind stress relaxation of tissue (decrease in the recoil force of skin when held under stretch)

    Biological creep: Cell proliferation and up-regulated ECM synthesis occurring in response to stretch that functions to restore resting tension of the stretched tissue toward baseline, necessitating an increase in surface area.

16. List 6 complications of tissue expanders

    Ans:
    (a) Hematoma/seroma
    (b) Infection, extrusion
    (c) Mechanical failure (leakage, rupture, valve or tubing obstruction)
    (d) Skin necrosis
    (e) Nerve injury
    (f) Vascular compromise
    (g) Muscle atrophy
    (h) Fat atrophy
    (i) Bone resorption
    (j) Insufficient expansion
    (k) Flap failure (following expansion)

17. Discuss the effects of long-term tissue expansion on the epidermis, dermis, subcutaneous fat, and dermal vascularity.

    Ans: See Table 22.7

Genioplasty

23

Matthew Johnson

Overview

The mandible is an important aesthetic feature in Western society. The mandible is not a structure in isolation, but has a significant impact on facial shape, nasal projection, occlusion, and neck aesthetics. A well-defined jawline and appropriate chin proportion provide the patient with balance and harmony in the lower face. Genioplasty and mentoplasty are methods for changing the size and shape of the mandibular symphysis. This can be recontouring the chin by burring away bone, placement of an implant, multiple osteotomies and repositioning of bone, or some combination of these. The goals of chin augmentation are to attain harmony of the lower face, appropriate facial height, aesthetic contour, and balance with the nose.

Definitions

- Genioplasty—recontouring or repositioning of the bony chin with burring or osteotomy, movement, and fixation
- Mentoplasty—augmentation and contouring of the chin with implant materials
- Retrognathia—the position of one of the jaws retrudes behind the normal position, often associated with class II malocclusion; may be the result of underdeveloped ramus but normal body
- Micrognathia—hypoplastic mandible, ramus, and body are underdeveloped, often associated with class II malocclusion
- Microgenia and Retrogenia—normal mandible with underdeveloped chin, retruded and deficient by palpation, may have class I occlusion
- Prognathia—the position of one of the jaws protrudes forward beyond a normal position
  - Mesognathic, straight profile, normal chin
  - Prognathism, large mandible

Anatomy

Arterial supply (external carotid system)

Maxillary artery → inferior alveolar artery → mental artery exits the mental foramen as the terminal branch providing blood supply to the anterior chin.

Facial artery → submental artery below the inferior border of the mandible; it travels superficial to the mylohyoid muscle supplying the submental region and inferior chin.

Facial artery → inferior labial artery above the inferior border of the mandible; this provides

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blood supply to the lower lip. It has anastomotic connections with the superior labial artery.

Venous Outflow

Veins (inferior labial vein, submental vein) accompany the arterial blood supply and return to the facial vein, which in turn drains into the internal jugular vein.

Mental vein returns to inferior alveolar vein and drains into the pterygoid plexus. This eventually drains into the maxillary vein, which merges with the superficial temporal vein to form the retromandibular vein.

Innervations

Inferior alveolar nerve (branch of V3, trigeminal) divides into incisive and mental nerves; mental nerve exits the mental foramen and provides sensation to cutaneous lower lip and chin. The nerve runs below the tooth roots and exits at the level of the second premolar. The most medial location of the nerve as it travels through the mandible is at the external oblique ridge (area of the vertical section of a sagittal split osteotomy).

Marginal mandibular branch of facial nerve, CN VII supplies motor innervations to the muscles of the chin and lower lip.

Muscles

Mentalis muscle—originates from incisive fossa on the anterior mandible and inserts into soft tissues and skin of chin. Contraction raises the central chin and lower lip; protrudes lip, innervated by mandibular branch CN VII.

Transversus menti—lateral lower lip and chin musculature; considered to be superficial fibers of depressor anguli oris; muscle located laterally along chin, originates from mandibular oblique line and platysma; it inserts into orbicularis oris and risorius. Innervated by mandibular branch CN VII.

Platysma muscle—extends up from the neck over the inferior border of the mandible extending up onto the chin region, originates in skin of lower neck, and inserts into mandible and skin of the lower face.

Geniohyoid—originates from inferior mental spine on posterior surface of the symphysis and inserts into superior border of hyoid body, depresses mandible and elevates hyoid bone, innervated by C1.

Mylohyoid—originates on the lingual surface of mandible and inserts onto the superior border of the hyoid bone; it supports and raises the floor of mouth, innervated by CN V.

Physical Exam

The surgeon should begin any assessment by asking the patient to identify their concerns, especially concerns about symmetry, projection, and height of the lower face.

The physical exam should include evaluation of the occlusion, chin, labiomental crease, hyoid position, nose, lips, and facial proportions. Standard photography is critical.

Occlusion

Prior to committed evaluation of chin size and position, dental occlusion should be evaluated and occlusal class established. When assessing occlusion, observe for significant variation between the patient's centric occlusion and centric relation; occlusion should be assessed in centric relation with the condyle seated in the temporomandibular joint in the most superior position. Overbite is overlapping of the maxillary incisors in relation to the mandibular incisors. Normal overbite is around 3–5 mm or 25–30 % the height of the mandibular incisor. Overjet describes the horizontal (anterior–posterior) extent that the maxillary incisors projects beyond the mandibular incisors.

Angle's Classification (1899) Fig. 23.1

1. Class I is orthognathic, neutroclusion
   (a) First molars contact normally; maxillary molar mesiobuccal cusp sits in mandibular molar buccal groove
2. Class II is retrognathic, distoclusion
   (a) First mandibular molar is displaced posteriorly with respect to the first maxillary molar (cusp sits anteriorly to the groove). Maxillary canine is anterior to embrasure formed by mandibular first bicuspid and canine
3. Class III is prognathic, mesioclusion
   (a) First mandibular molar is displaced anteriorly with respect to the first maxillary molar (cusp sits posteriorly to the groove)

Patients with malocclusion often have abnormal profile and an irregular chin position. Receding chin may be associated with class II; protruding chin may be related to class III occlusion. **Patients who have malocclusion should be evaluated and offered orthognathic surgery prior to consideration of genioplasty or mentoplasty**. Patients who do not want orthognathic surgery may be considered candidates for genioplasty or mentoplasty.

Chin

Chin abnormalities occur in 3 dimensions; therefore, assessment must include all three planes: vertical plane (frontal and lateral views), transverse plane (frontal view), and anteroposterior plane (lateral view). Most deformities occur in the anteroposterior plane Figs. 23.2 and 23.3 assessment and facial divisions.

There are multiple methods for assessing the horizontal projection of the chin:

- A vertical line perpendicular to the Frankfurt horizontal line dropped through the subnasale has consistent relationship with the upper and lower lip vermillion and the pogonion. Upper lip vermillion = 0 mm; Lower lip vermillion = −2 mm; soft tissue pogonion =−4 mm (Fig. 23.4).
- Steiner—line is placed tangential to the anterior projection of the upper and lower lip; the pogonion should be tangential to this line as well (Fig. 23.5).
- Ricketts—Line is placed tangent to the tip of the nose and pogonion; the upper lip is ~4 mm behind this line and the lower lip ~2 mm behind (Fig. 23.5).
- Burstone—a line is placed between the subnasale and pogonion; the upper lip extends ~3.5 mm beyond this line and the lower lip ~2.2 mm beyond this line (Fig. 23.5).

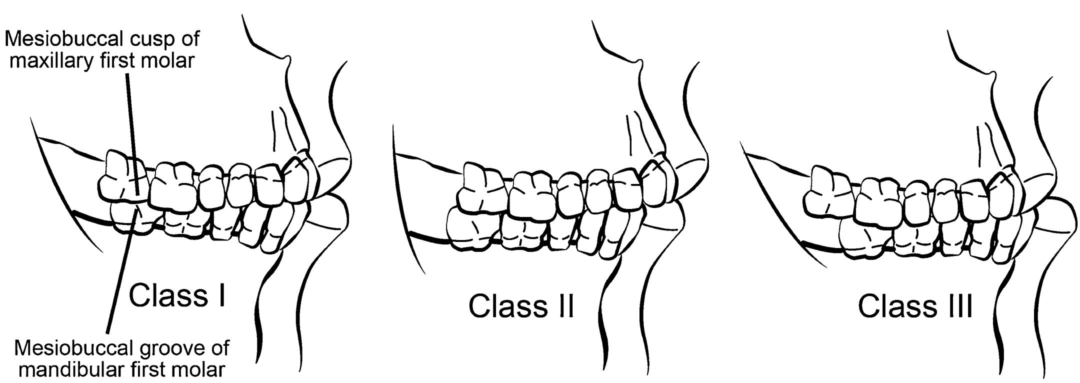

Fig. 23.1 Occlusal classes

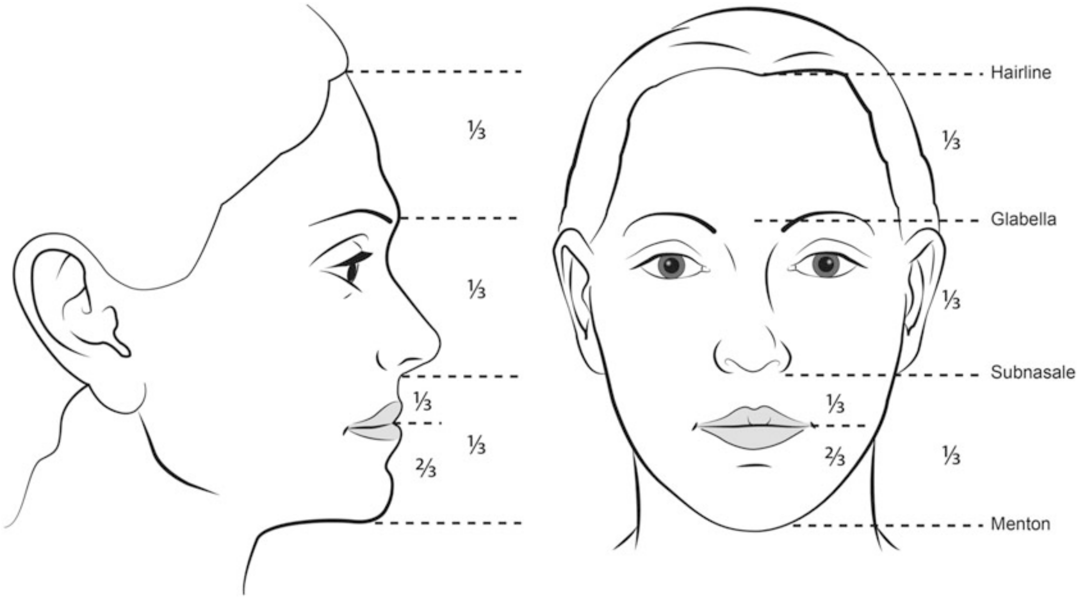

Fig. 23.2 Horizontal thirds of the face in anterior and lateral views

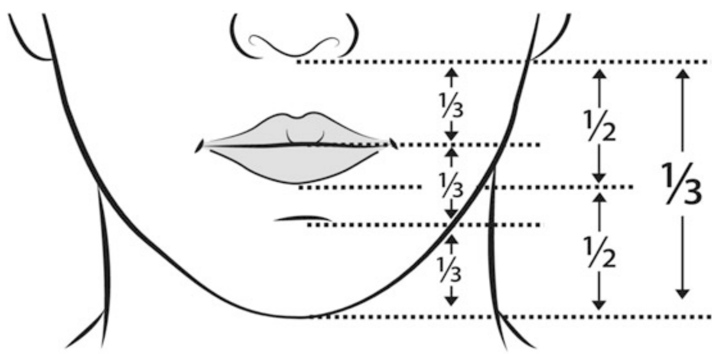

Fig. 23.3 Horizontal divisions of the lower third on anterior view

- Chin should ideally touch or be just behind a line from nasion perpendicular to the Frankfort line (also called the facial plane), tangent to the pogonion
- Alternatively, chin should approach line from the anterior lower lip perpendicular to the Frankfort line
- Another method is to draw an oblique line from the anterior aspects of the upper and lower lips, the chin should be at this line; the pogonion is tangent to the line

Methods of vertical analysis

- Golden Proportion
  – the ratio of upper lip to lower lip and chin equals 1:1.618; put another way, the upper lip is ∼62 % the height of the lower lip and chin
- A simpler method is to approximate as the subnasale to stomion as equal to ~1/3 of the lower third of the face and stomion to menton is 2/3 of the lower third of the face

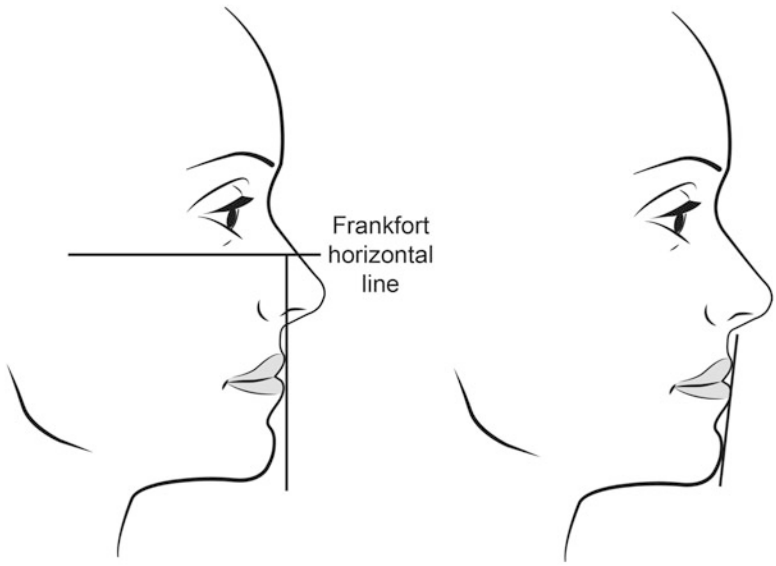

Fig. 23.4 Chin position. *Left*, a line is dropped perpendicular to the Frankfort horizontal line through the subnasale where pogonion is ~4 mm behind line. *Right*, oblique line touching most anterior projection of upper and lower lips should lie in tangent to pogonion

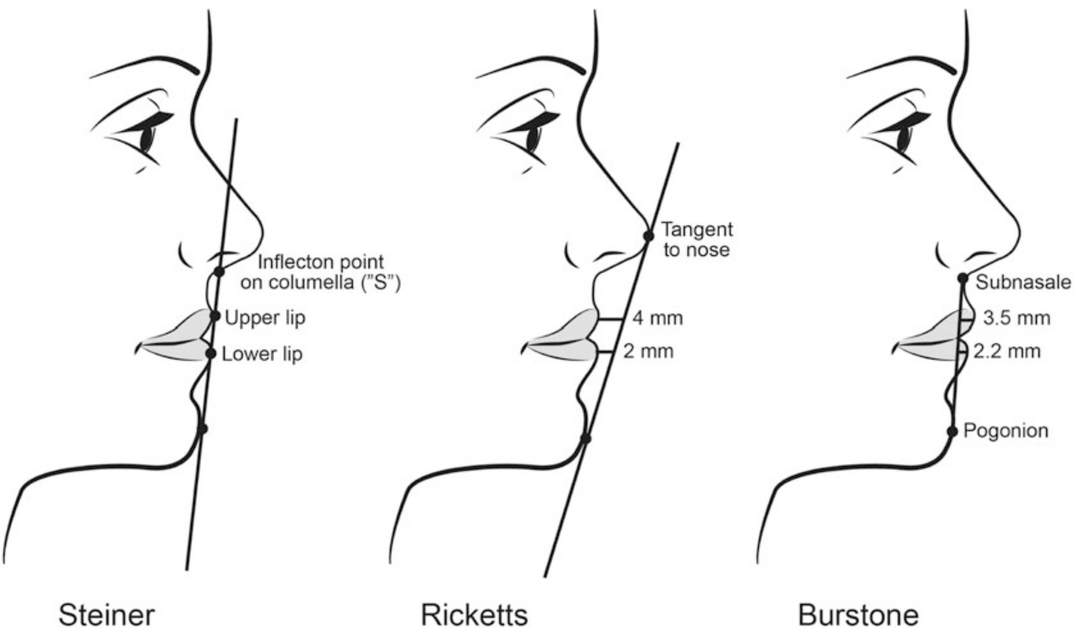

Fig. 23.5 Chin position. Steiner, Ricketts, and Burstone methods

- Powell and Humphreys method for ideal vertical facial-height dimensions
  - Lower third (subnasale to menton) should be 57 % of the lower two thirds (nasion to subnasale); therefore, the middle third should be 43 % of the lower two thirds.
- Glabella to subnasale distance should equal the distance from subnasale to the menton

Recessive chin has three associated anatomic abnormalities:

(a) Recessive procumbent lower lip
(b) Deep labiomental fold
(c) Diminished to normal lower facial height

Labiomental fold

The depth of the labiomental fold should be carefully evaluated. Advancement and/or shortening of the mandibular symphysis results in deepening the labiomental crease. Vertical lengthening results in effacement of the labiomental crease. Therefore, patients with long lower faces and deep creases should be cautioned about mentoplasty. These patients are often better served with orthognanthic surgery.

Lip

The ideal lip relationship is one in which the upper lip projection is 2 mm beyond the lower lip, and the lower lip projection is 2 mm beyond the chin. The position of the lower lip determines the degree of chin augmentation needed. Advancement beyond the lower lip leaves the patient with a distracting, artificial appearance; therefore, undercorrection is always preferred to overcorrection.

Nose

There is a balance relationship between the nose and chin. The size of one will influence the perceived appearance of the other. Nasal projection is the degree at which the nasal tip extends from the plane of the face. Pogonion projection normally extends to a vertical line dropped from the nasion through the lower lip (as mentioned above). The perception of nasal projection can be altered by adjusting chin position. Increased nasal projection would make the pogonion appear more posterior. Conversely, moving the pogonion anteriorly can reduce the perceived nasal projection.

Neck

Neck anatomy can vary from skin excess only at the mildest. At the severe end, there may be a low and anterior hyoid, little to no chin projection, excess skin, and significant subcutaneous or subplatysmal fat. Evaluation includes hyoid position and the submental transition.

Mentocervical angle

- Ideal angle is 105–120° with head in Frankfurt horizontal plane

Powell and Humphrey's triangle (Fig. 23.6).

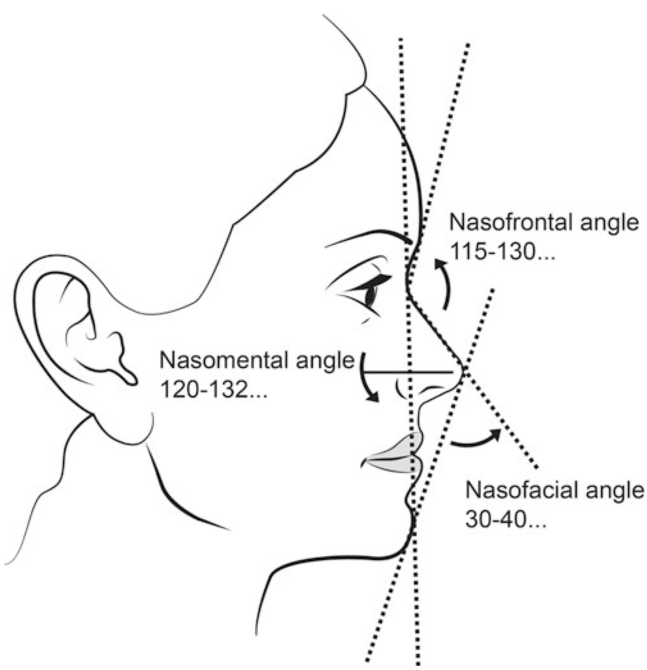

Fig. 23.6 Nasofrontal angle (defined by glabella-to-nasion line intersecting with nasion-to-tip line), nasofacial angle (defined by glabella-to-pogonion line intersecting with nasion-to-tip line), and nasomental angle (defined by nasion-to-tip line intersecting with tip-to-pogonion line) provide the boundaries of the aesthetic triangle of Powell and Humphreys

- Line from nasal tip to pogonion ("E" line) intersecting with a line from the cervical point (the innermost point between the submental area and neck) with the menton
- Should be 80–95°

Imaging: Lateral Cephalogram

Cephalometric assessment of maxillary and mandibular position assists in relating the position of the chin to that of the upper and lower jaws, and thus, occlusion. These should be obtained when patients are undergoing sliding genioplasty. Lateral cephalograms are taken with the patient facing the right.

Cephalometric Points: Fig. 23.7

- (n) nasion, most anterior point on fronto-nasal suture
- (s) sella, midpoint of sella turcica
- (a) point A: subspinale, position of deepest concavity on anterior profile of maxilla
- (b) pint b: supramentale, the most posterior point (position of deepest concavity on anterior profile of mandibular symphysis) in the outer contour of the mandibular alveolar process
- (Me) menton, the lowest most point on the mandible
- (Pg) pogonion, the most anterior point on the bony chin in the midline
- (Gn) gnathion, a point between the most anterior (Pg) and the most inferior (Me) on the chin
- (Go) Gonion, the midpoint at the angle of the mandible, the most posterior inferior point on angle of mandible

Common Reference Angles Fig. 23.8

- S-N-A: sella to nasion to subspinale angle: anteroposterior position of maxilla, 81° (+/−3), and mean of 82.
- S-N-B: sella to nasion to supramentale angle: anteroposterior position of maxilla, 79° (+/−3), mean of 80°

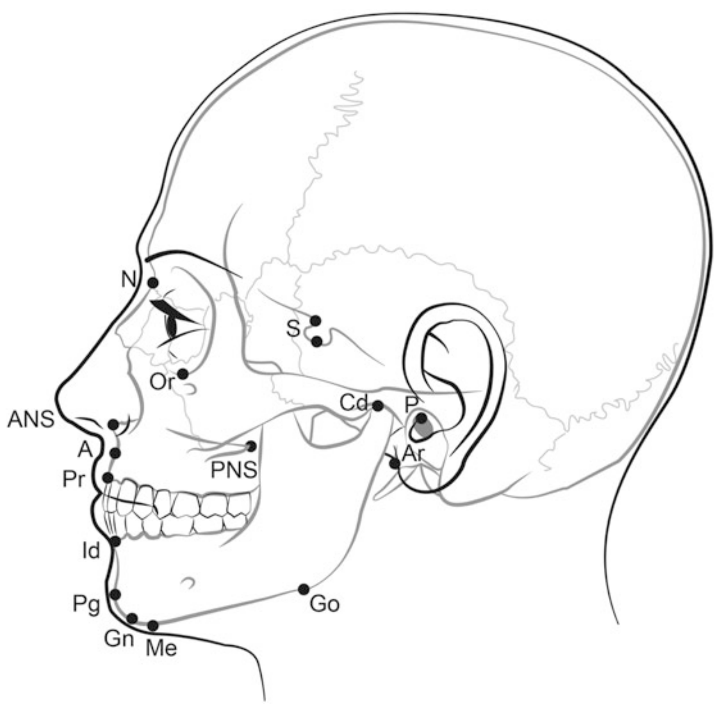

Fig. 23.7 Cephalogram points. Point A—subspinale or most concave point on maxilla, ANS—anterior nasal spine, Ar—articulare, Point B (not shown)—supramentale or most concave point on mandible, Cd—condylion (alternatively denoted Co), Gn—gnathion, Go—Gonion, Id—inferior prosthion Me—menton, N—nasion, Or—orbitale, P—porion, Pg—pogonion, PNS—posterior nasal spine, Pr—prosthion, S—Sellion

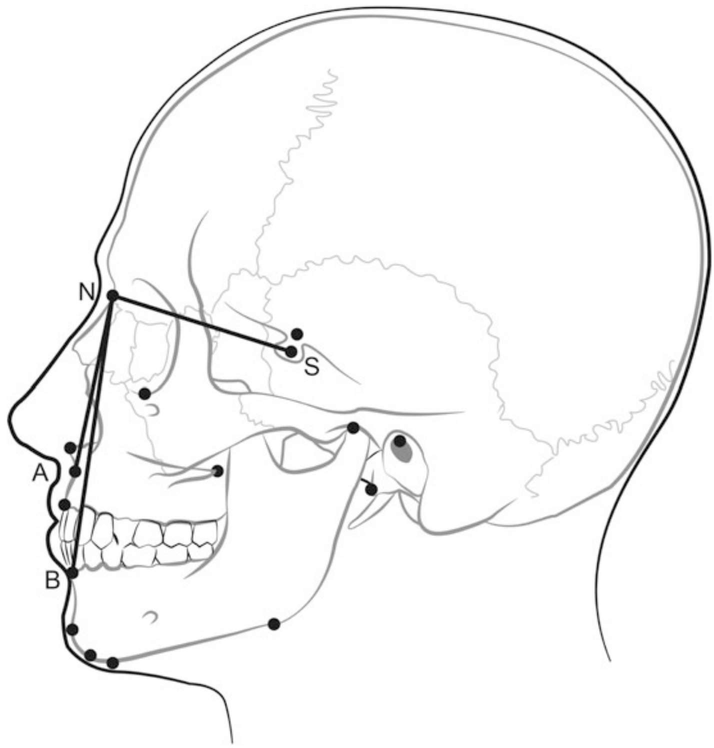

Fig. 23.8 Lateral cephalogram angles. SNA and SNB

- These angles provide information regarding the lateral relationship between the anterior skull base, maxilla, and mandible.
- A-N-B: difference between SNA and SNB
  - If greater than 4°, skeletal class II malocclusion
  - If greater than 4° and SNA is greater than normal, class II malocclusion is due to maxillary protrusion
  - If greater than 4° and SNA is less than normal, mandibular retrognathia is probable Fig. 23.9.

Surgery

Mentoplasty and genioplasty can be performed through an external or intraoral approach.

Submental—incision is placed just behind the submental crease. Dissection to the mandible enables subperiosteal placement of the implant without disturbing the mentalis. This approach also offers the surgeon the ability to perform adjuvant neck procedures, for example, submental liposuction, correction of platysma banding, etc. The main disadvantage of this approach is committing the patient to a facial scar.

Transoral, vestibular incision—mucosal incision made inside the lower lip. The mentalis muscle is traversed and divided with deep dissection toward the bone. Incisions should extend laterally to the canine/cuspid region on both sides. Subperiosteal elevation is performed exposing the symphysis region but are maintained at the inferior border of the mandible. It is important to expose the mental foramen bilaterally in the region between the first and second premolar, at the level of the origin of the mentalis muscle. The foramen is located at the approximate vertical midpoint of the mandibular height. In the edentulous patient, the nerve may be located more superficially resulting from alveolar recession. The surgeon must ensure accurate reapproximation of the mentalis muscle to prevent lower lip malposition, dysfunction, and chin ptosis (witch's chin deformity).

Fig. 23.9 Assessment of chin position on lateral cephalogram

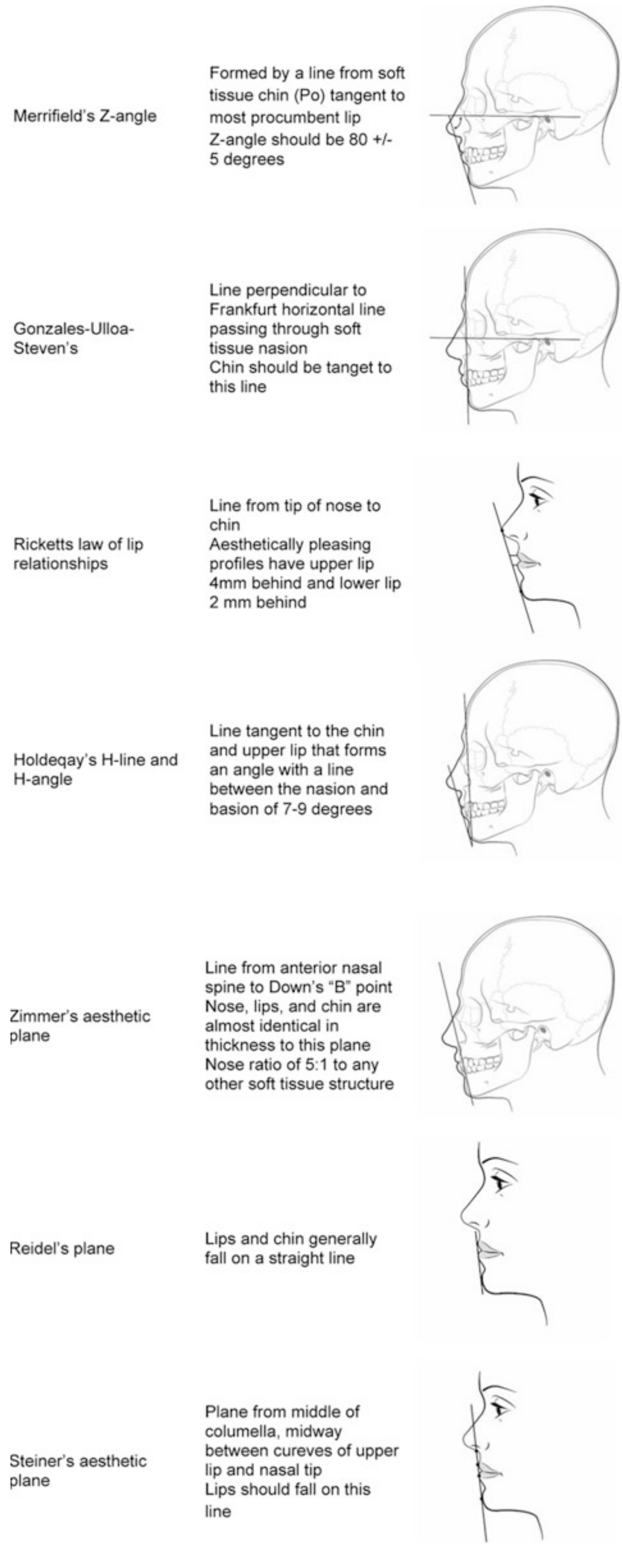

Table 23.1 Alloplastic Implants

Implants	Advantages	Disadvantages
Silastic (most commonly used)	Essentially inert Firm Easily sculpted	Rare foreign body reaction and rejection Infection risk Bone resorption below implant Extrusion when superficial
Polytetrafluoroethylene (Gore-Tex)	Perforated implant Pore size 10–30 μm Some soft tissue ingrowth Less tendency for migration	Some tissue ingrowth
Polyethylene (Medpore)	Firmer implant Pore size 125–250 μm More extensive fibrous ingrowth	More soft tissue adherence Difficult to remove
Supramid (organopolymer related to nylon and Dacron)	Stable, reliable Infiltrated by host tissues Slightly more resistant to infection	Extrusion after infection Foreign body response Possible resorption Does not give firm support
Proplast (highly porous Teflon polymer and vitreous carbon fibers)	Tissue reactivity and ingrowth Firm Easy to shape	Less resistant to infection and extrusion

Mentoplasty

Alloplastic implants remain a popular technique for the correction of **mild–moderate microgenia and a shallow labiomental fold**. This can be performed under local anesthesia as an office procedure or in the outpatient surgery setting. The surgical approach is often via the submental route; however, they may be placed via an intraoral approach.

Alloplastic implants can accomplish augmentation of the mandible and chin primarily in an **anteroposterior dimension**. It is important to ensure symmetric placement of implant in vertical plane and horizontal midline. Placement is usually performed subperiosteally, but supraperiosteal placement has been described. The implant is secured into position with sutures or screws (Table 23.1).

Disadvantages to mentoplasty include the inability to correct for asymmetries, vertical excess, the potential for infection/extrusion, and deepening of the labiomental crease. In addition, porous implants can be difficult to remove and revise due to tissue ingrowth and capsule formation.

Genioplasty

Osseous genioplasty is the second most commonly performed osteotomy of the facial skeleton for both reconstructive and aesthetic reasons (osteotomies in rhinoplasty being the first). While most agree alloplastic implantation is technically easier to perform with a low complication rate, osseous genioplasty remains a more versatile procedure, able to address deformities in all three dimensions.

The horizontal osteotomy is placed 4 mm below the mental foramen. If no vertical change is desired, the osteotomy is made parallel to the occlusal plane. This gives an anterior–posterior movement only. The osteotomy is carried as far posteriorly as possible to ensure a natural look with adequate skeletal volume advancement. Failure to complete the osteotomy at the lingual cortex may result in a mandibular fracture, nerve injury, irregular inferior mandibular border, and/or altered aesthetics. The upper limit of bony advancement is 8–10 mm; greater than this amount requires either stair-step osteotomies or release of muscular attachments. When advancing the chin, a horizontal movement up to 8 mm showing the **ratio of correlation from bone to soft tissue movements is roughly 1 to 0.9** (range of 1:0.6 to 1:1 in the literature).

Vertical changes can be achieved by angled osteotomies, interposition grafting, and wedge resections. Vertical augmentation of lower face height can be performed with an interposition graft of autologous grafting material. Means of performing vertical reduction include wedge ostectomy of mandibular bone utilizing two parallel horizontal osteotomies. This is easiest when removed from the central segment. Unfortunately, reduction genioplasty is not as predictable as advancement genioplasty. The ratio of bone to soft tissue movement is typically 0.5 to 1.

Stabilization of the bony segment can be performed by various techniques including unicortical or bicortical wires, adaptation plates, prebent chin plates, lag screws, and absorbable plate materials.

The major disadvantage of this approach is the potential for unnatural bony contours, step-off deformities, or notching.

Distraction Genioplasty

Primarily useful when soft tissue envelope is tight making concern for restricted movement and high chance of relapse (i.e., Treacher-Collins syndrome and Nager syndrome) where class 1 occlusion is present. These maneuvers may improve upper aerodigestive tract caliber when facial sling advancement is combined with the distraction and brings the hyoid forward. Gradual lengthening allows the muscle and soft tissue to compensate mechanical followed by biologic creep during the active and consolidation phases.

Post-operative Care and Recovery

Pressure dressings are placed and used for 3–5 days postoperatively to minimize the formation of hematoma and assist with soft tissue reattachment after degloving. Patients are generally placed on a 1-week course of antibiotics postoperatively. Patients are followed for varying periods of time from 3 months to 1 year.

Complications

Complications are generally minor and can be avoided by appropriate patient selection and technical execution. The surgeon must take care to avoid specific complications such as an infection, undesirable aesthetic outcome, tooth injury, nerve damage, and mandible fracture. Meticulous attention to sterile technique can minimize the majority of surgical infections and includes minimal handling of the implant, appropriate antibiotic coverage, appropriate oral hygiene, etc. Nerve damage can be avoided by intimate knowledge of the anatomy and attention to detail. Fortunately, the majority of neurosensory disturbances is temporary secondary to neuropraxia. If nerve transection occurs, immediate repair is indicated.

Undesirable aesthetic outcomes can be the result of a number of issues including soft tissue changes, asymmetries, malposition, or overcorrection. Chin ptosis results from inferior redistribution of the soft tissues of the chin. This leaves the appearance of redundancy of submental skin, flattening of the labiomental fold, excessive lower tooth display, and lip incompetence when severe. The cause is typically inadequate or failure of periosteal resuspension and mentalis closure and corrected with suspension. Preexisting or undiagnosed asymmetry may become more apparent after repositioning. Careful examination preoperatively and pointing out this to the patient is important, as postoperatively, the blame may be placed on the surgeon. Maintaining orientation intraoperatively with markings and measurements and immediate and careful inspection after placement of implants or movement minimizes the risk of iatrogenic asymmetry. Malposition can occur due to capsular contraction and movement; therefore, care is taken to fix the implant to the mandible. Overcorrection can be corrected by burring down excess bone or replacing the implant. Revision surgery should not be undertaken earlier than 6 months postoperatively.

Tooth injury can result from damage to the tooth roots or devitalized teeth from compromised pulpal blood flow. Therefore, it is recommended that osteotomies be placed 5 mm below tooth roots.

Mandibular complications can include nonunion, malunion, avascular necrosis of mobilized segments, bony resorption under the implant, and fractures. To minimize risk of necrosis, maintenance of a wide soft tissue pedicle with attached periosteum is important. Care is also taken to only expose the amount of bone necessary for augmentation. Bone deposition and osseous remodeling occurs in a somewhat consistent and predictable pattern. There is approximately ~10 % resorption rate of bone that is moved. Bony resorption with mentoplasty occurs under the implant with mean resorption volumes reported as 1.3 mm. The majority of the time this is of little cosmetic concern but, in cases of severe resorption, implant removal is recommended. Mandible fracture can occur with osseous genioplasty and is most commonly caused by an incomplete osteotomy through buccal and lingual cortices. The fracture occurs during the mobilization of the inferior segment and often extends through body, angle, or ramus.

This is managed by completion of the osteotomy, followed by open or closed reduction fracture management

Questions

1. A patient interested in chin augmentation has class II occlusion and a retruded chin; this most fits with:
   (a) Retrogenia
   (b) Microgenia
   (c) Micrognathia
   (d) Prognathia
2. Postoperatively, a patient who underwent genioplasty has lower lip incompetence and incisor show. This is prevented by:
   (a) Watertight closure
   (b) Limiting osseous advancement of < or = 10 mm
   (c) Resuspending the mentalis muscle in the midline
   (d) Preservation of the lateral mental neurovascular bundles
3. In osseous genioplasty, the relationship between bone movement and soft tissue change is best represented as:
   (a) 1:0.5
   (b) 1:0.9
   (c) 1: 1
   (d) 1:0.3
4. Recessive chin is most often associated with all of the following EXCEPT:
   (a) Horizontal midline shift
   (b) Recessive procumbent lower lip
   (c) Deep labiomental fold
   (d) Diminished to normal lower facial height
5. Preoperative evaluation of a patient for chin surgery. What radiographic study do you order?
   (a) Anteroposterior skull radiograph
   (b) Lateral cephalogram
   (c) Orthopantomograph
   (d) No radiologic tests are necessary
6. A woman has a long chin and blunted labiomental fold. What is the best method to improve the aesthetics of her chin?
   (a) Mentoplasty with silastic implant and wafer
   (b) Sliding osseous genioplasty
   (c) Recontouring of the mentum by burring down
   (d) Acute-angle osteotomy genioplasty
7. The relationship of the pogonion to the facial plane as dropped from the Frankfurt plane:
   (a) It is located at or just behind the facial plane
   (b) It is located 2–4 mm behind the facial plane
   (c) It is located 2–4 mm beyond the facial plane
   (d) It participates in the determination of the facial plane

Answers: 1. (c), 2. (c), 3. (b), 4. (a), 5. (b), 6. (d), 7. (a)

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24 Hair Restoration

Michelle G. Arnold

Anatomy

Scalp layers: skin, loose connective tissue, epicranium aponeurosis, loose areolar tissue, and periosteum.

Vascular supply: preauricular region by supratrochlear, supraorbital, and superficial temporal arteries. Postauricular region by posterior auricular and occipital arteries.

Venous outflow: anterior by supratrochlear and supraorbital veins which communicate with the ophthalmic vein and cavernous sinus and numerous emissary veins to intracranial venous sinuses.

Hair follicle: derived from ectoderm and mesoderm. Hair shaft lined by epidermal cells. Sebaceous glands associated with each hair follicle (pilosebaceous unit). Hair bulb, site of hair shaft formation, comprised of papilla and surrounding epidermal cells at the base of each follicle. Melanocytes in hair bulb confer hair color.

Follicular unit: naturally occurring group of 1–4 terminal hairs in scalp, contain sebaceous glands, neurovascular plexus, and erector pilorum muscle.

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Hair Growth Cycle (Fig. 24.1)

- Scalp hair grows ∼1 mm every 3 days.
- Each day, up to 100 hairs in telogen are shed and the same number enter anagen.
- The duration of anagen determines the length of hair
- The volume of the hair bulb determines the diameter
- We are born with
  - Approximately 100,000 terminal hair follicles on the scalp.
  - All terminal hair follicles are predetermined to grow long, thick hair.

Causes of Hair Loss

Androgenic alopecia (**AGA**): most common cause of hair loss, also known as male- or female-pattern hair loss. This alopecia is caused by the gradual conversion of terminal to vellus hairs. It occurs only in scalp follicles that have the genetic potential to be inhibited by androgens over a period of time. Hereditary thinning of the hair is induced by androgens in genetically susceptible men and women. Classified as male-pattern AGA, female-pattern AGA, or diffuse AGA. The effect of 5-dihydrotestosterone (DHT) on susceptible hair follicles leads to androgen-induced alopecia. Pattern hair loss is

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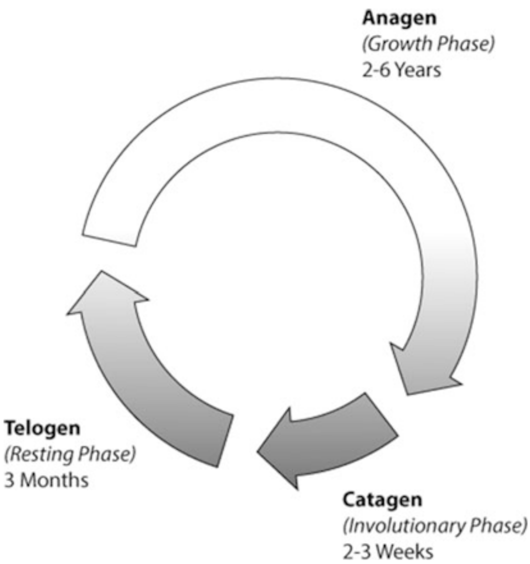

Fig. 24.1 Cyclical hair growth cycle

probably multifactorial and may be inherited as an autosomal dominant trait with variable penetrance.

- *Histopathophysiology*: AGA is characterized by a decrease in the number of terminal hairs and increase in the number of miniaturized vellus hairs. *Miniaturized* hairs of various lengths and diameters are the hallmark of AGA, a result of binding of dihydrotestosterone to androgen receptors in susceptible hair follicles. The hormone-receptor complex then activates the genes responsible for gradual transformation of large terminal follicles to *miniaturized* follicles. Affected hairs cycle more quickly due to the decreased length of anagen phase.
- *Dihydrotestosterone* is formed by peripheral conversion of testosterone by *5-α-reductase* which, together with other enzymes, regulates specific steroid transformations in the skin. Young men and women with AGA have: higher levels of 5-α-reductase, more androgen receptors, and lower levels of cytochrome P-450 aromatase which converts testosterone to estradiol in hair follicles in the frontal and occipital scalp regions. Various clinical patterns of AGA may reflect quantitative differences in the levels of 5-α-reductase, the number of androgen receptors, and the levels of aromatase in specific regions of the scalp at various ages. Finasteride is a *5-α-reductase inhibitor*.

Alopecia areata: A nonscarring alopecia, autoimmune-like disorder, results in patchy areas of hair loss, usually resolve with time. *Exclamation point hairs* which are narrower along the length of the strand closer to the base produce a characteristic exclamation point appearance. Patients may report that areas of hair loss may be painful or tingle. Treatment includes observation as the problem often spontaneously regresses. Consider injection of corticosteroids.

Triangular alopecia: Hair loss that may be congenital but usually appears in childhood as a focal patch of loss that may be complete or leave fine vellus hairs behind. Affected individuals are typically healthy. Hair transplantation is a successful treatment option.

Telogen effluvium: A form of nonscarring alopecia characterized by diffuse hair shedding, often with an acute onset. A chronic form with a more insidious onset and a longer duration also exists. Telogen effluvium is a reactive process caused by a metabolic or hormonal stress or by medications. Generally, recovery is spontaneous and occurs within 6 months. Treatment usually is limited to reassurance. Any reversible cause of hair shedding, such as poor diet, iron deficiency, hypothyroidism, or medication use, should be corrected. Although topical minoxidil is not proven to promote recovery of hair in telogen effluvium, it has a theoretical benefit and is well tolerated.

Anagen effluvium: A reversible condition of hair loss as a result of exposure to an offending agent such as antineoplastic chemotherapeutic agents, radiation, or toxic chemicals. Onset is within weeks of exposure and should be reversible within a few months after cessation of the agent.

Infectious causes: Dermatophytes, ringworm (tinea capitis), and syphilis can appear as scattered "moth-eaten" alopecia patches.

Inflammatory causes: seborrheic dermatitis, psoriasis, and pityriasis amiantacea.

Other causes: Thyroid disorders, radiation, autoimmune disorders, granulomatous disorders, developmental/hereditary causes, and poisons such as arsenic, lead, thallium, and boric acid.

Scarring alopecias: Clinical and histologic inflammation is typically present. Ultimately, histologic confirmation is the best method to confirm the presence of a fibrosing/scarring process with loss of hair follicles. Scarring alopecias include *Lichen planopilaris*, *central centrifugal cicatricial alopecia*, *traction alopecia*, systemic processes such as *scleroderma*, *discoid lupus erythematosus*, *and trichotillomania*. End-stage scarring alopecias can be treated with surgical hair transplantation procedures. However, koebnerization of the disease may occur. Surgical correction of alopecia should not be performed if the patient has any active scalp disease or inflammation.

- **Traction alopecia**: More common in African-American women, occurs because of excessive pulling of hair from hair weaves or hair systems. Slow gradual process that develops over a period of years. Once stable, can consider hair transplant options.
- **Trichotillomania**: An obsessive-compulsive disorder characterized by incessant hair pulling, can result in patches of baldness. More common in women, usually begins in adolescence, and can involve all hair-bearing areas, not just scalp. When psychologic aspect has been controlled, hair transplantation can restore permanent hair growth.

Drugs: Some medications known to cause hair loss include warfarin, isotretinoin, fibrates (gemfibrozil), antidepressants such as SSRIs (sertraline, prozac) and TCA (amitriptyline), male androgenic hormones, steroids, and anti-inflammatory medications (naproxen, indomethacin, and methotrexate).

Female Alopecia

Female pattern hair loss is basically a diagnosis of elimination. Medical causes need to be considered. Work-up includes a comprehensive history, and review of medications. Oral contraceptives, statins, coumadin, and beta blockers can cause hair loss. Oral contraceptives suppress ovulation by the combined actions of estrogen and progestin or in some cases progestin alone. Women predisposed to hormonal related hair loss or who are hypersensitive to hormonal changes can experience varying degrees of hair loss while on the pill or for several weeks to months after stopping the pill.

Physical examination focuses on abnormalities, hair loss pattern, and other signs of hormonal alteration. Work-up consists of CBC, TFTs, ferritin and iron, VDRL, ANA, DHEA-sulfate, and total testosterone levels. Scalp biopsy indicated to differentiate causes. For example, a smooth scalp devoid of pores is suggestive of cicatricial alopecia (biopsy indicated).

Female androgenic alopecia: Mostly thought to be genetic in origin. It is crucial to determine whether reversible causes exist such as hypothyroidism or nutritional deficiencies. The Ludwig classification along with the Savin Female Density scale is often used to classify female pattern hair loss (Fig. 24.2). Commonly, the anterior hairline is maintained but diffuse thinning occurs.

Many types of hair loss in women can be appropriately treated with hair transplantation. Criteria include adequate donor area, appropriate motivation with reasonable expectations, and absence of medical conditions that put success at risk.

Classification Systems

Norwood Classification for Hair Loss in Men (Fig. 24.3)

- ***Class I***: adolescent or juvenile hairline. Hairline generally rests on the upper brow crease. Not considered balding.
- ***Class II***: Progression to adult or mature hairline that sits 1.5 cm above the upper brow crease, with some temporal recession. Also does not represent balding.

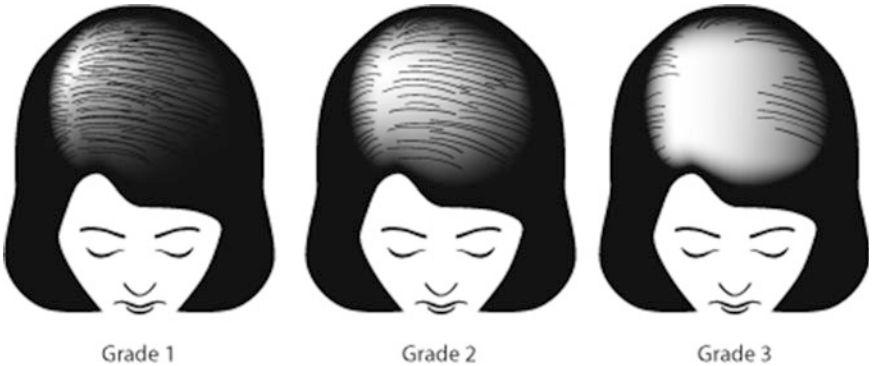

Fig. 24.2 Ludwig classification of hair loss in women

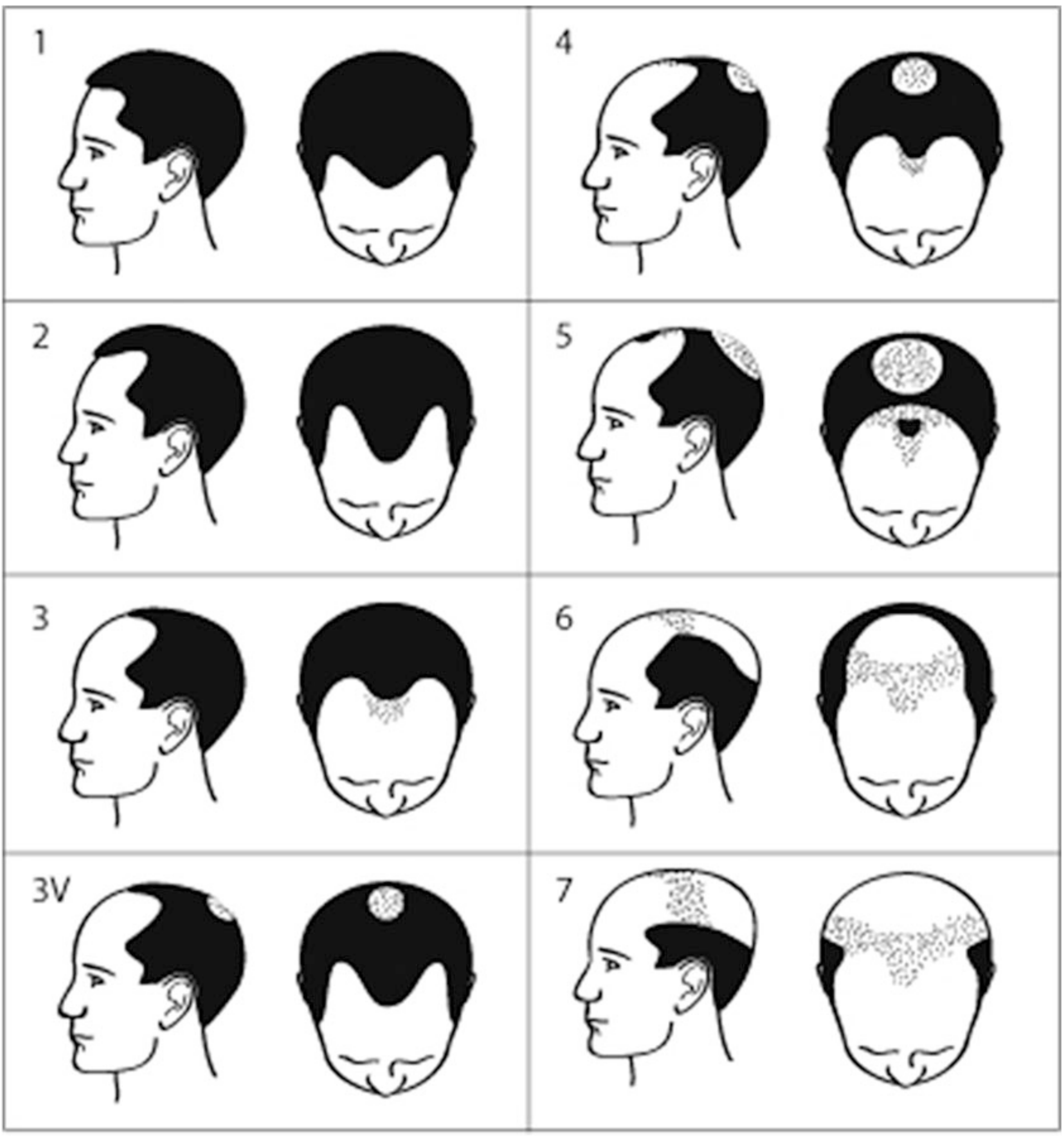

Fig. 24.3 Norwood classification of male-pattern alopecia

- ***Class III***: Earliest stage of male hair loss, characterized by a deepening temporal recession.
- ***Class III Vertex***: Early hair loss in the crown (vertex).
- ***Class IV*** is characterized by further frontal hair loss and enlargement of vertex, but there is still a solid band of hair across the top separating the front and vertex.
- ***Class V***: The bald areas in the front and crown continue to enlarge and the bridge of hair separating the two areas begins to break down.
- ***Class VI*** occurs when the connecting bridge of hair disappears leaving a single large bald area on the front and top of the scalp. The hair on the sides of the scalp remains relatively high.
- ***Class VII*** patients have extensive hair loss with only a wreath of hair remaining in the back and sides of the scalp.

Medical Treatment

Minoxidil

- First drug approved by the FDA for AGA.
- A piperidinopyrimidine derivative functions as a vasodilator (calcium channel blocker) initially used for cardiac purposes. Side effect of hypertrichosis noted in 70 % patients with oral minoxidil. Exact mechanism unknown.
- Currently topical 2–5 % minoxidil shows hair growth with continuous use in 4–6 months. Discontinuation leads to loss of gained hair over 3–4 months.
- Experts question the effectiveness of the treatment as the effects can be marginal, short in duration, and often disappointing.
- The American Hair Loss Association recommends it as a second drug to be added after finasteride or for patients who fail finasteride treatment. It is not considered a first-line therapy, but it does provide effective treatment for a small percentage of its users.
- In addition to its effectiveness in AGA, minoxidil may promote hair growth in patients with alopecia areata, congenital hypotrichosis, and loose anagen syndrome.

Finasteride

- Type II 5-α-reductase inhibitor (important in conversion of testosterone->DHT).
- Finasteride rapidly lowers serum and scalp DHT levels by >60 %. It has no affinity for the androgen receptor and therefore does not interfere with the actions of testosterone.
- Hair counts in men using 1 mg finasteride increase significantly within 1 year, then plateau.
- Finasteride increases the hair growth rate, thickness, and to a limited degree hair count when compared to placebo.

Side effects of finasteride include decreased libido in 1.8 % (vs. 1.3 % placebo), erectile dysfunction in 1.3 % (vs. 0.7 % placebo), and ejaculatory dysfunction in 1.2 % (vs. 0.7 % placebo). These sexual adverse effects gradually disappeared during prolonged treatment and disappeared in days or weeks after treatment was discontinued reported by the NEJM. There is a subset of men who develop persistent sexual dysfunction with a mean duration of 40 months, and 20 % reporting durations of over 6 years. Most men develop sexual dysfunction in multiple domains with 94 % experiencing low libido, 92 % experiencing erectile dysfunction, 92 % experiencing decreased arousal, and 69 % experiencing problems with orgasm.

In men with BPH, finasteride decreases serum PSA levels by about 50 %.

Medical Treatment for Hair Loss in Women

- Minoxidil appears to be more effective in female patients than in men. It is recommended for women to only use the 2 % formulation and not the 5 %.

- Spironolactone (Aldactone) is an antiandrogen that works to slow down the production of androgens in the adrenal glands and ovaries.
- Cimetidine (Tagamet) also has a fairly powerful antiandrogenic effect. It has been used in the past to treat hirsutism in women. High doses are needed to achieve hair-raising results; therefore it is not recommended for men due to possible feminizing effects and sexual side effect.
- Low androgen index oral contraceptives can be used to treat hair loss (high androgen index oral contraceptives can trigger hair loss).
- Topical ketoconazole currently used as an antifungal agent has antiandrogenic effects and can be used to help treat hair loss.

Surgical Treatment

Evolution of hair transplantation: Grafts have been getting smaller and smaller, from 15 to 20 hair plug grafts, to half and quarter grafts (8–10, and 3–5 hairs, respectively), to where in the late 1980s, minigrafts (3–5 hairs), and micrografts (1–2 hairs) came to the forefront.

Considerations

1. Classification of baldness: Norwood classification.
2. Classification of hair quality: density, texture, curl, and color.
3. Color similarity between hair and skin: Generally, similar hair and skin color leads to better result.
4. Future hair loss expectation: family history, can be maternal or paternal, warn pt of uncertainty.
5. Age of patient: <20 generally discouraged, too difficult to predict future alopecia.
6. Motivation, expectations, and desires of patient.

Hairline Placement

General guide for anterior hairline: 7.5–9.5 cm above the mid-glabella. Frontotemporal angle is most critical to design. Hairline should gently slope backward as it approaches the frontotemporal recession, which is located along a vertical line above the lateral canthus. Hairline should exist in an irregular fashion, scattered up to 1 cm in front of the area where the eye actually perceives the hairline.

Determining the number of grafts needed: Each square centimeter yields approximately 100 follicular units (80–120 per sq cm variability). If desiring 1000 graft-session, can harvest a donor strip 1.5 × 6.5 cm donor strip (or 1 × 10 if tight scalp). Some surgeons use a hair densitometer to ensure hair density in donor region and approximate the expected value.

When hair is distributed properly in hair restoration procedures, the density need not exceed 50 % of the patient's original density. The eye cannot perceive hair loss until it exceeds 50 %.

Follicular Unit Grafting (FUG)

Donor strip harvesting: Donor strip marked out just above the external occipital protuberance, either centered in the midline or off to one side, ending at the midline. Donor strip hairs are trimmed to 4 mm. Incision should be angled to parallel hairs to *minimize transection* of hair shafts. Strip is excised in a subcutaneous plane just below the hair follicles. The donor strip is no longer cut with a *multibladed knife* to minimize transection of hairs. For best donor site scar results and depending on scalp laxity and whether prior hair transplant work has been performed previously, the donor strip can typically be 8–15 mm in width. Donor site can be closed with a *trichophytic* closure in which the inferior edge of the donor site defect is de-epithelialized and sutured over the upper lip of the superior edge, thus permitting hair growth through the scar. Can be closed in one or two layers.

Graft preparation: Under microscopic visualization, the single strip is subdivided into slivers, each 1–2 follicular units wide, from which the individual grafts can then be more easily dissected. Because of the small size, these grafts can be placed into very tiny recipient sites. Grafts are kept in *chilled saline* until time of implantation; do not let grafts dry out.

Recipient site creation: Recipient sites are fashioned primarily with small limited-depth blades to minimize damage to the underlying vasculature. Sites should be spaced 1 to 2 mm apart with a transition zone at the hairline of less dense packing. Generally, densities between 20 and 30 follicular units per sq cm produce cosmetically favorable results. Diminished graft survival has been shown when placed at densities >30 follicular units per sq cm. Recipient site creation is the single most important aesthetic step, for the recipient sites determine the pattern and direction of hair growth. The recipient sites created are angled in the direction of hair growth. For example, frontal hair grows anteriorly and therefore the recipient sites are angled anteriorly for a natural appearance.

Special Considerations

Eyebrows: Best results attained when recipient sites are made such that the direction of hair growth is not so cephalic or caudal, but more horizontal/lateral. Angle of growth away from the skin should be minimal, so hairs basically grow flat along the surface rather than sticking out from the face.

Eyelashes: Goal is to have the hairs grow away from the leading edge of the eyelid. Patients often need a curler to direct the hairs in the proper direction of growth.

Graft Insertion

Decreased graft survival if graft dries or if outside the body for over 6 h. Trauma to grafts during placement (i.e., crushing with forceps) can decrease survival.

Overly deep placement of the grafts can cause EICs and ingrown hairs to form or lead to a “pitted” appearance.

“Popping”: When previously inserted grafts are displaced by the lateral or inferior forces of newly inserted grafts.

Follicular Unit Extraction

This is an alternate way to harvest grafts than FUG. Follicular unit extraction (FUE) avoids a donor strip scar by directly obtaining individual follicular unit grafts from the donor area using small punch excisions. The resultant small donor site wound heals by secondary intention with a theoretically undetectable scar. Donor site hair needs to be shaved down to approx. 2 mm in length for efficient graft harvesting. To obtain the same number of follicular units with FUE (compared to FUG), a much larger donor area is required.

Transection rates initially report at 30 %, now down as low as 2–5.5 %. Powered punch FUE devices with a 1.0 mm punch attached to a motor with a rotation capability of 700–1500 rotations per minute statistically lowered the transection rate ($P = 0.003$) and harvesting time ($P = 0.001$), thought to be due to the greater torsional forces that generate more distortion of the axis of the follicle in the manual group.

Once grafts are harvested, they are ready for insertion. The recipient site creation and graft insertion are the same as for FUG.

Postoperative Expectations of FUG and FUE

All hair will go into the *telogen phase* and temporarily fall out. New hair will generate from the follicle in 3–4 months. This interval can be shortened by as much as 6 weeks by using minoxidil starting the tenth day after the procedure. Patients are advised that it can take as long as 12 months before the final results are apparent. Sequential stages of transplantation can be done in 3–6 months.

Scalp Reductions

Balding scalp, usually in the vertex/crown area, is excised. Excisions largely performed in the axis of the lines of minimum tension (*Langer*’*s lines*). Patients with exclusive crown or vertex alopecia and >40 years old with stable hair recession are good candidates. Scalp elasticity should be assessed preoperatively, but less of a concern if an extender is used (implanted device tends to overcome some of the unfavorable tensile forces of the inelastic scalp). For the average patient, two or three scalp reductions are required and can be done either before hair transplantation or in sequence with it. Most useful in patients with class III to VI alopecia. Adjuvant techniques for increasing the yield of scalp reductions include tissue expansion and tissue extension.

Tissue expansion involves the surgical placement under the galea of one or more balloon expanders with progressive stretching of surrounding hair-bearing skin over a period of several months. Although not used anymore for cosmetic scalp reduction surgery, tissue expansion is still a valuable technique when dealing with areas of scarring, such as from burns or prior surgery, or for certain hairline advancement procedures in women.

Tissue extension involves the surgical placement of a playing card-sized elastic device with a row of hooks on each end. The hooks are seated into the galea along the opposite sides of the scalp reduction incision. Over a span of 30 days, the contractive forces of the extender further loosen the surrounding scalp (essentially inducing mechanical creep, rather than the expansion-induced biologic creep), permitting the removal of a greater amount of bald tissue than what would normally be expected. After 30–40 days, a second scalp reduction is carried out, during which the extender is removed. An extender can help achieve maximal reduction and minimal unfavorable *stretch-back* (reported up to 40 %), and shorten the interval between sessions.

Galea fixation in alopecia reduction refers to the suturing of the galea to the central pericranium with the effect of drawing the wound margins into close approximation so the scalp can be closed without tension. A decrease in *stretch-back* with galeal fixation has been reported from 40 down to 13 %.

Stretch-back is a biologic phenomenon in which any living elasticized tissue, for example, skin, when subjected to segmental excision and closure, will subsequently stretch out at the wound site and immediately adjacent tissues. As such, *stretch-back* should not be regarded as a complication, but as an inevitable consequence of excision and suture surgery in elasticized tissue. In most tissues it is not a problem except in alopecia surgery.

Once excised, the remaining bald area after one or a series of scalp reductions can be filled in with transplants.

The four basic types of alopecia reduction are (a) midline reduction; (b) Mercedes reduction; (c) paramedian reduction; and (d) circumferential reduction (Fig. 24.4).

Most patients require >1 scalp reduction. Limiting factors: scalp thickness and elasticity. Resulting scar must be covered with grafts in subsequent transplant procedures.

Scalp Flaps

Previously mainstay treatment, now uncommon.

Advantages: maintain blood supply to hair follicles, prevents telogen phase. Hair is not trimmed and does not fall out.

Ideal candidates: Alopecia restricted to the frontal area.

Juri flap: axial flap following the posterior branch of the superficial temporal artery proximally, can be 3–4 cm wide (up to 5–6 cm if

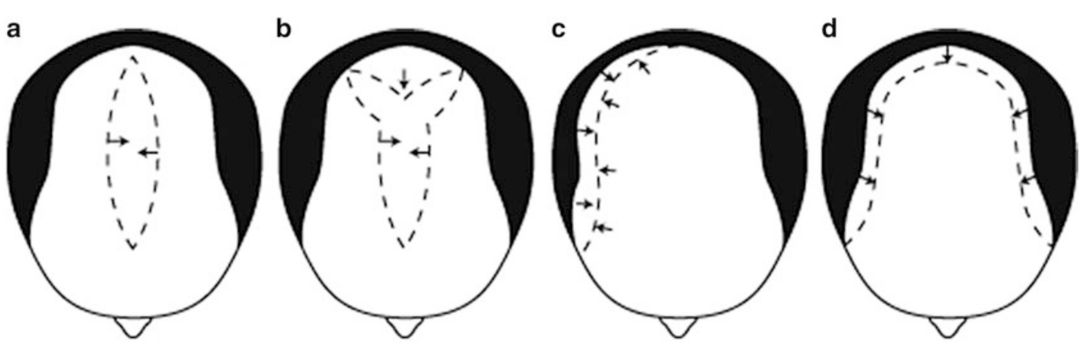

Fig. 24.4 The four basic types of alopecia reduction: (**a**) midline reduction; (**b**) Mercedes reduction; (**c**) paramedian reduction; and (**d**) circumferential reduction

expanded first) and 25 cm long, allows for the entire frontal hairline to be bridged with one flap. Distal flap is based randomly on the occipital and postauricular arteries. Can recreate an entire frontal hairline. Although the direction of hair growth is primarily posterior (instead of the natural anterior direction), the density achieved is unsurpassed; it has been estimated that a single flap provides over 10,000 hairs. For further coverage behind the flap, a second flap from the contralateral side and/or hair grafting can be performed. Base of flap starts 4 cm above the helical crus and spans a distance of 4 cm at an angle of 30–40° from the horizontal. Mild distal flap necrosis may occur, but extensive flap loss is rare if the flap is raised in a twice-delayed staged fashion (raise distal flap and replace first stage, 1 week later raise proximal flap and replace, then raise entire flap and rotate 1 week later) (Fig. 24.5).

Dardou flap: random flap, blood supply less predictable with potential early telogen or tip necrosis.

Flap procedures are rarely performed today with the ability of modern hair-grafting techniques to create such a natural-appearing result.

Disadvantages: Hairlines are abrupt, donor and recipient site scarring often requires the hair to be worn long, it is reasonably limited to patients who will not progress to a class 4 or greater hair loss pattern, and advancement of hair loss can lead to visible donor site scars or areas of baldness behind the flap.

Complications of Surgical Hair Restoration

1. Grafts that are too large or "pluggy": seen in the past with 4–5 mm plugs.
2. Hairline too low or broad: distorts expectations and is unsustainable to balance as patient ages.
3. Hair placed in wrong direction: creates an unnatural appearance.
4. Unrealistic coverage: *remember the first region to bald is where you should be most hesitant to transplant.*

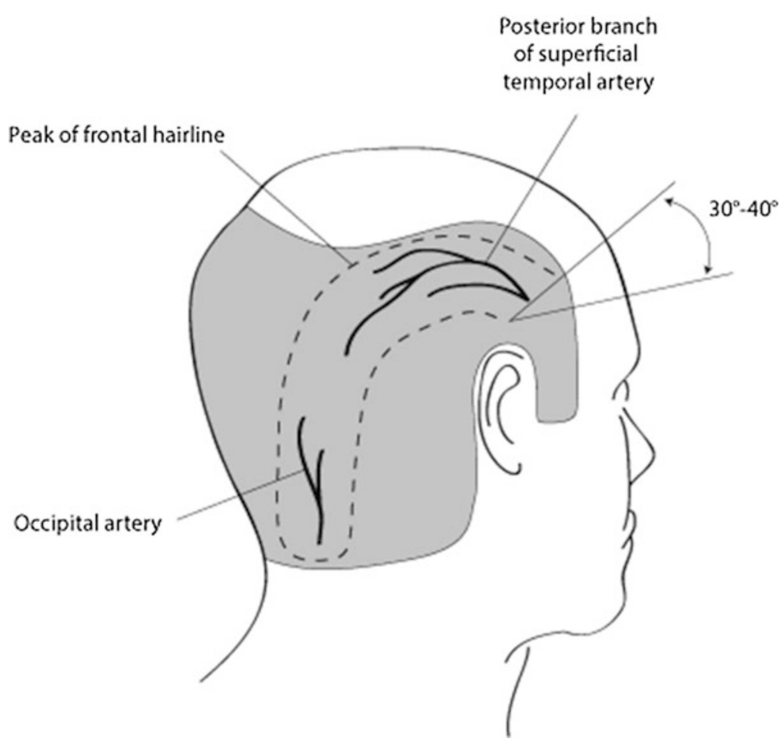

Fig. 24.5 Juri flap design

5. Scarring in recipient area: best to keep slit sizes to 1.7 mm (size of 18 G Nokor needle).
6. Ridging: problem with larger grafts where the transplanted area results in a ridge demarcating it from the surrounding bald scalp.
7. Donor scarring: incision too high, low, or too wide.
8. Low or depleted donor supply: donor hair limited by low density, fine hair caliber, poor scalp mobility, and scarring.
9. "Pitting": depression of the skin around a group of hairs from graft placement. To minimize pit formation, a small cuff of skin from the graft is left sticking above the surface of the surrounding scalp.
10. "Slot deformity" from scalp reductions: divergent directions of hair growth creating an unnatural appearance from a midline scalp reduction.
11. Bleeding, edema, infection, poor hair growth, AV fistula in the occipital region.

Questions

1. Which patient is likely to have the best result with hair transplantation?
   (a) Black hair on Fitzpatrick type 1.
   (b) Dark brown hair on Fitz type 1.
   (c) Red head on Fitz type 1.
   (d) Gray hair on Fitz type 1.
2. In a normal scalp, most hair follicles are in which stage of the hair cycle?
   (a) Anagen.
   (b) Catagen.
   (c) Telogen.
3. Hair loss becomes visible when the amount of hair reduction reaches _%.
   (a) 30 %
   (b) 40 %
   (c) 50 %
   (d) 60 %
4. Which of the following is true about the Juri flap
   (a) It is an axial flap based on the superficial temporal artery.
   (b) It is a random-based flap.
   (c) It is good for balding in the region of the vertex.
   (d) The flap is limited to a length of 10 cm.
5. A 40-year-old female comes in requesting hair transplantation. She is concerned about the thinning of her hair on the top of her head. Examination shows areas of significant thinning with miniaturization of hairs. She is otherwise healthy and not taking any medications. She is a good candidate for hair transplantation.
   (a) True.
   (b) False.
6. A 40-year-old female comes in requesting hair transplantation. She is concerned about the thinning of her hair on the top of her head. Examination shows patches of hair loss with exclamation point appearing hairs. She is otherwise healthy and not taking any medications. She is a good candidate for hair transplantation.
   (a) True.
   (b) False.
7. Based on the Norwood classification of hair loss in men, which stage represents the earliest stage of balding?
   (a) I
   (b) II
   (c) III
   (d) IV
   (e) V
8. Slot deformity is a complication of which type of hair restoration surgery?
   (a) Scalp flap surgery.
   (b) Scalp reduction surgery.
   (c) Follicular unit grafting.
   (d) Follicular unit extraction.

Answers

1. D: Like curliness, light-colored hair on white skin and/or black hair on black skin almost always ensures that a good result will ensue.

This correlation exists because light scalp does not project through light hair and dark scalp does not likewise project through dark hair. Conversely, a light scalp projects significantly through dark hair, making the patient appear balder than he or she may actually be.
2. A: 90–95 % of hairs are growing (anagen phase), less than 1 % are in the involution (catagen) phase, and 5–10 % are in the resting (telogen) phase.
3. The eye cannot perceive hair loss until it exceeds 50 %. Because of this redundancy, there is no reason to restore more than 50 % of the hair, especially in view of the fact that the balding individual has less total hair volume.
4. A: It is an axial-based flap based on the posterior branch of the superficial temporal artery used to reconstruct the anterior hairline and can be 25 cm in length.
5. A: True. Miniaturization is characteristic of androgenic hair loss. Would also consider trial of minoxidil.
6. B: False. This is alopecia areata which is autoimmune and typically self limited. Treatment includes observation with reassurance, possibly steroid injections. Biopsy could be performed if unsure of the cause.
7. C: Class III represents the earliest stage of balding in men.
8. B: "Slot deformity" from scalp reductions is the unnatural appearance of hair from a midline scalp reduction characterized by divergent directions of hair growth where hair was brought together.

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Lasers in Aesthetic Surgery

25

Myriam Loyo

The term laser originated as an acronym for "light amplification by stimulated emission of radiation". Lasers differ from other sources of light because the lights they emit are coherent, monochromatic, and collimated. Because of these characteristics, lasers can be used for selective photothermolysis. Laser light absorption and heat production in the targeted chromophore ultimately leads to its results. Lasers have been used in aesthetic surgery to improve skin texture, diminish dyspigmentation and rhytides, and tighten skin. More recently, lasers are being used for tattoo removal. In this chapter, we review the physics behind laser technology, the different lasers available, their clinical uses, and how to avoid complications. We will compare lasers to other competing available technologies such as pulse light devices, radiofrequency, and ultrasound therapy.

The primary principle behind laser in aesthetic surgery is selective photothermolysis.

Basic Science

The tissue reaction to lasers is the result of the absorption of light. Light is made of photons. Photons are released from an excited atom. In the case of lasers, photons are organized in a singular color and a non-ionizing radiation (because it is non-ionizing it is not mutagenic). Photons travel in waves.

The electromagnetic spectrum is used to describe the entire range of possible wave frequencies. Waves are typically described based on frequency, wavelength, or photon energy. The ranges include radio wave, microwave, terahertz, infrared, visible spectrum, ultraviolet, X-rays, and gamma rays. The visible spectrum has a wavelength from 390 to 700 nm. ***The fundamental difference between pulse light devices and lasers is in the spectrum of the light source. Lasers have a single wavelength***, ***while pulse light devices include a broader spectrum*** (Table 25.1). Because of the difference in light sources, pulse light devices and lasers have different components and properties.

Laser components include a flashlamp, a pumping source, a medium, and a series of reflective mirrors. A large portion of the photons will scatter (the room gets hot, use fans!). Different available mediums are: alexandrite, Nd:YAG (yttrium aluminum garnet), Ho: YAG, CO_2, Argon. The different wavelengths emitted by the various mediums result in different tissue absorption and relaxation times (Table 25.2). These properties determine a laser's clinical indications.

There are **Three laser modes**: continuous (rarely used), pulsed (most common), and

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Table 25.1 Comparison of laser to intense pulse light (IPL)

Characteristic	Laser	Intense pulse light (IPL) Broad band light (BBL)
Light	Monochromatic Collimated	Polychromatic Non-collimated
Target	Specific chromophores	Various chromophores
Clinical use	Scar revision Skin resurfacing Photorejuvenation Hair removal Tattoo removal	Vascular lesions Hair removal Pigmented lesions Photorejuvenation
Level of discomfort	Low to high	High
Filters	No	Yes
Cooling	No	Yes
Skin types to use it	All	Avoid darker skin types

Table 25.2 Wavelengths emitted by different devices

Device	Wavelength (nm)	Clinical application
CO_2 laser	10,600	Rejuvenation To a lesser extent dyschromia
Er: YAG laser	2,940	Rejuvenation To a lesser extent dyschromia
Vascular pulsed dye laser (PDL)	585 and 595	Vascular lesion
Potassium titanyl phosphate (KTP) laser	532	Vascular lesions
Intense pulse light (IPL)	500–1200	Small vascular lesions Pigmented lesions Hair removal To a lesser degree rejuvenation
Infrared laser Nd:YAG Diode laser Erbium: glass Broad band infrared	1000–1800 1320 1450 1540 1100–1800	Rejuvenation

q-switch or mode locked (extremely short, used for destruction of specific lesions).

The effect of the laser extends beyond the penetration of the light and the **residual thermal damage**. The heat transferred to the underlying collagen is believed to contribute to contraction and remodeling, leading to skin tightening. As an example, CO_2 lasers have a thermal damage zone of 100–150 mcm while Er:YAG lasers have a thermal damage zone of 10–40 mcm.

Fractional lasers treat only a fraction of the skin within a targeted area, leaving intervening areas of skin untouched. To produce this effect, the laser is emitted in numerous narrow, microscopic columns measuring 400 mcm in diameter and up to 1300 mcm deep. Higher energy with smaller spot sizes increases the depth of the laser. Re-epithelialization occurs from the sites of undamaged skin, resulting in shorter recovery. There are fractional varieties of CO_2, Er:YAG, and others.

Variables to Understand When Using the Laser

– Wavelength $\geq$ determines your targeted tissue.
  Wavelengths will have different chromophores and absorptions. Wavelengths with high absorption target superficial targets while low absorption target deeper targets. Example: At a setting of 5 J/cm^2 and pulse duration of less than 1 ms, CO_2 light penetrates 20–30 mcm (less absorption), while an Er:YAG has more affinity of water and only penetrates 10–15 mcm (higher absorption).
– Power per spot size $\geq$ density
  By decreasing the spot size you increase the energy.
– Time of pulse or pulse width $\geq$ thermal relaxation time
  Thermal relaxation time is the time required for the tissues to dissipate more than 67 % of the thermal energy. It tells us the time needed to cool a target before we can safely heat it again to prevent complications. Practical example: Pulse width for hair reduction in lighter skin is usually 15–30 ms, but in darker skin you increase the pulse width to 20–40 ms.

– Cooling ≥ protection for the epidermis and anesthesia

Choice of laser is heavily influenced by patient factors as well as laser availability and clinical expertise. Laser resurfacing first emerged in the 1980s with the use of continuous CO_2 lasers. These lasers were associated with high risks for adverse effects, and were modified, for example, by including rapid scanning to improve safety. In the 1990s, Er:YAG emerged with more precise control of the depth of the ablation and fewer side effects. The depth of penetration for CO_2 is 0.1 mm, while for Er:YAG the depth can range from 4 microns to 200 microns. Multiple passes can be used if necessary. Nanopeels (ranging from 4 to 10 microns) and micropeels (10–50 microns) are now possible with better control of depth. Fractional lasers subsequently emerged in the 2000s with decrease in the recovery time. There are limited studies and a few small, randomized trials. It is difficult to compare results between the different available lasers and settings, given the lack of outcome standardization.

Split-face trails comparing CO_2 and Er:YAG initially showed greater improvement in deep rhytides with CO_2 lasers. When more passes of Er:YAG was compared to CO_2, similar improvements were seen, but with reduced adverse effects. Some authors advocate combining Er:YAG for initial ablation followed by CO_2 for the residual thermal damage-mediated tightening effect. Certainly there is ***less coagulative effect with the Er:YAG*** compared to the CO_2 laser, and bleeding can influence the performance of the laser upon multiple passes.

Examples of studies: Khatri et al. (1999); Ross et al. (2001); Adrian (2006).

Pre-operative Evaluation

Selection of therapy depends on the desired goal and expected recovery time. Laser resurfacing can dramatically improve skin wrinkles and texture and moderately improve pigmentation, but the recovery time is more prolonged than non-ablative therapies. Length of time required for healing from full-face ablation with CO_2 laser is 2 weeks and there can be several months of persistent erythema. Shorter recovery times are achieved with Er: YAG and fractional lasers.

Laser resurfacing is particularly good to treat perioral and periocular rhytides; however, nasolabial and pre-jowl areas are best treated with surgery or dermal fillers. Severe skin laxity is best addressed with surgery. Dynamic rhytids usually respond well to neuromodulator injection.

– Skin color influences the decision to proceed with laser.
  Skin phototypes I to II are great candidates, with type III often suitable for skin resurfacing. **Darker skin has a higher risk of dyspigmentation with a laser**. Skin phototypes IV and V have higher risk than lighter skin.
– Non-facial sites (i.e., chest and neck) have a higher risk of scarring
  The re-epithelialization depends on the adnexal structures, which have a lower density in non-facial areas.
– Underlying cutaneous conditions can be considered a relative contraindication. Resurfacing after laser therapy is dependent on intact adnexal structures. Conditions such as scleroderma and prior radiation therapy compromise these structures, and are contraindications. Underlying cutaneous diseases can be exacerbated by cutaneous injury with the laser such as vitiligo, lichen planus, and psoriasis.
– Isotretinoin is a relative contraindication
  Most specialists recommend waiting 1–2 years because of the possibility of atypical scarring.
– Smokers may have delayed healing

Pre-Operative Medications

– Pain management. Local infiltrative anesthesia or nerve blocks are often used in conjunction with systemic anxiolytics and oral narcotics. Intravenous anesthesia is sometimes utilized.

– Oral antiviral therapy. Usually started the day before the laser session and continues until re-epithelialization. (acyclovir 400 mg tid, valacyclovir 500 mg bid or famciclovir 250 mg bid). Some practitioners treat only patients with history of HSV, while others use routinely in all full face or perioral laser treatments. It is recommended to use it in all patients undergoing a deeper peel (deeper than MLP).
– Antibacterial and antifungal. Opinions vary; most practitioners do not routinely prescribe prophylaxis.
– Pretreatment with topical tretinoin. Pretreatment is often recommended to improve healing time (and assess patient's ability to tolerate post intervention care); however, there is insufficient evidence on the efficacy of this practice. Many practitioners encourage the use for 4 weeks before a treatment.
– Oral glucocorticoids. Some clinicians use oral steroids to decrease edema and swelling post intervention; there is insufficient evidence to substantiate this practice.

Adverse Effects

– Persistent erythema.
  Usually resolved after 2 months of CO_2 laser and 1 month of Er:YAG but may persist for a year. Green-based makeup can help hide erythema. The erythema is predicted to be of shorter duration with fractional lasers (less than a month in most patients).
– Dyspigmentation.
  Transient post-inflammatory hyperpigmentation can occur in 30 % of patients and is more likely to occur in patients with skin photo type III or higher. For these patients, consider to administer laser therapy in the fall and winter (reduced sun exposure). Daily sunscreen and sun protection is recommended. Hyperpigmentation can be treated with topical steroids, hydroquinone, retinoids, and/or peeling agents such as glycolic acid. Unfavorable color contrast between treated and non-treated areas can occur. Full-face treatments or full facial units are advocated and transitioning (feathering) between treatment zones to minimize the color differences.
– Herpes labialis infection may occur after laser.
  Prophylaxis is recommended (as described above).
– Bacterial and candida infections.
– Acneiform eruptions and milia.
  Particularly exacerbated by occlusive ointments often used during healing.
– Scarring.
– Ectropion when the lower lid skin is treated.

Competing Technologies

Ablative Vs. Non-Ablative Skin Rejuvenation

Ablative technologies remove the epidermis and portions of the superficial dermis to stimulate the underlying skin and induce collagen remodeling.

Examples of ablative lasers: CO_2 and Er:YAG.

Non-ablative lasers do not remove the epidermis and instead stimulate skin resurfacing by targeting deeper collagens, pigment, or blood vessels. The advantage is less down time (shorter recovery) and less risks, but might also lead to more modest results in skin tightening.

Example non-ablative technologies: IPL, radiofrequency, infrared, and ultrasound.

Pulse light devices are also called intense pulsed light (IPL) or broad band light (BBL). They are broad spectrum lights that target various chromophores (often pigment, hair, and vascular lesions). Hair reduction will not work in white hair (no chromophore). In this case, electrolysis is recommended. Filters are commonly used to narrow the spectrum (take the forms of the slides). Common filters are 515, 560, 640, and 775 nm and they block shorter wave forms. *Pulse light devices use a crystal and gel* *that is cooled to increase conduction and protect the skin by decreasing the amount of heat that stays in the tissue*. Sapphire is the most common crystal used. IPL was first approved for the treatment of lower extremity telangiectasias by the Food and Drug Administration (FDA). The indications for IPL have expanded to hair removal, treatment of small blood vessels, pigmented lesions, and dyschromias. They can also be used for photoaging, although to a lesser extent than other lasers.

Example of results for intense pulsed light (IPL): Split-face trial of 3 months of once a month IPL, which resulted in improvement in telangiectasias, pigmentation, and skin texture, but there was no difference in rhytides (Hedelund L et al. 2006).

Note: IPL is not recommended for hair reduction for phototype III and higher due to the risk of dyschromia. Near-infrared laser at 1064 nm has a very low absorption in the epidermis and is recommended for hair reduction in darker skin types.

Non-Invasive Skin Tightening

Surgical lifting remains the gold standard for treatment of skin laxity in the face. In this section, we discuss less invasive techniques that are now available. The mechanism of these technologies is heating of the dermis and subdermal region leading to contraction and remodeling while preventing injury to the epidermis. Common adverse effects are pain, swelling, erythema, and epidermal burns.

Radiofrequency devices generate an electrical current and as this current encounters resistance in the dermal tissues, it generates heat leading to collagen remodeling and skin tightening. Wound remodeling takes 3–6 months. Different modalities of radiofrequency are available. The initial studies showed modest and unpredictable results. As a consequence, the protocols were modified so that multiple lower energy passes were used. Results are still considered to be moderate with this technology.

– Monopolar: Thermage is an example of monopolar technology and the first radiofrequency technology to hit the market.

  Examples of radiofrequency results: The first monopolar study was in the forehead and it showed a 0.5 mm improvement in brow elevation by photoanalysis (Fitzpatrick et al. 2003). Treatment of the jowl leads to a 22 % decrease in 2D surface analysis (Nahm WK et al. 2004). A survey of 5400 patients who had treatment reported 54 % of patients in the original protocol noticed any change while 92 % of the patients on the later protocol noticed tightening (Alam et al. 2003).
– Unipolar: A grounding pad is used. Depth of penetration is deeper (20 mm) and, hence, used in body contouring. Similar results as monopolar with concerns for minimal to moderate results in facial skin tightening.
– Bipolar: The current goes between two electrodes and no grounding pad is needed. The depth of penetration is 2–4 mm. Bipolar is frequently used with IPL for synergistic effects. Vacuum technologies to bring the target closer to the machine have also been used.
– Fractional radiofrequency: The tip of the device has an array of needles that are inserted into the skin.

Infrared lasers have wavelengths between 1000 and 1800 nm. They penetrate deeply and exert their effects in the reticular dermis, leading to skin tightening. Technology to cool the skin surface is essential to prevent heat-related damage to the epidermis during treatment. Mild results have been reported, but so have superficial skin burns. Broad band infrared spanning 1100–1800 is also available and is used with minimal discomfort (in contrast to IPL or infrared laser).

Examples of results with infrared technology: wavelengths 1100–1800 nm with 20–40 J/ cm^2 resulted in skin tightening lasting 12 months. Two patients had second-degree burns (Ruiz-Esparza & Gomez 2003). A1450 nm diode laser lead to 15 % of patients having moderate improvement in rhytides, 50 % mild, and 35 % no change. Goldberg DJ, et al. Laser Surg Med 2002.

Intense focused ultrasound tightens the skin by delivering thermal energy to the dermis and subcutaneous tissue. This technology can target deeper tissues including the SMAS, while completely sparing the epidermis. Small areas of coagulative necrosis measuring 1 mm^3 are seen in histological studies. The first technology to be available in the market was Ultherapy.

Example of ultrasound studies: Blinded evaluators reported moderate improvement in the jowl of 50 % of treated patients after two passes (4 MHz 4.5 mm probe and 7 mHz 3.0 mm probe). Lee HS et al. Dermatol Surg 2012.

Laser Tattoo Removal

Tattoos used to be considered permanent but it is now possible to remove tattoos partially or totally. Before laser technology was available, tattoo removal methods were dermabrasion, peels, and surgical excision. Today, **laser tattoo removal usually involves Q-switched lasers**. The laser targets the tattoo pigment particles and fragments it into smaller pieces that can then be removed by the body. The Q-switched laser is ideal because it can heat the ink in a very short pulse that prevents heat dissipation to the surrounding normal skin. Black and darker inks are more completely removed. Multiple passes are required and the number needed is calculated using the Kirby-Desai scale.

Available lasers for tattoo removal:

– Nd:Yag: 532 nm used for red and orange tattoo.
– Ruby: 694 nm green and dark tattoo.
– Alexandrite: 755 nm: green and dark. It is less absorbed by melanin than ruby, resulting in less risk of inflammatory post-hypopigmentation. This also leads to less dramatic results.

Questions:

1. Match the wavelength with the laser:

Alexandrite	2940 nm
CO_2	1000–1800 nm
KTP	532 nm
Er:YAG	10,600 nm
Infrared	755 nm

2. Which is the best technology to treat pigment in the skin?
   (a) CO_2
   (b) Er:YAG
   (c) IPL
   (d) Infrared
3. Which laser has higher absorptions?
   (a) CO_2
   (b) Er:YAG
4. Which laser has higher coagulation?
   (a) CO_2
   (b) Er: YAG
5. IPL is not a laser and eye protection is not needed. True or False
6. Explain what is a fractional laser?
7. Which is considered an absolute contraindication to laser resurfacing?
   (a) Psoriasis
   (b) Smoking
   (c) Isotretinoin therapy
   (d) Neck skin
   (e) Active herpes labialis
8. Radiofrequency, ultrasound, and infrared lasers all have similar skin tightening effects in the jowl as a face lift but with less recovery time. True or False
9. Which is the best mode of laser to use for tattoo removal?
   (a) Continuous
   (b) Pulse
   (c) Q-switch
10. Which is the best technology for hair reduction for darker skin types?
   (a) IPL
   (b) 1064 nm
   (c) CO_2
   (d) Er:YAG

Answers

1. Table 25.2, 2. (c), 3. (b) (12 times higher), 4. (a), 5. not a laser but you do need eye protection False, 6. refer to text, 7. (c), 8. False, 9. (c), and 10. (b)

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Liposuction

26

Andrew D. Beckler

Anatomy

The tissues of the face and neck are comprised of various layers including skin, subcutaneous fat that is highly compartmentalized into superficial and deep subunits, superficial fascia including the SMAS and platysma, deep fascia, facial mimetic muscles, and bone. The subcutaneous fat is contained in a fatty-fascial layer that covers the face and neck and thickens anteriorly in the midface to become the malar fat pad. Once originally thought to be a large confluent mass of fat, recent studies have shown that the fat of the face and neck is organized into distinct anatomic compartments (Table 26.1, Fig. 26.1). These compartments are separated by fascial septae that originate from the superficial cervical fascia and insert into the dermis. Perforating vessels travel through the septae to supply the skin in distinct angiosomes.

These fat compartments are thought to age differently causing noticeable contour differences through both volume and position changes (volume loss and ligament laxity/tissue descent). When performing liposuction, the surgeon may encounter areas that are easier to dissect and others with more resistance—the areas of resistance usually correspond to transition zones between compartments, which can be subject to injury to deeper tissues, including nerves. Therefore, it is very important to maintain the correct plane during the procedure.

Sensory Nerves
CN V (Trigeminal Nerve)

- V1 (*ophthalmic division*): supraorbital n., supratrochlear n., palpebral branch of lacrimal n., infratrochlear n., external nasal branch of anterior ethmoidal n.
- V2 (*maxillary division*): infraorbital n., zygomaticofacial n., zygomaticotemporal n.
- V3 (*mandibular division*): mental n., buccal n., auriculotemporal n.

Cervical plexus (C2–4)

- Greater occipital n. (C2).
- Lesser occipital n. (C2, 3).
- Great auricular n. (C2, 3).
- Transverse cervical n. (C2, 3).
- Supraclavicular n. (C3, 4).

Motor Nerves
CN VII (Facial Nerve)
Innervates the muscles of facial expression via five terminal motor branches: **temporal**, **zygomatic**, **buccal**, **marginal mandibular**, **cervical**. These branches are found at four different depths in the face and neck.

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Table 26.1 Fat compartments of the face. The layers of facial fat are organized into distinct compartments that contain important structures and constitute noteworthy surgical landmarks

Region	Superficial fat compartments	Notes
Forehead	Central, middle temporal, lateral temporal-cheek	Supratrochlear a. is the boundary between central and middle temporal; lateral temporal-cheek is the most lateral compartment and spans from forehead to neck
Orbital	Infraorbital fat (malar mound)	Superior margin is at lid/cheek junction. Above junction, little fat is present, below junction fat covers orbicularis oculi
Nasolabial	Nasolabial	Most medial; lower border of zygomaticus major m. adheres to compartment; angular a. perforators run in NL septum
Cheek	Medial, middle, lateral temporal-cheek	Facial v. found at deep surface of medial cheek fat; where medial and middle compartments meet is parotidomasseteric ligaments; lateral cheek septum is first transition zone in face lift
Cheek	Jowl fat compartment (superior/inferior)	Adherent to depressor anguli oris (DAO) medial boundary is lip depressor, inferior boundary is a membranous fusion with platysma (mandibular retaining ligament)
Region	Deep fat compartments	Notes
Cheek	Deep medial cheek	Deep to medial and middle superficial cheek fat; potential space between deep medial cheek fat and maxilla periosteum (Ristow's space) can be used for fat transfer, located medial to zygomatic major. Important for central cheek prominence. Inadequate volume results in anterior flattening
Cheek	Buccal	Lies adjacent to deep medial cheek fat in masticator space. Extends from edge of upper mandible into the temple affects the jowl prominence. Facial nerve and parotid duct travel through this compartment
Orbit	SOOF-medial and lateral compartment	Lies along orbital rim and zygomatic arch immediately above periosteum, medial compartment smaller than lateral. V2 travels through medial compartment, zygomaticofacial travels through lateral compartment. Lateral soof is important for cheek projection

Motor nerve function to the mimetic muscles of the first three layers is supplied through the deep surface of the muscle whereas the deepest layer of muscles, including the **buccinator**, **levator anguli oris**, **and mentalis**, receive their **innervation via the superficial surface** of the muscle (Table 26.2).

Vascular Supply

The blood supply to the face and neck is provided by the facial artery, which further branches into the superior/inferior labial and angular arteries, superficial temporal artery, transverse facial, submental, and posterior auricular arteries. Venous drainage is carried by the internal, external, and anterior jugular veins as well as the veins that run with their corresponding arteries.

Neck

Anterior compartment—bounded by the midline of the neck, the inferior border of the mandible, and the anterior border of the SCM.

Posterior compartment—bounded by the posterior border of the SCM, the anterior border of the trapezius, and the middle third of the clavicle.

Superficial cervical fascia is deep to the skin and envelopes the platysma muscle. The **deep cervical fascia** invests the neck structures and is divided into **three layers**: the **investing layer** surrounds the SCM and trapezius; the **visceral (pretracheal) layer** is limited to the anterior neck and surrounds the trachea, esophagus, infrahyoid strap muscles, and thyroid gland—posteriorly it is called the **buccopharyngeal fascia** and covers the buccinator and pharyngeal

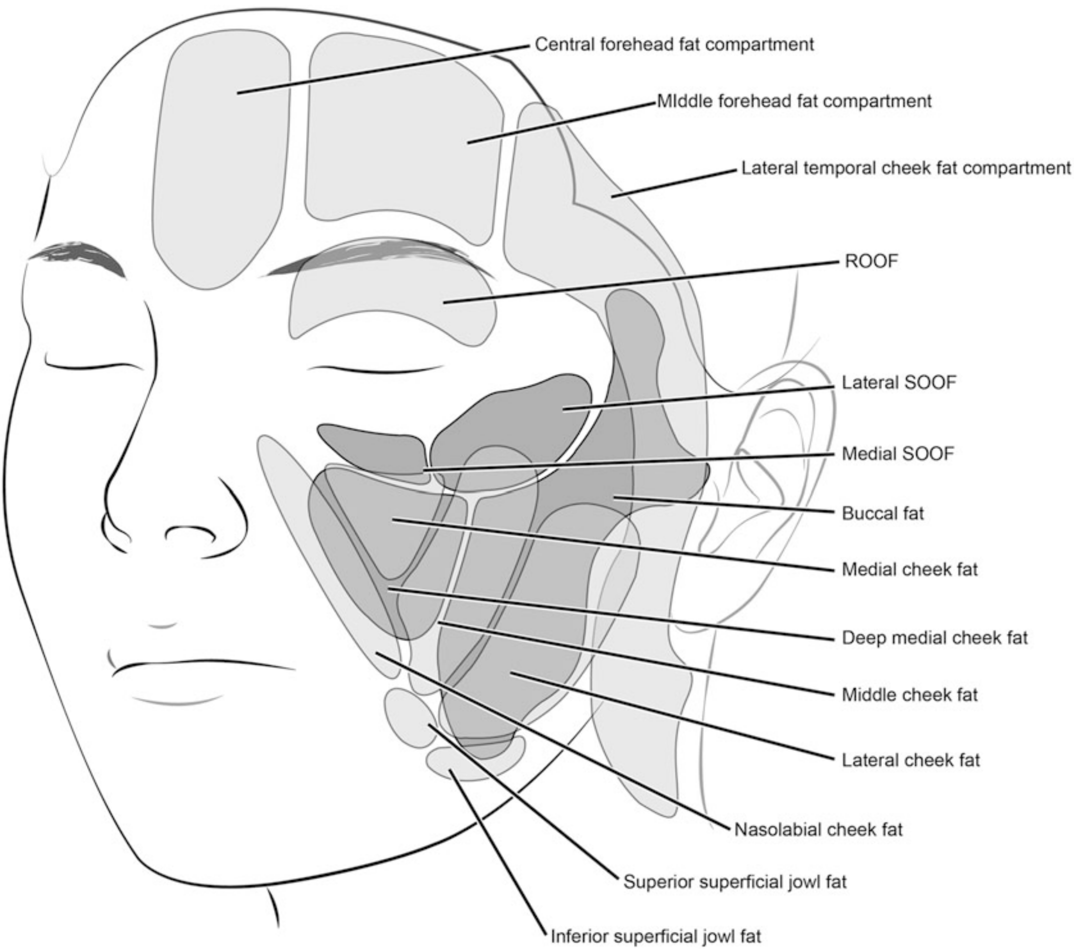

Fig. 26.1 Facial fat compartments. The fat of the face and neck is organized into distinct anatomic compartments. *Light gray* = superficial fat compartments, *dark gray* = deep fat compartments

constrictors; and the **prevertebral layer** invests the vertebral column and the prevertebral muscles—anteriorly it includes the **alar fascia**. The **carotid sheath** blends with all three layers to form a distinct layer over the IJ, common carotid, and vagus nerve.

Introduction to Liposuction

Physiology of Adipose Tissue

Adipose tissue is composed of adipocytes (with variable fat content) surrounded by a connective tissue matrix (collagen, elastin) along with macrophages, pericytes, fibroblasts, and mast cells. Fat in the fetus is thought to develop from fibroblasts and appears in month four of gestation. The number of fat cells triples during year one of life and increases again at puberty. Weight gain is initially through lipid accumulation and **adipocyte hypertrophy**. As weight gain continues, however, immature precursors form new fat cells—this **adipocyte hyperplasia** is thought to be permanent and resistant to future weight loss.

Fat deposits in the face and neck can be attributed to genetics, hormonal imbalance, poor diet, and lack of exercise. Facial fat compartments are isolated and as a result they do not respond to diet and exercise like other fat

Table 26.2 Mimetic muscles. The mimetic muscles are supplied by the facial nerve (CN VII) and are involved in facial movements and the expression of human emotions

Muscle layer	Mimetic muscles	Innervation
1 (Superficial)	Depressor anguli oris, zygomaticus minor, and orbicularis oculi	Deep surface of muscle
2	Depressor labii inferioris, risorius, platysma, zygomaticus major, and levator labii superioris alaeque nasi	Deep surface of muscle
3	Orbicularis oris and levator labii superioris	Deep surface of muscle
*4 (deep)	*Mentalis, levator anguli oris, and buccinator (MLB = mnemonic for these muscles)	*Superficial surface of muscle

* muscles that are innervated along their superficial surface

deposits in the body, and they are the first to hypertrophy with an increase in weight.

Lipolysis is a biochemical pathway that involves the breakdown of triacylglycerol (TAG) stored in adipocytes. Non-esterified fatty acids (FA) are produced from the hydrolytic cleavage of TAG, which are then used as energy substrates, precursors for lipid and membrane synthesis, or mediators of cell signaling. The process of lipolysis occurs in almost all tissues, but is most prevalent in white and brown fat.

Facial adiposity has complicated efforts at facial rejuvenation over the years. The goal of suction lipectomy is to create a more refreshed appearance and restore definition of natural facial angles through recontouring of fat deposits that are ptotic, malpositioned, and redundant. Since the number of fat cells in the adult is relatively stable the **goal of liposuction** is to **permanently remove facial/neck fat cells** by suction-assisted avulsion and facilitate **contraction of the subdermis** (including the subcutaneous tunnel network) during the healing process.

History

- 1970s: Schrudde discussed the idea of "lipoexeresis."
- Manipulation of fat was initially performed as an adjunct to rhytidectomy.
- Fischer, Fischer, and Kesselring described using a tube connected to a suction device to suction fat through small incisions.
- Illouz utilized the technique of lipolysis by injecting hypotonic saline and then using a blunt-tipped cannula to aspirate fat under high vacuum. His extensive studies showed fat cells multiply from birth to puberty and then stabilize in number—obese children have a large number of adipocytes (hyperplastic), whereas obese adults have large fat cells (hypertrophic) from FA and TG deposits increasing the overall volume.
- Many innovations in suction lipectomy of the face/neck have derived from body contouring research.

Benefits

- Minimal scarring.
- Shorter recovery.
- Decreased tissue/nerve trauma.
- Cosmetically favorable and hidden incisions.
- Neurovascular pedicles are preserved resulting in less bleeding and less hypoesthesia.
- Despite many advantages, deep midline fat is not adequately treated with liposuction and often requires direct excision.

Analysis

History

Liposuction has essentially replaced direct lipectomy techniques due to its safety and ease. It can be performed as an isolated procedure or in conjunction with other facial rejuvenation procedures. Optimal candidates have excess fat deposits on exam, which the surgeon and patient agree to address with surgery. As with any elective surgical procedure, it is critical that the patient has realistic expectations of the anticipated outcome. The facial plastic surgeon needs to elicit information from the patient regarding their past medical history, past surgical history, medications, allergies, tobacco/alcohol use, history of easy bleeding, and problems with anesthesia. Specific questions regarding prior neck surgery, trauma, history of radiation, or history of collagen, vascular, or systemic diseases that would impede wound healing should be identified. Additionally, patients that are overweight and who have generalized fat deposition in multiple tissue layers are difficult to correct with liposuction alone and may benefit from a weight loss program. Failure to recognize these important considerations can lead to complications, poor results, and patient dissatisfaction.

Physical Exam

The ideal candidate for liposuction is a younger patient with good skin elasticity and muscle tone. As patients age, the ability of the skin to contour to the neck is diminished due to breakdown of elastic fibers and collagen and progressive muscle laxity.

Characteristics of a youthful, **aesthetically pleasing neck**: distinct border of inferior mandible with no jowl, visible thyroid cartilage, subhyoid depression, visible anterior border of SCM, and a cervicomental angle between 105 and 120°. Definition of the cervicomental angle can be affected by a low/anterior hyoid, retrusive chin, prominent digastrics, ptotic submandibular glands, and skin elasticity/tone. The surgeon must therefore carefully consider these when evaluating a patient for surgery.

The **Illouz test** can be used to assess the skin tone. The distance between the earlobe and menton is measured. It is then measured a second time after pulling the skin away from the face; if the difference is less than 15 % then suction lipectomy is likely all that is needed; if it is greater than 20 % then rhytidectomy may be indicated.

Table 26.3 Dedo classification of cervical abnormalities. The Dedo classification is used to assess the types of neck deformities as well as the best surgical techniques to address them

Dedo classification		
Class	Deformity	Proposed technique
1	Minimal deformity, well-defined cervicomental angle, no fat accumulation, good platysma tone, younger patient (<40)	N/A
2	Skin laxity, no fat accumulation, good platysma tone	Rhytidectomy
3	Fat accumulation	Suction-assisted lipectomy
4	Platysma banding	Platysmaplasty
5	Congenital/acquired retrognathia	Mentoplasty, genioplasty
6	Low hyoid	Difficult to optimize cervicomental angle

The Dedo classification system provides a useful reference for the surgeon to highlight certain physical exam findings as well as the aesthetic procedures that are commonly used to address them (Table 26.3).

The hyoid and chin position are critical to analyze as the underlying bony anatomy ultimately determines the appearance of the neck. The position of the hyoid is a critical factor in determining the cervicomental angle. A low hyoid position is difficult to correct and can lead to disappointing results. The **ideal chin projection** is defined as 3 mm posterior to the nose-lip-chin plane, which is the line extending from a point one-half the distance of the ideal nasal length through the upper and lower lip vermillion. Alternatively, it has been defined as one in which the anterior border of the chin closely approximates a vertical line from the vermillion border of the lower lip. Patients with retrognathia or microgenia may benefit from chin augmentation in addition to suction-assisted lipectomy for an optimal outcome.

The submandibular glands and anterior digastric muscles should also be inspected for their role in obscuring the cervicomental angle. Digastric prominence, submandibular gland ptosis, and/or hypertrophy should be distinguished from fat deposits as correction of these deformities is optimally achieved with reduction techniques through an anterior neck approach.

Patients with platysmal banding should be cautioned regarding liposuction. Removal of fat can exacerbate or unmask platysmal banding resulting in **cobra neck deformity** of the submental area. In this patient population, a platysmaplasty is often required to produce an improved neck contour.

Patients with good skin elasticity (leads to skin contraction, otherwise can have sagging) no platysmal banding, and localized fat deposits, e.g., palpable submental fat mass, stand to benefit the most from this procedure. Other characteristics that make a patient a good candidate for this procedure include lack of wrinkled/lax skin as well as no visible platysmal banding.

Photo Documentation

Standard facial photographs should be obtained preoperatively for documentation and to use for photo manipulation to demonstrate anticipated postoperative results. Photographic views should include anterior, lateral, oblique, and neck flexion. Additional photographs with the patient smiling and grimacing document the form and function of the platysma.

Patient Counseling

Skin irregularities and asymmetries should be noted and discussed with the patient preoperatively. The expected postoperative course should also be discussed with the patient including bruising and discoloration, which can last for 1–3 weeks, as well as edema and induration, which can last for months. Less commonly, patients can experience pigment changes related to hemosiderin deposits. Patients commonly wear a facial sling continuously for a week to help limit swelling and then intermittently for up to 4 weeks after surgery. Irregularities are usually transient and are treated conservatively with reassurance, gentle massage, and occasionally with steroid injections. Temporary numbness and tingling are also possible. Activity is usually restricted for 2–3 weeks to prevent additional swelling, decrease the chance of bleeding, and allow the soft-tissue envelope to adhere to the subcutaneous tissues. Results are unpredictable and vary by patient and may take up to 6 months to be evident.

Incisions, Approaches, Techniques

Incisions can be placed in the following areas: **submentum**, **infralobular crease**, **nasal vestibule**, **pretragal**, **postlobular**, **and temporal hairline**. Incisions must be made large enough (4–8 mm) to avoid friction burns and skin excoriation. It is important to use a carefully designed and evenly distributed tunnel system to avoid irregularities and bulges.

Facial regions typically treated with liposuction include submentum, lateral neck, jowls, and buccal region. Also may treat nasolabial folds and lower jowls, although results are less predictable. Treatment of the mid-face is risky because of the natural tendency for fat atrophy in this region. Areas of excess skin laxity and tissue descent are not good areas to treat with this procedure.

Equipment

- Cannulas: 1, 2, and 3 mm (most precise) up to 4 and 6 mm (used judiciously for larger fat deposits).
- Fat cells are sucked up through the perforated cannula and avulsed.
- High vacuum pressure can cause cell lysis directly.
- Low vacuum pressure is used if fat transfer is going to be performed to decrease trauma to adipocytes and increase the yield of viable cells (usually with Luer-Lock aspiration cannula).

- Negative pressure generated by electrical machines is 1 atm = 960 mmHg; handheld syringe is 700 mmHg initially, then drops to 600 mmHg.

Description of Procedure

Patient marked preoperatively for important landmarks (SCM, hyoid, angle of mandible) and areas to be treated while sitting down (tissue can become distorted when supine).

Approaches:

Closed is often used when suction lipectomy is performed as an isolated procedure.

Open is common when the procedure is performed along with a facelift and larger incisions are used (an electric vacuum must be used for the open technique because there is no seal present to allow for use of handheld syringes).

Tumescence of treatment area with hypotonic saline solution mixed with local anesthetic (causes hydrodissection and facilitates fat aspiration); additionally local anesthetic is used for nerve blocks along planned incisions and throughout the treatment area.

Incisions are made based on the areas to be treated and scissor dissection is carried out to establish the appropriate plane; the cannula is then used for pretunneling before attaching the vacuum to facilitate passage of the cannula during the procedure.

Perforated rigid blunt-tipped cannula (1, 2, and 3 mm—best control/precision) attached to a suction device inserted through skin incision and passed back and forth through fatty deposits through subcutaneous tunnels just deep to the dermal-subcutaneous interface; fenestra of the cannula is **pointed away from the dermis** to avoid injury.

Superficial tunnel is used by tenting skin away from deep tissues; the left hand is the "smart" hand and is used to guide the cannula, direct fat into the fenestra, and maintain the correct plane; the right hand is the "motor." Care is taken to avoid perforation of the platysma, which could put the patient at risk of injury to the underlying neurovascular structures and promote bleeding.

Treatment extends to SCM laterally and hyoid/sternum inferiorly in a radially directed fan-shaped pattern. Areas of greatest fat density can be treated with larger cannulas to aide in fat removal; more distant sites are treated more conservatively to help achieve a feathering/blending effect.

Care should be used when removing the cannula through incision site to avoid skin injury (simply pinching the suction tube temporarily will stop the vacuum to allow safe withdrawal and reinsertion).

Use of multidirectional crisscross approach generates extensive overlapping tunnel network that facilitates contour enhancement (Fig. 26.2). Avoidance of fat overexcision is accomplished by frequent checking of progress and the **pinch-and-roll technique**, which involves gently pinching the skin between thumb and forefinger and rolling it—a sufficient amount of fat is excised when a thin layer of fat is felt between the layers.

Extraction volumes vary per person, but usually require 10–100 cc.

Sometimes fat deep to the platysma needs to be excised to improve the cervicomental angle either using careful liposuction or direct excision.

At the conclusion of the procedure, the sites are irrigated and hemostasis is achieved, drains are usually not needed, but a compression dressing is used to help prevent edema/hematoma.

Complications

Transient irregularities are common and should be discussed with patients preoperatively. There is a less than 1 % chance of infection, hematomas, seromas, and sialoceles. Skin sagging and dermal scarring can result in longer lasting irregularities. Asymmetry may result from uneven aspiration from poor technique. Depressions can develop that require treatment with filler. Rarely patients may experience

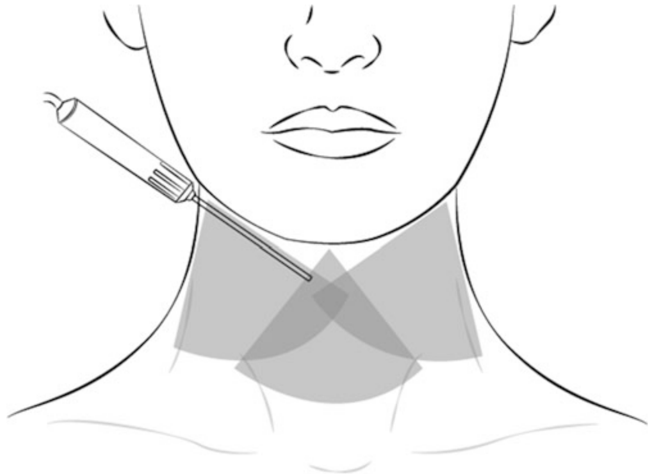

Fig. 26.2 Radial fan-shaped tunnels are used to perform suction-assisted lipectomy. Multiple access points and overlapping treatment areas help to blend and feather transition zones

weakness of the marginal mandibular branch of the facial nerve or hypoesthesia.

Bulges, asymmetries, and dimples that persist after 6 months can often be treated with additional suction lipectomy, fat injection, or subcutaneous steroid injection. Treatment that is too aggressive can result in hollowing, concavities, or unmasking of platysmal banding.

Autologous Fat Transfer

Since the introduction of liposuction, autologous transfer of harvested fat has been used for facial rejuvenation, traumatic deformities, lipodystrophy, hemifacial atrophy, rhytides, malar and chin augmentation, post-liposuction irregularities, etc. Knowledge of adipocyte physiology and optimal harvesting techniques has led to the use of cannulas no larger than 3 mm—common technique uses 3–10 cc syringe with 14-G needle or blunt micro-cannula for aspiration of fat. The harvested fat is then separated by allowing it to settle over time, by filtering it with gauze, or with light centrifugation. Minimizing trauma to the fat cells helps to improve yields. Extra fat can be frozen and used for up to 2 years. The recipient area is anesthetized with care not to distort the tissue. Fat is injected in a retrograde fashion from deep to superficial with a 1 ml syringe using a cannula or needle. It is done using minimal positive pressure with multiple passes to achieve a natural and smooth appearance. Usually injected into subcutaneous plane with slight overcorrection. After injection the area can be molded for further refinement and contouring. May require multiple treatments for optimal results.

Additional Considerations

When used alone suction lipectomy is most effective in creating *contour changes* in the cervicomental angle and jowl regions. Less predictable results are achieved when treating the nasolabial folds and lower jowl fat pads. Patients over 40 may not possess enough skin elasticity to allow for adequate contraction after liposuction alone; therefore, rhytidectomy may be necessary to achieve optimal results.

Suction lipectomy can also be used as an adjunctive procedure for further refinement along with chin implant, rhytidectomy, or platysmaplasty. For example, pretunneling followed by closed liposuction is done in the neck and lower face. After reduction of cervicofacial fat collections, undermining of facial flaps is facilitated by the atraumatic subcutaneous tunnels created from suction lipectomy, which only requires division of the subcutaneous bands to complete the dissection. Once the flaps are raised, open liposuction may be carried out using a spatula-shaped cannula tip to further refine the lower face and neck.

New innovations in the field of liposuction of the face and neck include the introduction of smaller and varying types of cannulas, tumescence of the areas to be treated, use of ultrasound, and the liposhaver (actively excises fat instead of avulsion, less traumatic).

Questions

1. A 46-year-old female patient comes to your clinic for evaluation of prominent bands in her medial neck with horizontal rhytides. On exam, she has good skin elasticity with no appreciable skin excess and no lipodystrophy. What is the best management of her problem?
   (a) Giampapa suture-suspension neck lift.
   (b) Suction-assisted lipectomy with platysmaplasty.
   (c) Platysmaplasty.
   (d) Injection of bands with neurotoxin.
   Answer (d): Not all patients with cosmetic neck deformities warrant surgical intervention as some may be candidates for treatment using a neurotoxin. A classic example is a woman between 45 and 50 years old with platysmal banding, horizontal rhytides, and no lipodystrophy, excess skin, or submandibular gland ptosis.
2. Which of the following facial mimetic muscles receives facial nerve innervation from its deep surface?
   (a) Depressor anguli oris.
   (b) Mentalis.
   (c) Platysma.
   (d) Zygomaticus major.
   Answer (b): The three muscles that receive facial nerve innervation from the deep surface are mentalis, levator anguli oris, and buccinators (MLB).
3. Negative pressure levels generated by electric vacuums and handheld syringes used in suction-assisted lipectomy are?
   (a) 960 mmHg/700 mmHg.
   (b) 900 mmHg/660 mmHg.
   (c) 1.5 atm / 600 mmHg.
   (d) 1.0 atm/650 mmHg.
   Answer (a): The correct answer is (a). Of note, after the initial negative pressure of 700 mmHg is achieved with a handheld plunger, the pressure drops to 600 mmHg.
4. Techniques for harvesting autologous fat for transfer include all of the following EXCEPT?
   (a) Tissue filter.
   (b) Centrifuge.
   (c) Cell sorter.
   (d) Separation in syringe.
   Answer (c): The best methods are the ones that handle the cells as gently as possible. Less trauma to the fat cells translates to a higher yield for transfer.
5. A 58-year-old female patient comes to your office to consult with you regarding her concerns about the appearance of her neck. She has fat deposits in the submental and submandibular regions, skin laxity, and no obvious platysmal banding. What procedures would you recommend for her facial rejuvenation?
   (a) Rhytidectomy and liposuction.
   (b) Liposuction and platysmaplasty.
   (c) Rhytidectomy and platysmaplasty.
   (d) Rhytidectomy, liposuction, and platysmaplasty.
   Answer (d): The patient certainly needs liposuction to address her fat deposits and rhytidectomy for her lax skin. Platysmaplasty would also be recommended even if anterior platysmal banding is not evident clinically. Experience has shown that the combination of rhytidectomy and liposuction predisposes the patient to postoperative platysmal band deformity; therefore, addressing the medial edges of the platysma at the time of surgery is the most prudent option.

Rhinoplasty

27

Jacob O. Boeckmann

Anatomy

Arterial supply: *internal carotid* (the nasal lining → ant. and post. ethmoidal arteries) (terminal branch of the ophthalmic), *external carotid artery* (external skin envelope—facial artery → angular artery and superior labial artery), and also sphenopalatine and greater palatine arteries.

Venous outflow: corresponds to artery distribution. Directly connected to cavernous sinus due to lack of valves → intracranial extension of infections.

Innervation: ophthalmic division of V1 and maxillary division of V2.

Skin/soft tissue envelope: the skin covering the nose is of variable thickness—thick over radix, thin at rhinion, and thickening again toward the tip (more sebaceous glands are present).

The **nasal lining** → squamous epithelium lining the vestibule before transitioning to psuedostratified columnar epithelium. The nasal **SMAS** of the nose connects the nasal muscles together (Letourneau and Daniel 1988).

Paired nasal bones: superiorly attached to the frontal bone, laterally attached to the lacrimal bone, and ascending process of the maxilla.

Upper lateral cartilage: Two trapezoidal cartilages fused to the cartilaginous septum superiorly. Cephalic edge travels under the caudal border of the nasal bone for a variable distance (**keystone area**), and is attached to lateral edge of pyriform aperature by loose ligaments.

Lower lateral cartilage (Fig. 27.1): Consists of medial, middle/intermediate, and lateral crura.

– **Medial crura**: two components, footplate segment and columellar segment. **Columellar-lobule junction**: distinct entity where the paired vertically oriented medial crura diverge at the middle crura, serving as breakpoint of double break. Middle crura-lobular and domal segments: **Domal junction**: transition from middle crus to lateral crus, critical landmark for nasal tip. Ideal domal anatomy has a convex domal segment next to a concave lateral crura (Daniel 1992). The **distance between tip defining points** should be **6–8 mm** for females and **8–10 mm** for males. The medial crural foundation is supported by the attachments to the caudal septum.
– **Lateral crura**: primary component of lobule, influences shape, size, and position. Normal position when angled 45° or more from the

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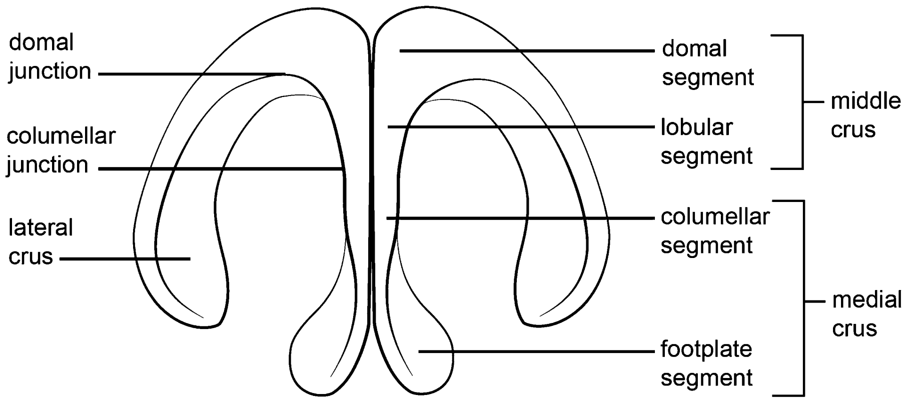

Fig. 27.1 Lower lateral cartilage anatomy

midline directed at the lateral canthus. **Normal angulation of lateral crura** is 15° (Daniel 1992).

Seasomoid/accessory cartilages: located at the lateral aspect of the lateral crura in fibrofatty tissues—support the ala.

Nasal Valves

External nasal valve: alar sidewall, medial crus of alar cartilage, nasal spine and floor of the nose. The dilator nasalis muscle opens during inspiration. Assessed on basal view → alar collapse on inspiration.

Internal nasal valve: septum, caudal end of upper lateral cartilage, nasal floor, and head of the inferior turbinate. Site of maximal airway resistance. Airflow velocity increases at areas of narrowing which increases transmural pressure resulting in inspiratory collapse (Bernoulli principle). A larger cross-sectional area remains patent due to decreased transmural pressure. The valve angle should be **10–15°**. Patients with short nasal bones can be predisposed to internal nasal valve collapse due to the collapse of long upper lateral cartilage during inspiration. Airflow measured by classic rhinomanometry or acoustic rhinometry (measures sound reflection secondary to nasal volume). Widespread application is limited.

MAJOR TIP SUPPORT: (1) size, shape, thickness, and resilience of the lower lateral cartilage; (2) upper lateral cartilage attachment to the cephalic margin of the alar cartilage; and (3) medial crural footplate attachment to the caudal septum

MINOR TIP SUPPORT: Anterior septal angle, Skin of nasal tip, Membranous septum, Caudal Septum, Nasal spine, Paradomal ligament, Sesamoid cartilage

Analysis

Careful nasal analysis is the essential first step for a successful outcome (Papel et al. 2008). If the surgeon fails to preoperatively identify a specific anatomic anomaly, long-term results will be compromised. The ideal nose is one that is balanced with other facial features of the patient. The ideal nose does not draw attention to itself, but instead draws attention to the eyes. Proper analysis begins with a thorough history to identify the patient's perceived complaint, motivation for surgery, and surgical expectation following treatment. The surgeon must determine if the patient's expectations are reasonable, realistic, and obtainable. Men typically are more resistant to changing their external appearance than women. It is during the history that the rhinoplasty surgeon evaluates the patient's psychiatric status. The majority of individuals seeking rhinoplasty are psychiatrically normal, but one must always be cautious when dealing with someone with body dysmorphic disorder. In addition, preoperative high levels of anxiety can be a risk factor for postoperative mild depression and must be considered in the consultation process (Goin and Rees 1991).

Standard photo documentation for all patients consists of frontal view, left and right lateral, left and right oblique, and base view. All photographs should be taken with the patient in the Frankfort horizontal position (line from EAC to infraorbital rim).

Frontal View

Frontal view begins with assessment of the vertical thirds and horizontal fifths. The vertical thirds consist of trichion to glabella, glabella to subnasale, and subnasale to menton. The horizontal fifths are divided with the width of the nasal base equal to the intercanthal distance. Ideal nasal length should be 2/3 the length of the midfacial height.

Symmetry, the **brow-tip aesthetic line**, contour abnormalities, and tip definition are all assessed on frontal view. The brow-tip aesthetic lines follow a path from the supraorbital rim to the tip-defining points and should be symmetric. The nasal width is also assessed on frontal view. The **bony base** should be 75–80 % the width of the alar base. The **alar base** should approximate the intercanthal distance (½ the interpupillary distance). Asymmetry or a wide bony base may require osteotomies to correct. **Tip definition** should be assessed. A well-defined tip is associated with a **double break** appearance (supratip: junction of nasal tip and dorsum, infratip: junction of infratip lobule and columella). **Bulbosity of the tip** should be noted as well as the underlying cause (thick skin, widened lateral ala crura, divergent interdomal angle, wide domal angle (Fig. 27.2), lateral crural cephalic positioning). The nasal rim should have a **gull-in-flight** configuration with the columella hanging just below the alar rims. Excessive nostril may be present in the setting of over rotation.

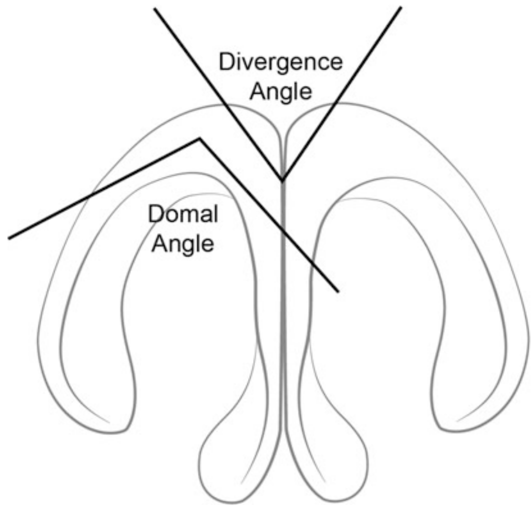

Fig. 27.2 Lower lateral cartilage angle of divergence and domal angle

The width of the bony base at the level of the maxilla is compared to the intercanthal distanced to establish if the nasal dorsum needs to be narrowed. If the width is larger than the intercanthal distance, lateral osteotomies are recommended.

Lateral View

Often one of the most concerning to the patient, the lateral view is a 2-D analysis of the profile. **Projection**, **rotation**, **columellar show**, the **dorsal contour**, **nasal length**, and **chin position** are assessed on lateral view. **Projection** is the distance to the nasal tip from the facial plane. There are several methods to evaluate it:

1. Crumely-Lanzer method: 3–4–5 triangle.
2. Simon method: Columella to vermillion : subnasalae/tip = 1:1 ratio
3. Goode method: projection/length ratio 0.55–0.60

Rotation is the position of the tip-defining point along an arc in relation to the porion (EAC). Most often measured using the **nasolabial angle** (females, **95–115**°; males 90–95°). Shorter patients can tolerate more rotation, while taller patients need less.

The dorsum is then inspected for contour, height, and length. The **nasofrontal angle** (angle of line from **glabella** to nasion and nasion to tip defining point) should be **115–130°**. The deepest point of the nose (**nasion**) is ideally positioned at the **supratarsal crease**. It ideally lines **4–6 mm** posterior to glabella and **11 mm** anterior from supratarsal crease. A shallow angle results in a longer nose, while an acute angle gives the nose a short appearance. The nasion may be positioned at the upper lash line instead of the supratarsal crease. One then examines the dorsal height. For females, the ideal dorsum should lie 1–2 mm posterior to a line drawn from the nasion to the tip. A slight supratip break is a sign of a well-defined tip in females. The male dorsum should be straight without a supratip break.

Chin position evaluated relative to the **Gonzales-Ulloa** line (dropping a line from the nasion perpendicular to the Frankfort horizontal line). The chin should be within **2 mm** of this line. Alternatively, one can drop a perpendicular line from the lower lip. Males should meet or closely approximate this line. Inadequate projection may be due to **microgenia**, **micrognathia**, or **retrognathia** and should be managed accordingly.

The alar–columellar relationship is important with **2–4 mm** of columella show. Excessive show can be due to an overprojected caudal septum, overdeveloped medial crura, or alar retraction. Inadequate show can be the result of a hanging alar lobule or a retracted columella.

Base View

When viewed from the base, the nose should resemble an isosceles triangle. The lobule should be 1/3 the height of the triangle with the columella making up the remaining 2/3 (columella: lobule ratio 2:1). The nostrils should be pear/tear drop shaped with the widest portion at the base. The ala base should equal the **intercanthal width**.

Ethic Variations

Variations exist in different ethnic groups that must be recognized to ensure balanced approached to rhinoplasty. African Americans, Asians, and Latinos typically have a wider nasal base, weak cartilage, thick skin, and an under projected dorsum. The Middle Eastern patients frequently have strong alar cartilages with an overprojected dorsum.

Physical Exam

The skin thickness evaluation is critical: **thick skin** → inelastic and requires aggressive techniques for refinement. Thin skin → small imperfections can result in postoperative contour deformities.

Palpation of the nasal framework is crucial when examining the nose, as the strength of the lower lateral cartilages has a significant impact on the chosen technique. **Tip recoil** → inherent strength of the nose. Palpation of the nasal spine → relationship between posterior septal angle and nasal spine. If significant cartilage is needed, such as in revision cases, the septum is palpated to ensure sufficient grafting material is available.

An intranasal exam: should include assessment of the septum, turbinates, mucosa, and internal nasal valve. A Cottle maneuver → internal nasal valve collapse. Lateral displacement of the upper lateral cartilage with a fine tip q-tip improves airflow when internal valve incompetence is present. In the setting of a **septal perforation**, one must elicit a history to determine the causes (previous surgery, cocaine abuse, Wegeners/autoimmune disease, medication abuse). If the diagnosis is unclear, proceed with a biopsy to rule out an autoimmune disorder.

An overactive **depressor septi muscle** can result in lowering of the tip with rounding.

Nasal Obstruction can be from reversible or irreversible causes.

Reversible nasal obstruction: typically the result of mucosal abnormalities from infectious etiologies (viral, bacterial, fungal) or medically induced (rhinitis medicamentosa). **Irreversible obstruction** can be from a number anatomic issues such as upper lateral cartilage collapse, dorsal septal deflections, synechiae, and turbinate hypertrophy.

The rhinoplasty surgeon needs to carefully evaluate the relationship of the caudal and dorsal septum as deviations in these segments may require more extensive correction to eliminate obstruction. Posterior deflections and turbinate hypertrophy of significant size can result in posterior nasal obstruction but are less common causes.

Incisions, Approaches, and Techniques

Incisions

1. Transfixion/hemitransfixion—between septum and medial crura of LLC. Provides access to the caudal septum bilaterally.
2. Intercartilaginous—between ULC and LLC
3. Marginal incision—at the inferior/caudal border of the LLC
4. Intracartilaginous incision—going through the LLC transnasally
5. Rim Incision—nasal rim
6. Killian Incision—unilateral septal incision
7. Columellar—inverted V placed at the narrowest portion of columella. Meets marginal incision at a right angle. Care must be taken to avoid placing below the medial crural footplates and to avoid injury to the underlying medial crura to avoid postoperative notching.

Approaches

1. Closed: delivery versus nondelivery
   (a) Nondelivery approaches are used for conservative tip refinement. Accessed from transcartilaginous or intercartilaginous incisions. Transcartilaginous approach is preferred due to its simplicity. Used when favorable anatomy, medium skin thickness, tip symmetry, minimal bulbosity.
   (b) Delivery approach is used for more significant tip deformities: performed through intercartilaginous and marginal incision to develop a chondrocutaneous flap. More exposure than nondelivery, but more aggressive.
2. Open rhinoplasty: indicated for nasal tip asymmetry, anatomically complex (revision, trauma, cleft noses), significant projection/rotation abnormalities, severe bulbosity, teaching.

Endonasal rhinoplasty advantages: see Table 27.1.

Major disadvantage is exposure and potential for asymmetric resection

Advantages of open rhinoplasty

1. Direct exposure, inspection, and assessment of the osseocartilaginous framework
2. Precise modification and stabilization of the abnormality (tip and dorsum modification, graft placement, osteotomies)
3. Excellent tool for training purposes.

Disadvantages of open rhinoplasty

1. transcolumellar scar and columellar flap necrosis
2. extensive dissection of skin off the osseocartilaginous framework with increased scarring
3. increased operative time
4. postoperative nasal tip edema and numbness

Table 27.1 Advantages of endonasal rhinoplasty

Decreased need for surgical dissection	Shorter operative times
Decreased risk of scarring, unfavorable healing	Elimination of visible external scar
Reduced postoperative edema	Quicker return to normal appearance
Ability to make exacting changes in situ	

Table 27.2 Techniques utilized to modify nasal tip projection

Methods to increase projection	Methods to decrease projection
Tip Graft	High, partial, or full transfixion incision
Plumping graft	Lateral crural overlay (also increases rotation)
Premaxillary graft	Nasal spine reduction
Transdomal suture	Vertical dome division with excision of excess medial crura with suture reapproximation
Septocolumellar sutures (buried)	
Columellar strut (maintains projection)	
Caudal extension graft	
Illusion of projection with supratip break	
Lateral crural steal (also increases rotation)	

Table 27.3 Techniques utilized to modify nasal tip rotation

Increasing rotation	Decreased rotation
Lowering nasal dorsum	Transfixion incision
Shortening caudal septum	Shorten medial crura
Cephalic resection of lower lateral cartilage	Caudal extension graft
Vertical dome division	Double layer tip graft
Lateral crural overlay	Reconstruction of L-strut with extended spreader grafts
Plumping graft to nasolabial angle	

Techniques

The tripod concept, described by Anderson (1984), provides an understanding of the dynamics of tip rhinoplasty. The anatomy of the two alar cartilages forms a functional tripod that provides tip support. Projection is preserved when major and minor tip support mechanisms are left largely. Control of projection and rotation are critical for successful rhinoplasty and a number of techniques may be utilized depending on the situation (see Tables 27.2 and 27.3). A more detailed discuss will follow.

Tip

The tip is considered one of the most challenging aspects of rhinoplasty. Unlike altering the dorsum which is a 2D undertaking, the nasal tip is a 3D structure with complex anatomy that must be contoured appropriately for favorable light reflexes and shadowing (Toriumi 2006). Frequently, the patient presents with a desire to narrow the nasal tip. In the past, emphasis on tip reduction resulted in long-term sequelae of pinching and distortion. With increased understanding of these maneuvers, augmentation techniques have been implemented to provide stability against long-term forces of contraction.

Base

When approaching the nasal tip, one must take into account a number of factors to ensure long-term stability. A **stable base** is critical for maintaining the desired projection, nasolabial angle, and alar–columellar relationship. A number of maneuvers are available to the rhinoplasty surgeon, which enable a firm foundation for the lower third of the nose. The **columellar strut graft** is a commonly used graft for maintenance of structural support, columellar shape, and projection of the nasal tip. It is typically 20 mm long, 2.5 mm wide, and 1.5 mm thick and is useful for those patients with short medial crura but an appropriate alar–columellar relationship. The surgeon must ensure placement is just below domes to avoid a distorted tip. In addition, preserving a small amount of soft tissue at the nasal spine helps prevent postoperative clicking or graft displacement with movement.

The **tongue-in-groove** technique is a useful maneuver in the patient with excessive columellar show and a prominent caudal septum (Kridel et al. 1999). The crura are fixated with a horizontal mattress suture to the caudal end of the septum allowing the surgeon to achieve precise rotation and projection depending upon placement. This technique also provides some length to the upper lip, which is advantageous for those patients with short upper lips. A tongue in groove set back may also allow for decrease in nasal tip projection. When there is deficiency of the caudal septum or if significant tip stability is needed, the **caudal septal extension graft** provides the strongest stable foundation nasal tip support. This graft can be placed in an end to end or end to side position can be shaped depending upon the patient's need. This graft significantly strengthens the tip and is particularly useful for controlling projection, rotation, and the columellar-lobule angle.

Finally, when augmentation of the premaxilla is needed (e.g., cleft nasal deformity), a **premaxillary graft or alar base graft** consisting of bone, cartilage, fat, or alloplast material can be used.

Tip Refinement

Once the foundation is stabilized, the surgeon can focus on refinement of the tip. This typically requires a combination of reduction and augmentation techniques with the specific techniques dictated by the individual anatomy. The majority of primary rhinoplasty patients present with the complaint of too large a tip. This may be the result of tip bulbosity, broadness, bifidity, cephalic malpositioning, soft tissue fullness, or a combination of these factors. Traditional approaches have relied on excessive reduction of the alar cartilage, which result in long-term collapse with aesthetic and functional distortion of the tip. Cartilage sparring techniques have been introduced and replaced a number of older techniques improving long-term results. It is critical that the rhinoplasty surgeon be well versed in a variety of techniques to optimize patient outcomes. When dealing with a wide nasal tip, a number of techniques are available including excision, suturing, morselizing, and incision techniques.

Excision techniques can be classified as **complete strip and interrupted strip techniques**. The **interrupted strip technique**, popularized by Goldman, was introduced as a means of increasing tip projection and narrowing the nasal tip. It involved **vertical dome division** 2–3 mm from the dome with advancement and transdomal suturing of the medial cartilage strips. The lateral strips were left unattached which weakened the tripod, and predisposed patients, especially those with thin skin, to a number of complications including alar notching, a tent-pole appearance, bossae, and a pinched tip deformity. Thus, many surgeons have abandoned this technique and if vertical lobule division is utilized for tip refinement, reconstruction of the lateral crura is performed for maintenance of a lateral crural stability. This interrupted strip method remains useful for those patients needing deprojection and increased rotation. In contrast to the Goldman method which attempted to achieve increased projection, vertical lobule division combined with **lateral crural overlay** and suture fixation of the lateral crural segments has been utilized as a powerful technique for patients with severe underrotation and overprojection (Adamson et al. 1994).

The **complete strip method** remains a reliable technique for those patients requiring tip refinement from overdeveloped lower lateral cartilage (Constantinides et al. 2001). When performing a cephalic trim, it is critical to preserve a minimum of **6–8 mm** of lateral crura to avoid pinching and lateral wall collapse. This can be performed in combination with the **lateral crural steal technique** to increase projection while narrowing the domes (Kridel et al. 1991; Foda and Kridel 1999). Alternatively, a cartilage sparing technique can be performed with regard to a limited cephalic trim, in which a coservative paradomal trim is completed at the site of the neodomes after a lateral crural steal maneuver. Paradomal trim allows for increased lateral crural conservation.

Suture techniques are utilized to complete the tip refinement and consist of a number of sutures depending on the clinical situation (Daniel 2011). **Domal creation sutures** (**transdomal sutures**) are useful when additional tip definition and narrowing is need. These are horizontal mattress sutures through the domal segment at the notch which reduce the intradomal distance and increase tip projection. Care is taken for precise placement to avoid too sharp a tip. The surgeon must also be aware of the position of the lateral crus, as this suture can result in descent of the caudal margin of the lateral crus and concavity of this segment. If these remain unrecognized, a pinched tip and notching of the ala can result. **Alar rim grafts** are useful in this setting as they provide support to the alar margin and soften the transition from the tip complex to the alar lobule (Boahene and Hilger 2009; Rohrich et al. 2002). They are typically 12–15 mm in length and 2–3 mm in length and placed in a precise subcutaneous pocket at the alar margin. When convexity of the lateral crura is an issue, **lateral crura convexity control sutures** (**Gruber sutures**) can be placed as a horizontal mattress suture at the site of convexity (Gruber et al. 2005). When these are ineffective, **Lateral crural strut grafts** may be needed for optimal contouring (Gruber et al. 2015; Gunter and Friedman 1997). **Interdomal sutures** (**dome-binding sutures**) are useful for controlling tip width at domes and infralobule. These are placed at angle of divergence 2–3 mm from the caudal edge. If placed too tight, a pointed tip appearance will result. Finally, in those patients with strong lateral crura who require additional refinement of the supratip after cephalic trim, a **lateral crural spanning suture/alar-spanning suture** can be placed to eliminate supratip dead space an refinement of the supratip (Perkins and Sufyan 2011). It is a horizontal mattress suture placed cephalic to domes at mid portion of the lateral crus incorporating the caudal septum (see Fig. 27.3).

In certain situations (revision noses, inadequate medial crura, thick-skinned patients), tip sutures are not able to achieve the desired definition and contour and must be combined with other grafts. **Onlay tip grafts** (**cap or Peck grafts**) are occasionally needed to camouflage irregularities or achieve increased projection and tip contour. These typically consist of crushed or morcellized cartilage placed over the caudal margin of the domes to maintain tip

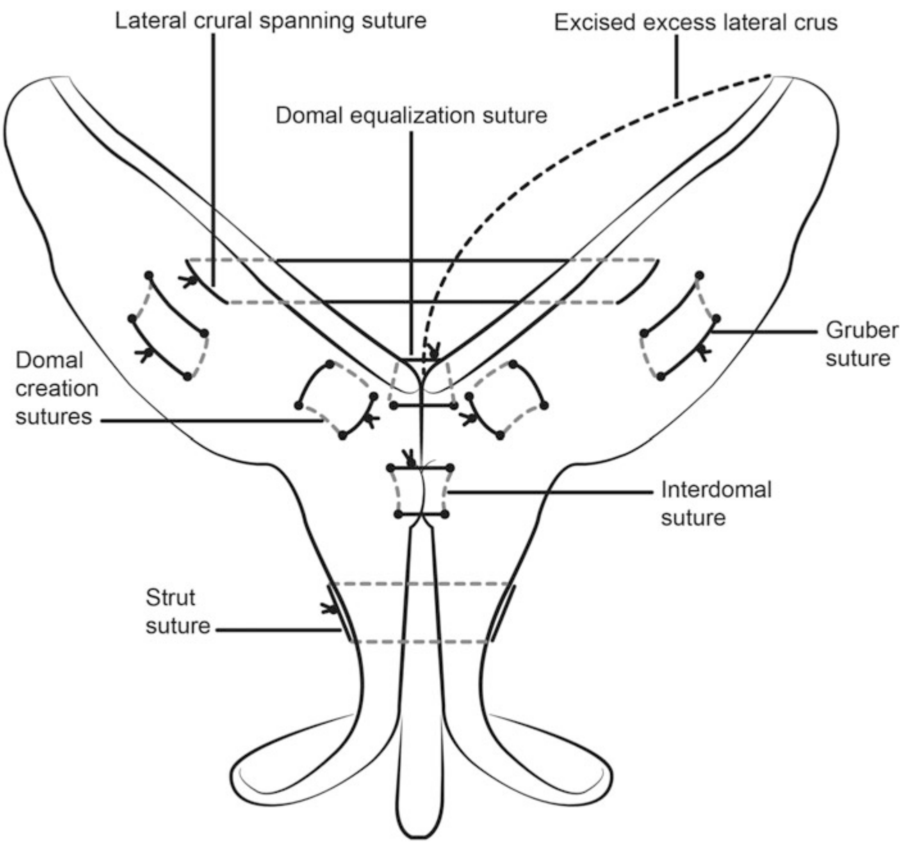

Fig. 27.3 Lower lateral cartilage suture techniques

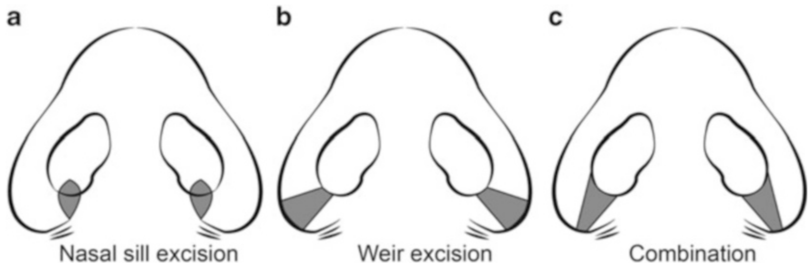

Fig. 27.4 Alar reduction techniques

aesthetics and to provide a smooth transition from the tip to the alar lobule. These grafts are contraindicated in thin-skinned patients as these grafts will become visible with time with skin contraction. **Shield grafts** (**aka Sheen graft**) are rarely useful in primary rhinoplasty and are most commonly used in the revision patient needing tip projection, improved contour of the infratip lobule, or derotation of an overrotated nose (Sheen 1993). The graft is positioned over the medial crura from the tip to the medial crural footplates. Again, this graft is best suited for thick-skinned patients as it has a tendency to become visible in thin-skinned patients or when not appropriately contoured.

Patients with cephalic malpositioning of the lateral crura require special consideration for tip refinement. The normal orientation of the lateral crura is 45° or more off midline and toward the lateral canthi. Cephalic malposition is described as lateral crura 30° from midline and directed toward the medial canthi. Cephalic malpositioning can create a "parentheses" appearance on frontal view. This frequently leads to a deficiency in the alar lobule following cephalic trim if this deformity in not recognized and appropriate maneuvers are taken (Yeh and Williams 2009). For excessive convexity of the lateral crura, a cephalic trim with lateral crura strut grafting and repositioning can produce a more favorable tip contour and prevent lateral wall collapse. If cephalic malpositioning is not contributing to tip bulbosity, repositioning can be avoided and the lateral wall can be supported with alar rim grafting.

Final tip definition should assess the width of the ala. The width of the ala should be equal to the intercanthal width and when excessive, reduction should be considered. Increased alar width of excessive show can be congenital for secondary to placement of alar rim grafts. **Weir excisions** are useful for the correction of alar flare. They are fusiform excisions of the lateral nasal base and must be performed carefully to avoid blunting of the nasofacial angle, nostril width is not affected by this maneuver. Nostril **sill excisions** are internal reductions, which reduce the nostril sill. They are trapezoidal excisions inside nasal base and have the added advantage of limited risk of alar-facial blunting (Fig. 27.4). This should be the final maneuver in rhinoplasty (Kridel and Castellano 2005).

Middle Third

Correction of the middle vault is commonly required in primary and revision rhinoplasty. The two most common complaints that arise from the middle vault are nasal obstruction and dorsal overprojection. In many cases, the aesthetic result of the dorsum is the determining factor for a successful rhinoplasty. Therefore, the rhinoplasty surgeon must thoroughly evaluate this area for form and function in order to ensure a happy patient and surgeon.

Dorsal Reduction

When patients desire dorsal "hump" removal, a number of factors are considered. This must be individualized to the patient and one must take into account the patient's sex, ethnicity, anatomy, and aesthetic goals. The surgeon must first establish the desired nasion and tip position to determine the ideal dorsal height. Failure to establish these points can put the patient at risk of an over-resected dorsum and functional nasal obstruction. The brow-tip aesthetic lines are evaluated to determine if modification is needed.

Whenever reduction is indicated, it is important to perform **prior to septoplasty** in order to preserve an adequate 10 mm dorsal strut. Traditional reduction techniques were performed in a composite manner using sharp dissection with an osteotome to resect the osseocartilaginous hump en-bloc. Unfortunately, this technique can lead to significant complications when poorly performed including inverted-V deformities, keystone instability, and contour abnormalities. Contemporary techniques have been developed which focus on a component reduction of the osseocartilaginous hump which respects the anatomic, aesthetic, and functional relationship of the middle vault (Rohrich et al. 2004). Component reduction is performed by sharply excising the upper lateral cartilages from the septum after the creation of submucoperichondrial tunnels. When dissecting the mid vault, care must be taken to preserve the mucosal attachment of the upper lateral cartilage to the septum to minimize the risk of scarring and resultant nasal valve stenosis. The cartilaginous and bony dorsum are then taken down incrementally with sharp dissection and an osteotome until the desired dorsal height is achieved.

Spreader grafts are routinely placed in primary and revision rhinoplasty to provide functional and aesthetic correction. Spreader grafts restore the brow-tip aesthetic line, correct midvault asymmetry, prevent inverted-v deformities, increase the cross-sectional diameter of the internal nasal valve, and provide structural support to the L-strut. These grafts are frequently harvested from septal cartilage and are 1.5–2.5 cm in length, 1.5 mm in height, with the width dependent upon the amount of midvault correction needed. **Autospreaders** (**turn-in flaps**) can be used in select patients undergoing a significant hump reduction with long upper lateral cartilages (Byrd et al. 2007). Grafts are secured to the septum and upper lateral cartilage using horizontal mattress suture fixation to complete the reconstitution of the midvault. The "**butterfly**" **conchal cartilage graft** has also been described which takes advantage of the native curvature of the conchal cartilage to increase the cross-sectional area of the area (Clark and Cook 2002a). It has been shown to be an effective treatment of internal nasal valve collapse without compromising aesthetics in the properly chosen patient. The concern with this graft is that it can become noticeable in the supratip region because of excessive bulk or the cephalic edge showing. Unfortunately, the learning curve is steep for those surgeons not trained in this technique.

For those patients with minimal valve obstruction or who are not candidates for spreader graft placement, an **upper lateral cartilage spanning suture** (Fig. 27.5) has be described to increase the cross-sectional area of the internal nasal valve (Park 1998).

Dorsal Augmentation

Dorsal augmentation can be indicated for functional and aesthetic reasons and can be achieved with a variety of grafting material. It is not uncommon for the Asain or platyrrhine rhinoplasty patient to request dorsal augmentation for a more

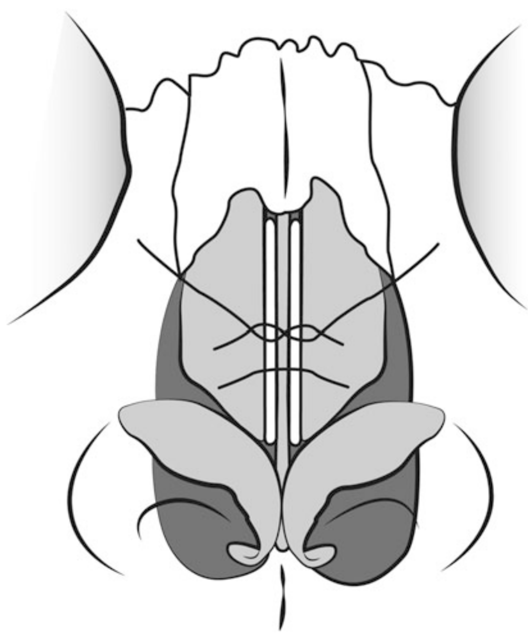

Fig. 27.5 Upper lateral cartilage spanning suture used for improving cross-sectional diameter of the internal nasal valve

"western" nose. This patient population typically has thicker skin with weak cartilage support. Alloplast grafts are popular in the Asian culture for dorsal augmentation. Meticulous placement is indicated for alloplast implants and special care must be taken to ensure there is no tension over the implant or contact with the dermis. Despite care placement, these grafts remain at a higher risk of infection and long-term extrusion.

For mild dorsal irregularities or revision cases, autogenous grafts are favored. **Fascia** can be used to provide a smooth dorsum in those thin-skinned patients at risk of minor contour abnormalities. When mild to moderate correction is needed in a patient with normal or thicker skin, dorsal onlay grafts or diced cartilage/fascia grafts can be used for contouring. **Dorsal onlay grafts** are useful for correction of minor dorsal deformities and are typically morsalized to minimize irregularity. **Diced cartilage/fascia grafts** (aka Turkish delight) are cylinder-shaped graft consisting of diced cartilage wrapped in temporalis fascia useful for correction of secondary dorsal depressions, primary excessive hump reduction, saddle nose deformities, or ethnic rhinoplasty (Daniel 2008; Erol 2000; Daniel and Calvert 2004).

When structural support is needed, a more robust grafting material must be obtained and frequently requires the harvesting of osseocartilaginous rib, calvarial bone, or irradiated homograft costal cartilage. Autogenous costal cartilage is the preferred source due to its availability, ease of carving, and ease of fixation. It provides excellent structural and functional support to the middle vault.

Bony Vault

Management of the bony vault is critical for a successful surgical outcome. Many patients present with complaints of a dorsal hump or a wide nose. A "balanced approach" is recommended to maintain a strong dorsal profile and a natural result. It is critical to **establish the ideal nasion point**, which will influence the nasofacial angle and determine if radix reduction or augmentation is needed. A shallow nasofrontal angle gives the appearance of a longer nose, while an acute/deep nasofrontal angle contributes to a short nose. The nasion can then be compared to the tip to establish the ideal dorsal height.

Reduction of the radix can be challenging, as an over-projected radix can be the result of soft tissue (adipose, procerus muscle) or bone. Soft tissue reduction can be managed with excision or in extreme cases an endoscopic forehead lift with central release. Bony reduction is achieved with rasps, osteotomes, or powered reduction.

Augmentation is achieved with a **radix graft** consisting of fascia, or diced cartilage in fascia (Becker and Pastorek 2001). It can be a single or layered graft. Solid cartilage grafts are not recommended due to the tendency to become visible with time. Repositions radix more cephalic and anterior. Decreases the amount of dorsal reduction required. Can soften an "angry" appearance.

Osteotomies

Osteotomies are frequently required for those undergoing aesthetic rhinoplasty and have been traditionally classified according to their location. The bony nasal base should approximate 80 % of the alar width. Techniques vary among surgeons for performing osteotomies and include percutaneous, endonasal, and intraoral techniques (Fig. 27.6).

Percutaneous osteotomies can be performed along the traditional location of osteotomies or along the junction of the nasal bones with the frontal bone and the maxilla ("anatomic osteotomies"; Cochran et al. 2007; Goldfarb et al. 1993). Those in favor of the percutaneous approach state the advantage of periosteal preservation, reduced lateral wall collapse, less airway compromise, and reduced bleeding, ecchymosis, and edema. Opponents site the potential risk of a visible external scar and an irregular osteotomy due to the postage stamp technique.

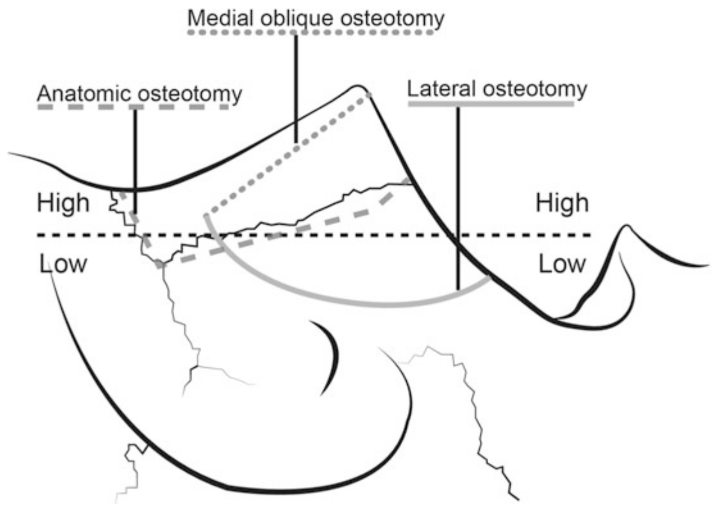

Fig. 27.6 Osteotomies

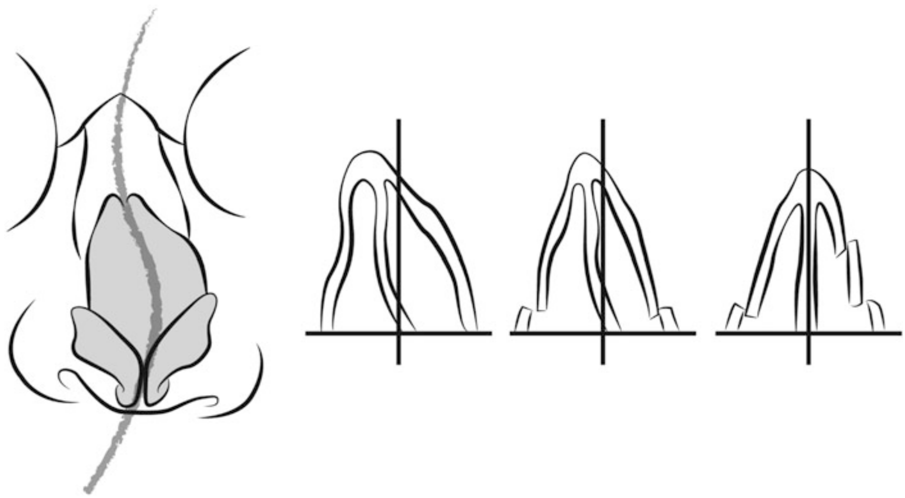

Fig. 27.7 Utilization of intermediate osteotomies to correct a crooked nose

Indications for osteotomies are: (1) to close an open roof deformity, (2) narrow the bony nasal base, and (3) to straighten a deviated nose.

Lateral Osteotomies: utilizing a low–high osteotomy is traditionally performed when a *greenstick* fracture of the lateral nasal bone is indicated for narrowing. It begins at the pyriform aperture **above the attachment of the inferior turbinate** to prevent airway compromise (preserving Webster's triangle). The osteotomy is carried cephalically along the nasal process of the maxilla and ends at the nasal base at the level of the medial canthus.

When complete mobilization of the nasal bones is required, a **low-low osteotomy** can be considered. The lateral osteotomies can be connected to a **medial-oblique** or **transverse osteotomy**. Medial oblique osteotomies are useful for those patients with a wide bony dorsum to achieve full mobilization and sufficient narrowing. It is performed using a curved osteotome angled laterally 15–20° off midline.

Intermediate osteotomies (**double osteotomies**) (Fig. 27.7) are useful for narrow extremely wide noses (bilateral intermediate and bilateral lateral) or to correct crooked noses (unilateral intermediate on the longer nasal bone and bilateral lateral ± transverse) such as in the setting of significant nasal bone asymmetry, convexity, or trauma. This consists of an osteotomy along the inferior nasal bone parallel and combined with a low-low osteotomy. It is performed prior to the inferior osteotomy. **Anatomic osteotomies** are performed percutaneously along the nasal bone suture lines. This allows for precise manipulation of the nasal bones for correction of minor bony nasal vault asymmetry in a stable, controlled manner (Cochran et al. 2007).

Finally, osteotome size is important when performing lateral osteotomies. Becker studied nasal bone thickness along osteotomy lines and discovered that the bone thickness is 2.4–2.29 mm thick in males and females, respectively (Becker et al. 2000). When a 2.5- mm osteotome was used, mucosal tearing occurred in 4 % of patients. In contrast, the mucosal tearing incidence increased from 34 % to 95 % when using 3.0 and 4.0 mm osteotomes, respectively. Therefore, to minimize ecchymosis and edema some surgeons recommend **osteotomes no larger than 3–4 mm in size**.

Surgical correction of the bony vault can be challenging and when performed incorrectly, a number of complications can result including rocker deformities, collapsed nasal side walls, open roof deformity, irregularities, step-offs, persistently wide bony vault, and bony dorsum over resection.

Septum

The cosmetic and reconstructive rhinoplasty surgeon must be prepared and trained to manage septal deformities that arise among rhinoplasty patients. These may be congenital or post-traumatic and can be challenging to even the most experienced rhinoplasty surgeon. From an aesthetic perspective, septal deflections can result in a twisted nasal appearance, underprojection, columellar deformity, and tip ptosis. From a functional perspective, deflections can be present anywhere along the bony or cartilaginous septum which can result in static or dynamic airway obstruction of the internal and external nasal valves. If structural integrity of the dorsal and caudal L-strut is disrupted or weakened, a number of undesirable complications will arise including loss of tip support, saddle nose deformities, and valve collapse. Therefore, a 1 cm L-strut must be left intact to minimize postoperative morbidity.

Caudal Septal Deflection

The rhinoplasty surgeon must be component and comfortable treating the caudal septum due to the critical role the caudal septum plays in form and function. When left untreated, columellar deformities, tip ptosis, twisted tip deformities, and external valve collapse are potential sequelae.

The **swinging door technique** was first described in the 1920s as a way to correct the caudal–septal deflection (Pastorek and Becker 2000). It involves release of the inferior attachments of the septum off the maxillary crest with or without excision of a wedge of inferior cartilage and repositioning the septum on the contralateral side. It is secured in place with a nonabsorbable suture through the anterior nasal spine. Some authors use **extended bilateral spreader grafts** placed on either side of septum to buttress and stabilize the septum. Other techniques include **scoring** or **morselizing** the concave side of the septum and attaching it to an ethmoid bone or cartilage **batten grafts** to maintain a straight position. The surgeon must take care not to weaken the caudal support with this maneuver by excessive scoring. For significant deformities, an **extracorporeal septoplasty** may be indicated to remove and reconstruct the offending cartilage (Gubish 2005). It involves complete dissection of the cartilaginous septum with disarticulation from the perpendicular plate of the ethmoid, vomer, and maxillary crest. The septum is then reconstructed using various techniques and replaced into position. When performed by an experienced surgeon, results are reliable. Complications related to this technique include dorsal irregularities, keystone collapse, and the potential for saddling. A new modification of this technique includes preserving a portion of the dorsal cartilage at the keystone which facilitates easier reconstruction.

Recently, **polydioxanone** (**PDS**)-perforated plates have been incorporated into septal techniques (Boenisch and Nolst Trenite 2006). The original use was described in extracorporeal septoplasty but has been expanded for use for a number of applications. The PDS plate value is providing structural support in situations when the native cartilage is unable to provide appropriate form for function. In the case of extracorporeal septoplasty, the cartilage pieces can be secured to the PDS plate, which provides a scaffold to increase stability and provide a matrix for chondrocyte regeneration. Disadvantages to PDS are that it is resorbable, it can result in prolong edema, and it can increase the risk of infection. PDS plates are available in different thicknesses, with the perforated 0.15 mm plate being the most popular for rhinoplasty.

Finally, in the case of significant cartilage loss, the surgeon must seek material from elsewhere and frequently has to resort to costal cartilage.

Septal Perforation

Septal perforation can be the result of a number of conditions including iatrogenic, traumatic, infectious, autoimmune, inhalant drugs, and malignancy (Watson and Barkdull 2009). Therefore, it is prudent for the rhinoplasty surgeon to determine the etiology of the perforation prior to surgical intervention. When a biopsy is indicated, it is important to avoid biopsy from the superior aspect of the perforation to avoid enlarging the defect.

A number of complaints can be associated with anterior perforations including pain, crusting, epistaxis, obstruction, whistling, and saddling. When asymptomatic, repair is rarely indicated and treatment consists of medical management with humidification and antibiotic ointment to prevent crust build up and inflammation. Temporary closure can also be achieved with a prosthetic **nasal button**. Unfortunately, patient compliance can be an issue and requires adherence to nasal hygiene maintenance. Complications of button use include discomfort, crusting, epistaxis, and enlargement of the perforation.

Surgical correction is indicated for failed medical management with significant symptoms (Romo et al. 1999). **Bilateral mucoperichondrial flaps with an interposition graft** are the preferred flap choice for repair. Smaller perforations have a higher success rate for closure. Interpositional grafts used have included acellular dermal matrix and fascia lata. The endonasal approach can be utilized for anterior perforations less than 5 mm in size. For perforations 5 mm to 2 cm in size, the open approach is preferred as it provides unparalleled access for repair. For larger (>2 cm) perforations, other flaps must be utilized including: inferior turbinate flaps, sublabial mucosal flaps, and radial forearm free flaps. Whatever technique is chosen, a **tension-free closure** is critical to minimize a persistent perforation.

Special Circumstances

The crooked nose: If minor asymmetry with or without a history of trauma, careful facial analysis is needed to identify potential facial asymmetries (e.g., midface flattening, pyriform aperature displacement, facial width asymmetry). When severe asymmetry is present, it frequently is the result of trauma. Can be managed with (1) camouflaging, (2) deconstruction/reconstruction, or (3) combination of techniques (Pontius and Leach 2004). True correction of the crooked nose requires complete dissection and correction of the intrinsic deformities with reconstruction. Correcting the septum is the initial step (and can require extracorporeal techniques), followed by asymmetric spreaders for midvault and asymmetric osteotomies.

Lengthening the short nose—A number of factors result in a shortened nose, or the appearance of a short nose. These include concavity of the dorsum, tip projection to nasal length ratio >0.6:1, low, deep nasion, overprojected tip, obtuse nasolabial angle. **Treatment techniques** depend upon the causative factor and include **complete release of the mucoperichondrium**, **caudal septal extension grafts**, **tip grafts**, **radix**

grafting, **interposition graft between upper and lower lateral cartilage**, **extended spreader grafting combined with columellar strut** (Naficy and Baker 1998).

The tension nose: tip overprojection secondary to overdeveloped, long caudal septum. Typically associated with weak alar cartilage inferiorly displaced. Treatment involves dorsal septal reduction for deprojection (consider autospreader grafts) followed by stabilization with struts/caudal septal extension grafts for support (Johnson and Godin 1995). Tongue in groove can also be a helpful technique. Reduction of the nose often leads to alar base flairing/widening which requires wedge excision of ala for symmetry. Can have internal and external nasal valve collapse.

Pediatric rhinoplasty: deferred until age **15–16** if possible to limit growth disturbance of quandrangular cartilage. Exceptions to this rule include cleft rhinoplasty, which is discussed elsewhere.

Graft Materials in Rhinoplasty

Various materials are available to the rhinoplasty surgeon. These are categorized as autogenous, homogenous, and alloplastic. Autogenous grafting is the material of choice when available and can include cartilage, bone, and fascia (perichondrium, temporalis fascia).

Autogenous

Material of choice due to lower rate of tissue reaction, resorption, and infection (Parker 2000).

Septal cartilage—preferred as first line due to proximity, availability, firm, flexible, provides structural support. Can be limited in revision cases.

Conchal cartilage—used in revision cases or when septal cartilage is limited. More malleable and curved limiting broad application of this graft. Harvested from preauricular or postauricular approach. **Composite grafts** are harvested from auricle and consist of skin and cartilage. These grafts are particularly useful for correction of significant alar retraction or vestibular stenosis (Constantian 2002). Graft survival is maximized when the graft radix is no greater than 10 mm.

Costochondral—donor site of choice when sufficient cartilage is needed for traumatic or revision cases. Solid, carvable, typically harvested from 6th to 7th rib (Marin et al. 2008). Disadvantage: potential for warping, donor site discomfort, separate field, pneumothorax, and scarring. Pneumothorax risk can be minimized by careful dissection with preservation of the posterior perichondrium. Age should be taken into consideration when evaluating for costal cartilage, as increased age may predispose patient to increased ossification and less malleability for graft use. Needles can be used to evaluate degree of ossification before the skin incision is made, or even used in the office under local.

Bone-calvarial, rib, iliac crest, ethmoid. Used for upper 1/3 reconstruction but are less favorable due to lack of flexibility, fixation techniques required, and higher metabolic demand. Calvarial preferred choice as it is of membranous origin, therefore resist absorption unlike the iliac crest which is of endochrondrial origin (Cheney and Gliklich 1995). Calvarial bone harvested from parietal bone above the temporal line (Frodel et al. 1993). Risks include sagittal sinus injury, csf leak, epidural/subdural hematoma, intercranial injury.

Fascia-perichondrium and temporalis fascia. Good for softening nasal contours and correction of minor irregularities. Little to no donor site morbidity. Can have potential for prolonged edema after placement.

Homologous

Derived from human cadavers. Potential risk of transmission of human pathogens.

Irradiated homograft costal cartilage—obtained from young donors (no calcification) and screened for systemic disease, infection, cancer, drug abuse, syphilis, HIV, hepatitis and exposed to gamma radiation. Advantages: readily available, easily carve, low infection/extrusion rate, large quantity, no donor site. Disadvantages: potential for warping/absorption, infection (Kridel et al. 2009; Clark and Cook 2002b).

Acellularized dermal matrix (**Alloderm**)—useful for camouflage or graft coverage (Ferril et al. 2013). Risk of absorption in first year.

Alloplast

The ideal synthetic should be noninflammatory, noncarcinogenic, nonallergic, have an adaptable shape, readily available, able to integrate into the host tissue, sterilizable, and resistant to mechanical strain. Unfortunately, no material has yet to meet all these requirements. Therefore, the patients own cartilage remains the best choice for augmentation. Unfortunately, situations arise when the patients' own tissue may not be available for reconstruction and alternative grafting material is needed. A number of alloplast materials have been used (Romo and Kwak 2006). Popular due to readily available, endless supply, adaptable shape, lack of donor morbidity. Disadvantage is that all alloplasts cause an inflammatory response upon placement and have risk of complication. The presence and size of pores influence the amount of tissue ingrowth and infection risk. No definitive evidence has proven a reduced risk of extrusion with presoaking the implant in antibacterial solution.

Expanded-porus polytetraflouoethylene (**Gortex**)—has been used for >20 years in various surgical fields. Smaller pore size so there is less tissue in-growth (easier to remove). Higher infection risk with **revision cases**, **septal perforations**, **or when in contact with dermis** (Godin et al. 1999).

Porus high-density polyethylene (**Medpor**)—larger pore size allows for more tissue ingrowth (harder to remove) and strength. **Increased infection risk** until ingrowth complete. So should be used with caution especially in revision cases, incomplete soft tissue covering, or thin skin (Winkler et al. 2012).

Polydioxanone (**PDS**)—available as perforated or unperforated plate. Recommend perforated plate to allow for blood supply preservation (Tweedie et al. 2010). Degraded by hydrolysis by 25 weeks. Provides structural support to weakened cartilage and acts as scaffold/guide for regenerating chondrocytes.

Silicone—used primarily in Asian population for dorsal augmentation. Fibrous capsule forms without tissue in-growth. Persistent risk of infection. Extrusion at higher risk when tension is over the implant. Need to place subperiosteal. When infection and extrusion, it is preferable to reconstruct immediately to limit tissue contracture (Peled et al. 2008).

Revision Rhinoplasty and Treatment of Rhinoplasty Complications

Knowledge of common rhinoplasty complications and their etiology is fundamental knowledge for all rhinoplasty surgeons. Although adherence to rhinoplasty principles will help prevent a number of these from happening, complication rates remain relatively stable in the literature with reported incidences of 8–15 %. It is the surgeon's responsibility to have a detailed knowledge of the anatomic variants encountered, knowledge of surgical alternatives, and the result of healing over time to optimize patient outcomes (Davis and Bublik 2012). Below is a list of common complications and their prevention/management strategies.

1. **Pollybeak deformity**—overprojection of the lower nasal dorsum. **Causes** include loss of tip support, inadequate cartilaginous hump removal at anterior septal angle, supratip scar formation. Treatment is directed to the cause and includes adequate lowering of the cartilaginous component, surgical defatting of supratip nasal SMAS, reestablishing appropriate tip support, or

interval steroid injections with skin taping. The best treatment is avoidance.

2. **Saddle-nose deformity**—characterized by a loss of nasal dorsal height with nasal vault collapse. Most saddle-nose deformities are acquired resulting from an over-resected dorsum or septal L-strut. Other causes include Wegners granulomatosis, relapsing polychondritis, cocaine abuse, and chronic nasal decongestants. For patients with no nasal airway obstruction and minor-to-moderate nasal dorsal saddling, onlay grafting techniques can be used. Moderate-to-severe saddle nose requires structural reconstruction of the dorsum, middle vault, and tip support with costal cartilage or other alloplast material. Contraindications include patients with malignancy, poorly controlled chronic medical conditions, active autoimmune disease, continued intranasal drug use, and patients who are poor candidates for rhinoplasty in general.
3. **Inverted V deformity**—inferiomedial collapse of the upper lateral cartilage secondary to inadequate support after dorsal hump reduction. Appearance is washed out with prominence of the caudal end of the nasal bones. Usually associated with internal nasal valve collapse. Corrected with spreader graft placement. Patients at risk have **short nasal bones**, **long upper lateral cartilage, and large dorsal hump reduction**.
4. **Overresection of lateral crura**—common problem seen in revision rhinoplasty, results in pinched tip, supraalar collapse, tip asymmetry, bossae, alar retraction. Prevention includes adequate preservation of lateral crura (6–8 mm) when performing cephalic trim. **Alar batten grafts** are the first-line treatment for supra-alar collapse with alar retraction (Toriumi et al. 1997). These curvilinear grafts are placed at the precise point of lateral wall collapse and extend to the pyriform for lateral support. Special consideration must be made for those patients who are thin skinned due to the potential for fullness or a bulbous appearance following placement.
5. **Bossae deformity**—knuckling of the lower lateral cartilage in the dome resulting in visible or palpable nasal tip asymmetry. Predisposed with the **triad of thin skin**, **strong alar cartilage, and tip bifidity** after aggressive cephalic trim in a young patient (Gillman et al. 1999). Treatment involves trimming or resection of knuckled cartilage, transdomal suturing, on-lay camouflaging grafts, or reconstruction of the lateral crura
6. **Alar retraction**—overzealous resection of lower lateral crus or in cephalic trim of cephalically- oriented lower lateral cartilage. Recommended to preserve at least 7 mm of cartilage. Treated with alar rim grafting, lateral crural strut grafts, auricular composite grafts, or alar batten grafts (Gunter et al. 1996).
7. **Hanging columella**—usually due to failed correction at original surgery. Correction involves resection of excessive caudal membraneous or caudal septum or tongue in groove technique (Adamson et al. 1990).
8. **Retracted columella**—consequence of over-resection of caudal septum. Treatment involves columellar strut, plumping grafts, or caudal septal extension grafts
9. **Vestibular stenosis**—due to excessive scarring in vestibule from collapsed cartilage, skin excision, or excision of lesions. Correction involves composite auricular grafting, z-plasty, injection with kenalog/5-fu, or stents
10. **Open roof deformity**—results from inadequate lateral osteotomies or failure to perform osteotomies after dorsal reduction. Can give appearance of surface indentation with longitudinal shadowing. Corrected with spreader grafting and lateral osteotomies with infracture.
11. **Rocker deformity**—results from carrying the osteotomy too cephalic into the frontal bone. Results in lateral displacement of the superior segment with infracture. Corrected with transverse percutaneous osteotomy.

Questions

1. All of the following are useful in the correction of the bulbous tip except:
   (a) interdomal suture
   (b) lateral crural overlay
   (c) cephalic trim
   (d) lateral crural repositioning
2. A patient presents with excessive columellar show. Describe the potential causes and the maneuvers for correction.
3. Correction of a short nose can include all of the following techniques except:
   (a) plumping graft to nasolabial angle
   (b) radix graft
   (c) dorsal augmentation
   (d) caudal septal extension graft
   (e) tip grafting
4. A patient presents to the clinic with the complaint of bilateral nasal obstruction. The patient states this started 3 months after her rhinoplasty and has gradually become worse with time. Upon further questioning, the patient states she had been unhappy with the appearance of her nose and underwent surgery to "remove the hump" and to refine the tip. On examination, you note the patient has a somewhat washed out appearance with slight prominence of the caudal ends of the nasal bones. The tip is refined and appropriately projected. Improvement in airflow is noted with the Cottle maneuver bilaterally. All of the following preoperative findings would alert the operating surgeon that the patient is at risk for this complication except:
   (a) long upper lateral cartilage
   (b) prominent dorsal hump
   (c) thin skin
   (d) short nasal bones
5. Describe the characteristics of the platyrrhine nose and the impact of nasal maneuvers for rhinoplasty.
6. A patient comes to your clinic with a history of redness, drainage, and swelling of the nasal tip for the last several weeks which has not responded to topical antibiotic ointment. The patient has no recent trauma, infection, or procedures. Her past surgical history is significant for a rhinoplasty 5 years ago in Korea for dorsal augmentation. You strongly suspect an alloplast infection. Describe the most appropriate course of management of this patient. Describe the risk and benefits associated with surgical intervention with immediate versus delayed reconstruction.
7. A 20 year old patient comes in for rhinoplasty evaluation complaining that her nose was too large. She was wishing for a smaller, cuter nose. The patient is 5′6, 120 lbs. On examination, the patient has a mild dorsal hump, her nasal rotation is 90°, and she appears overprojected. She has normal skin thickness and strong tip support. It is otherwise unremarkable in appearance. Further facial analysis reveals that her chin lies 3 mm posterior to a vertical line drawn from the glabella to the pogonion and the patient has Class I occlusion. You are considering all of the following techniques except:
   (a) dorsal hump reduction
   (b) columellar strut
   (c) chin augmentation
   (d) sagittal split osteotomy with sliding genioplasty
8. Calvarial bone graft is harvested from which site?
   (a) temporal bone
   (b) occipital bone
   (c) parietal bone
   (d) frontal bone
9. After performing lateral and medial osteotomies, the rhinoplasty surgeon attempts superior infracture of the bony segment and notes lateral displacement of the caudal segment. Correction of this deformity is achieved by:
   (a) internal and external nasal splinting
   (b) intermediate osteotomy
   (c) percutaneous lateral osteotomy
   (d) percutaneous transverse osteotomy

10. All of the following techniques are potentially useful in straightening a crooked nose except:
    (a) intermediate osteotomies
    (b) spreader graft placement
    (c) incomplete elevation of mucoperichondrial flaps
    (d) swinging door technique
    (e) scoring of cartilage
    (f) extracorporeal septoplasty
11. Correction of a pollybeak deformity may include all of the following except:
    (a) columellar strut
    (b) kenalog injection to the supratip
    (c) resection of anterior septal angle
    (d) dorsal onlay graft

Answers

1. (d) Rohrich RJ, Adams WP. The Boxy nasal tip: classification and management based on alar cartilage suture techniques. Plast Reconstr Surg. 2001;107(7): 1849–1863.
2. The alar–rim columellar relationship is best assessed on lateral view. The ideal configuration is 2 mm of columellar on each side. When excessive, can be the result of (1) alar retraction, (2) hanging columella, or (3) both. For mild alar retraction (<2 mm), alar rim grafts can be used to lower or blunt the notched ala. For more significant alar retraction, conchal composite grafting is needed. Columellar can be the result of an overdeveloped caudal septum, membraneous septum. Treatment can include tongue in groove, caudal septal resection, membraneous septal resection. For combination deformities, surgical correction involves combined maneuvers for optimal correction.

   Gunter JP, Rohrich RJ, Friedman RM. Classification and correction of alar-columellar discrepancies in rhinoplasty. Plast Reconstr Surg.1996; 97(3):643–648.
3. (a)

   Naficy S, Baker SR. Lengthening the short nose. Arch Otolaryngol Head Neck Surg. 1998; 124(7): 809–13.
4. (c)
5. The platyrrhine nose is characterized by a broad, flat, underprojected tip, wide flaring alae, with an underprojected, wide dorsum. The nasal skin is typically thicker with a large amount of subcutaneous tissue while the cartilage and bony support is lacking. Frequently, there is premaxillary hypoplasia. Rhinoplasty principles remain the same and the surgeon should practice a balanced approach that is in harmony with the face. If significant augmentation is anticipated, one must take into consideration available grafting material as the thicker soft tissue envelope does not enable traditional reduction techniques for improvement in definition. Frequently, patients require additional grafting material such as conchal cartilage, costal cartilage, or alloplast to achieve the desired aesthetic changes. Dorsal augmentation, osteotomies, alar base excisions, and tip projection are all frequent maneuvers in this patient population.

   Romo T, Abraham MT. The Ethnic Nose. Facial Plast Surg. 2003; 19(3): 269–278.
6. Alloplast infection and extrusion is a known complication following rhinoplasty. Traditional wisdom has been to treat the patient with culture-directed antibiotics, graft removal, with delayed reconstruction following the resolution of edema. Unfortunately, this leaves the patient with an aesthetic deformity, enables scar contraction of the nasal skin and SMAS, and results in a more difficult reconstruction. An alternative technique has been proposed which involves immediate reconstruction with autogenous or irradiated homograft costal cartilage at the time of implant removal. This approach provides the patient with the benefit of immediate reconstruction and lack of aesthetic deformity and minimizes the risk of skin and SMAS contraction. Patients must be

informed of the potential for wrapping, infection, absorption, extrusion, and need for further surgery.

Clark JM, Cook TA. Immediate reconstruction of extruded alloplastic nasal implants with irradiated homograft costal cartilage. Laryngoscope. 2002;112(6):968–974.

7. (d)
8. (c)
9. (d)
10. (c)
11. (d)

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Rhytidectomy Essentials

28

David Shamouelian

Anatomy

Topographical analysis of the face

Soft Tissue Landmarks

- Trichion—Anterior hairline in the midline
- Glabella—Most prominent point of the forehead on profile
- Nasion—The deepest depression at the root of the nose; typically corresponds to the nasofrontal suture
- Radix—Root of the nose, a region and not a point; part of an unbroken curve that begins at the superior orbital ridge and continues along the lateral nasal wall
- Rhinion—Osseocartilaginous junction on the nasal dorsum, area of thinnest skin over nasal dorsum
- Sellion—Soft tissue correlate of the nasofrontal suture line
- Supratip—Point cephalic to the tip
- Tip—Ideally, the most anterior projection of the nose on profile

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- Subnasale—Junction of columella and upper lip
- Labrale superius—Vermilion border of upper lip
- Stomion—Central portion of interlabial gap
- Labrale inferius—Vermilion border of lower lip
- Mentolabial sulcus—Most posterior point between lower lip and chin
- Pogonion—Most anterior midline soft tissue point of chin
- Menton—Most inferior soft tissue point on chin
- Cervical point—The innermost point between the sub-mental area and the neck

Skeletal Cephalometric Reference Points

- Sella: The midpoint of the hypophyseal fossa
- Orbitale: The most inferior point on the infraorbital rim
- Porion: The most superior point on the external auditory meatus
- Condylion: The most superior point on the head of the mandibular condyle
- Articulare: The point of intersection of the posterior margin of the ascending mandibular ramus and the outer margin of the cranial base
- Anterior nasal spine
- Posterior nasal spine

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- Subspinale: The deepest point in the concavity of the premaxilla
- Prosthion: The lowest most anterior point on the alveolar portion of the premaxilla
- Infradentale: The highest most anterior point on the alveolar portion of the mandible
- Supramentale: The most posterior point in the outer contour of the mandibular alveolar process
- Pogonion: Most anterior point on the bony chin in the midline
- Gnathion: A point between the most anterior (pogonion) and inferior point (menton) on the chin
- Menton: The lowest point on the mandible

Aging Face

Microscopic Skin Changes

Intrinsic Processes Due to Senescence

- Thinning epidermis: impaired cell turnover resulting in slower wound healing and less effective desquamation
- Flattening of the dermal-epidermal junction: increased skin fragility and impaired nutrient transfer between dermis and epidermis. Thinning occurs due to the flattening of the rete ridge pattern
- Atrophic dermis: reduced numbers of fibroblasts with reduction in collagen and fragmentation of the dermal collagen matrix. Ratio of type III collagen to type I collagen increases
- Subdermal adipose tissue atrophy

Extrinsic processes primarily due to photoaging (others include gravity and smoking)

- Elastosis: Accumulation of elastin material just below the dermal-epidermal junction
- Epidermal atrophy and loss of orderly differentiation
- Fragmentation of collagen and elastic fibers
- Reduction of melanocyte density but higher density of melanocytes in sun-exposed skin
- Reduction in Langerhans cells: permissive development of skin cancer

Alteration of Aesthetics with the Aging Face Syndrome

The basic shape of the face is a function of skin, soft tissues, and underlying skeletal support that changes with aging. Skin becomes wrinkled and loses elasticity. Subcutaneous tissues shift under the constant force of gravity while fat atrophies and bone demineralizes.

Upper Third of the Aging Face

Brow/Forehead

- Elongation of the upper third as the hairline recedes and the brow descends
- **Brow ptosis and lateral brow hooding**: increased skin laxity, gravity, and chronic downward contraction of the orbicularis oculi
- **Crow's feet**
- **Deep furrows** of the forehead and glabella: repeated pull on the skin by frontalis (horizontal forehead rhytides), procerus (horizontal glabellar rhytides), and corrugator supercilii (vertical glabellar rhytides) muscles

Periorbital Area

Periorbital aging may convey unintentional expression of disinterest, fatigue, anger, and sadness, which may not be consistent with actual feelings.

- Skeletal changes of the orbit alter the aging face with increased orbital width and change in shape/contour—increase in the height of the superior orbital rim medially and the inferior orbital rim laterally. This contributes to hollowing of the eyes and flattening of the malar eminence.
- Aging, ptotic brow (see above) pushes skin over the upper eyelid, worsening eyelid

cosmesis and potentially causing visual field deficits.
- **Excess lid skin (dermatochalasis)**: loss of eyelid skin elasticity and brow descent (should not be mistaken for blepharoptosis or blepharochalasis).
- **Blepharoptosis**: abnormal drooping of upper eyelid with reduction in MRD1; most commonly due to levator aponeurosis dehiscence.
- **Entropion**: inversion of the eyelid margin
- **Ectropion**: due to weakening of the lateral canthal tendon due to stretching and descent of the orbicularis oculi

Middle Third of the Aging Face

Midface

- Drooping of the orbicularis and malar soft tissue complex due to attenuation of the facial retaining ligaments—loss of youthful "cherubic" appearance
- The cheek fat of the midface descends inferomedially
  - Deepening and accentuation of the nasolabial fold
- Simultaneously, the orbicularis oculi muscle stretches and descends inferolaterally.
  - Exposure of the inferior and lateral bony orbital rims, and loss of malar prominence
  - **Tear trough deformity**, a hollowness developing in the area of transition between lower eyelid and cheek

Nose

- Thinning skin and subcutaneous tissue reveal and accentuate underlying cartilage and osseous structure (dorsal irregularities)
- **Loss of tip projection**: loss of tip support due to skin soft-tissue envelope changes
- Weakening fibrous attachment at the scroll with separation of the upper lateral cartilages from the lower lateral cartilages
- Stretching and weakening of interdomal ligaments resulting in a boxy tip and loss of tip definition
- **Tip ptosis/loss of tip rotation**: due to midface osseous resorption with loss of maxillary and alveolar height
- These changes may result in narrowing of the nasal valve and result in obstructive nasal breathing

Lower Third of the Aging Face

Jowl Formation

A central stigmata of the aging face: obscured fine osseous definition of the mandible due to fat and soft-tissue descent along the mandibular line

- "Bulldog-looking" cheeks due to fullness of the jowls along the mandibular body lateral to the oral cavity
- Attributed to accumulation of fat in the neck and subcutaneous tissue, ptosis of the skin, submandibular gland, and superficial musculoaponeurotic system (SMAS)

Neck

A youthful neck is characterized by thin soft tissue with apparent underlying structures (anterior border of the sternocleidomastoid muscle and thyroid cartilage), mento-cervical angle 75–90°, and an absence of liposis, tissue sagging, and wrinkles.

- **Platysmal bands**: Vertical bands extending from the submentum to the clavicle
- **Turkey gobbler neck**: Platysmal dehiscence leads to subplatysmal soft tissue, submandibular gland, and fat descent into the submentum and lower midline neck

Perioral Changes

The youthful perioral area has significant fullness, exhibits minimal depth of the nasolabial folds, and lack of rhytides.

- **Upper lip elongation** with thinning of the red lip and vertical expansion of the cutaneous portion. The vermillion becomes less prominent, the lateral commissures tend to droop, and the upper teeth are less visible
- **Fine rhytides** radiate from the circumference of the oral cavity to the nose superiorly and the labiomental sulcus inferiorly.
- Lower teeth become more visible due to the effects of gravity on the lower lip

Chin Ptosis

- **Witch's chin deformity**: excess submental fullness and prominent submental crease due to premental fat ptosis and loss of mandibular osseous height and projection

Ear Lobe Elongation

- Attributed to long-standing earring use and increased skin laxity

Superficial Musculoaponeurotic System (SMAS) and the Retaining Ligaments of the Face

An understanding of the superficial muscular aponeurotic system (SMAS) is essential to facial surgery. The SMAS is a fibromuscular fascial layer that envelops and interconnects the mimetic muscles of the face. It maintains consistent relationships with vessels and nerves and serves as a guide to the depth of key neurovascular structures in the lower face. Facial nerve branches and the parotid duct are seen deep to the SMAS and superficial to the masseter and the buccal fat pad.

The SMAS is contiguous with the platysma inferiorly and the temporoparietal fascia superiorly. The SMAS invests the frontalis muscle and is continuous with the galeal aponeurosis. In the periorbital area, the SMAS interlocks with the orbicularis oculi. Medially, it has attachments to the zygomaticus major and minor as well as the dermis of the upper lip.

With sub-SMAS dissection of the cheek anteriorly, fascial condensations of the SMAS are encountered. These so-called ligaments support the soft tissues of the cheek. The major (osseocutenous) retaining ligaments of the face include the zygomatico-cutaneous ligament (McGregor's patch) superiorly and the mandibular ligaments inferiorly. The other fascia–fascia retaining ligaments include the parotid and masseteric ligaments.

Superficial to this SMAS layer in the cheek lies the malar fat pad that becomes ptotic with age. A plane can be developed between the fibromuscular SMAS and malar cheek pad. This malar fat pad can be repositioned separately from the SMAS. The fibromuscular SMAS, if followed anteriorly, merges with the superficial layer of the orbicularis oris muscle. The orbicularis oculi muscle when elevated exposes the sub-orbicularis oculi fat (SOOF). Deep to this fatty layer along the orbital rim lie the insertions of the elevator muscles of the lip. There is a perforating branch of the transverse facial artery, which is encountered inferior to the malar eminence and before reaching the zygomatic major muscle. There are no branches of the facial nerve along the zygomatic prominence and infraorbital rim. As a result, this area can be used safely for suturing the malar fat pad. Because of the osseous insertions and prominence of the zygomatic major and other lip elevator muscles, it is safer to begin elevation above these muscles and elevate inferiorly toward the platysma. An inferior-to-superior elevation would more likely result in injury to a facial nerve branch as one may slide into a deeper plane given the more tenuous nature of the SMAS at the mid-cheek.

Facial Nerve Anatomy for the Rhytidectomy Surgeon

The facial nerve traverses anteriorly through the parotid gland after exiting the stylomastoid foramen. It branches into five branches: temporal (or frontal), zygomatic, buccal, marginal mandibular, and cervical branches. Within the parotid gland, the main trunk usually divides into a superior temporofacial and inferior cervicofacial branches. Familiarity with the anatomy of the facial nerve is critical to avoiding nerve injury. The frontal and marginal branches are the most commonly injured branches of the facial nerve in facelift.

The frontal branch of the facial nerve innervates the frontalis muscle and the orbicularis oculi muscle. This division of the facial nerve courses from the parotid gland, anterior to the superficial temporal artery, toward its final destination, where it pierces the undersurface of the frontalis muscle 1.5 cm above the lateral canthus. The frontal branch of the facial nerve lies deep to the superficial musculoaponeurotic system fascia (SMAS) and its continuation in the temporal region, the temporoparietal fascia. The course of the nerve may be approximated by a line drawn from a point 0.5 cm anterior to the tragus to a point 1.5 cm lateral to the lateral brow.

The danger zone of the frontal branch of the facial nerve has been further delineated—the region overlying the zygomatic arch between 1.8 cm anterior to the helical root and 2 cm posterior to the lateral canthus. As the nerve crosses over the zygomatic arch, it lies between the periosteum of the zygoma and the SMAS. Dissection in the region of the zygomatic arch requires caution to avoid injury to the nerve and should be carried out either subcutaneously or subperiosteally. This is relevant during a subperiosteal midface lift approach that requires elevation of the periosteum from the anterior portion of the zygomatic arch.

The temporal branch is also particularly at risk when combining forehead and face lifting. Above the zygomatic arch, the nerve travels in the temporoparietal fascia. To avoid injury when dissecting in the temple and lateral orbital areas, the plane of dissection for the lateral portion of the forehead lift is in the subgaleal plane below the temporoparietal fascia. The facelift dissection anterior to the hairline in the temple is in the superficial subcutaneous tissue plane. Therefore, there are two planes of dissection overlapping in the lateral orbital and temporal region. The temporal branch is located between these planes.

As the deep plane rhytidectomy transitions from a sub-SMAS plane in the inferior cheek to a supra-SMAS plane in the superior medial cheek the zygomatic branch of the facial nerve is at risk for injury. This is because the shifting of the plane to a more superficial plane anterior to the zygomatic major muscle requires sharp dissection.

The subperiosteal approach for midface lifting places the buccal branch of the facial nerve at risk. Releasing the periosteum off the inferior border of the zygoma requires dissection over the masseter muscle tendon that lies in proximity to the buccal nerve.

The marginal mandibular branch is at risk for injury while developing the posterior platysmal flap for correction of platysmal laxity. The "danger zone" for the marginal mandibular nerve is from the angle of the mandible to its crossing by the facial artery and extends from the inferior border of the mandible to a line that is 3 cm parallel and inferior to the mandible. Below the angle of the mandible the branch is located immediately beneath the platysma. The surgeon must be vigilant to remain superficial to the muscle during dissection to avoid the marginal mandibular branch. Atrophy or hypoplasia of the platysma muscle may have little protection of the marginal mandibular nerve.

Rhytidectomy Preoperative Assessment

Patient Selection

- Understand patient's motivation for having plastic surgery
- A patient with poor self-image or body dysmorphic disorder, whose motivation for surgery is to create personal happiness often, is dissatisfied with the surgical result
- Warning signs—patient in the midst of a life crisis, unhappy patients, psychologically impaired (paranoia, psychosis, obsessive-compulsive disorder, borderline personality, SIMON syndrome), body dysmorphic disorder, "package of pictures" syndrome, etc.

Table 28.1 Absolute contraindications for rhytidectomy

• Active smoking
• Active vasculitides
• Active autoimmune disease of facial vasculature
• Active chemotherapy or immunosuppression
• Full-course facial radiation exposure
• Largely fluctuating weight
• Uncontrolled hypertension
• Medically unfit for anesthesia
• Psychologically unprepared or unfit
• Unrealistic expectations

- The patient's general health status, past medical history, medications, allergies, previous surgeries, and social habits need to be reviewed to ensure fitness for anesthesia and surgery
  – Bleeding history, supplement use, drug use, recent skin infections, isotretinoin use
- Tobacco use is a contraindication for facial surgery. Refraining 2–4 weeks prior to and after surgery are essential due to deleterious effects on healing. Cigarette smoking is associated with a 12-fold increase in risk of flap necrosis. (Nicotine patches should also be avoided in the perioperative period)
- Table 28.1 reviews absolute contraindications for facelift surgery.

Physical Exam

- Evaluation includes inspection and palpation of facial structures.
- Facial aesthetic ideals and the changes associated with aging are recognized (see above).
- Facial asymmetry—due to bony skeleton, the preference for sleeping on one side of the face, and involuntary repetitive facial expressions.
- Fitzpatrick skin types—patient with darker skin may have a tendency for hypertrophic scar formation and pigmentation changes along incision lines.

Table 28.2 Favorable and unfavorable rhytidectomy candidates

Favorable features	Unfavorable features
Strong forward chin	Retrognathic or weak chin
Prominent cheek structure	Deep oral commissure grooves
Good facial bone structure	Thin skin
Fuller midface	Severely wrinkled and sun-damaged skin
Sharp cervicomental angle	Low hyoid with obtuse cervicomental angle
Shallow cheek/lip grooves	Deep cheek/lip grooves
Nonsmoker	Weak cheek bones
Good skin tone	Deficient midface tissues
Few wrinkles with minimal photoaging	Visible submandibular glands

- Patients with thinner faces tend to demonstrate better postoperative contour improvement when compared with patients with fuller faces. Table 28.2 reviews favorable and unfavorable physical exam features for rhytidectomy.

Photo Documentation

Before and after photographs should highlight the surgical difference by keeping all other elements the same—background, clothes, hair style and makeup, distance of subject from camera, positioning of head, and light source. Two-point light is preferable to ring flash. For lateral views, position the Frankfort horizontal plane parallel to the floor.

Facelift Standard Views

- Full-face front, neutral gaze
- Full-face front, smiling
- Lateral, neutral gaze
- Lateral, smiling
- Lateral, neck in flexion
- Oblique

Table 28.3 Medications and supplements that impair blood clotting and may induce perioperative arrhythmia

Medication/ supplement	Example
Vitamin/health supplement	St John's wort, ginkgo biloba, vitamin E, Echinacea, ginseng, valerian, Ephedra, glucosamine, vitamin C (>2000 mg daily), Feverfew, goldenseal, fish oils (omega-3 fatty acids), garlic, licorice, Kava, Dong quai
No steroidal anti-inflammatory drugs	Ibuprofen, indomethacin, naproxen, nabumetone
Anti-inflammatory medications	Toltetrin, dipyridamole, fenoprofen
All aspirin-containing medications	

Facial Surgery Perioperative Care and Anesthesia

Safe, consistent anesthesia instills a positive perception of the experience, elicits confidence, and prevents conditions that can significantly hinder the healing process.

- Stop nonsteroidal anti-inflammatory medications, herbal supplements, and vitamins (excluding multivitamins) at least 2 weeks before surgery; the use of aspirin is stopped at least 3 weeks before surgery.
- Table 28.3 reviews medications and supplements that impair blood clotting and may induce perioperative arrhythmia.

Patient Safety and Airway Considerations

- Antibiotic prophylaxis
- Patient position with padded support to avoid ulnar/brachial neuropathy
- Deep vein thrombosis prophylaxis with sequential compression device and/or compression stockings
- Airway Options
  - IV sedation with oxygen supplementation and oral airway
  - Deep sedation with laryngeal mask airway (LMA)
  - General Anesthesia with endotracheal intubation

Perioperative Management in Rhytidectomy

Blood pressure management and control of postoperative nausea are key in the prevention of hematoma after rhytidectomy.

Rhytidectomy Techniques

Limited Facelift Procedures

Short Flap Rhytidectomy (AKA Mini-Lift, "Weekend" Lift)

Selected in cases with the desire for a safe and sensible, yet subtle improvement in the signs of aging. Typically reserved for young patients with mild degree of skin laxity without significant midface ptosis or jowling.

- *Advantages*
  - Excellent safety record
  - Reduced operating time and expense
  - Rapid recovery
- *Drawbacks*
  - Limited and short-lived benefits

Technique key points

- Limited preauricular incision terminating just behind the lobule
- Short segment of skin undermining and minor SMAS treatment with plication or imbrications

Extended Rhytidectomy Procedures

This group includes several approaches with variable degree of tissue undermining. Selected in cases with more significant signs of aging affecting the face and neck, and where a more dramatic improvement is sought

Subcutaneous Rhytidectomy (AKA Long Flap Technique)

- Advantages:
  - Excellent safety record with low risk to facial nerve
- Drawbacks:
  - Limited improvement of the jowl
  - No correction of the midface.
  - Greater risk of scarring as tension on subcutaneous, not deeper, structures

Technique key points

- Skin flap is elevated in the subcutaneous tissue plane.
- The extent of anterior dissection of the face is based on surgeon's preference and the degree of facial skin laxity.
- Dissection to the lateral bony orbital rim in the temple releases the skin from the underlying orbicularis oculi. This helps address the crow's feet and facilitates redistribution of the vertically advanced preauricular skin flap.
- The skin of the upper neck is also elevated in a preplatysmal plane. Dissection may continue forward in the neck to the midline.
- The SMAS can be plicated by folding it on itself using sutures to suspend it to the parotid fascia.

SMAS Techniques

- Advantages:
  - Striking improvement of the jowl
  - Longer lasting results
- Drawbacks:
  - No corrective lift of the midface

Technique key points

- Elevation of a thick flap below the SMAS (**sub-SMAS dissection**) limited to the area over the parotid gland or extending anterior to the parotid gland
- The SMAS flap is then suspended in a posterior-superior vector
- SMAS dissection with mobilization of a composite flap of platysma and overlying soft tissue is favorable for correcting the jowl
- Plication/imbrication versus sub-SMAS dissection to address SMAS
- Use of multiple vectors for resuspension: more superiorly based vector in preauricular area to avoid windswept look; more posterolateral pull on lateral platysma/infra-auricular area to resuspend to mastoid fascia
- **Baker's Strip (Lateral) SMASectomy**
  - Removing a portion of the SMAS in the region directly overlying the anterior edge of the parotid gland. Usually, a 2- to 4-cm-wide strip of SMAS is excised, depending on laxity
  - Excision of SMAS along a line extending from the angle of the mandible to the lateral malar eminence
  - The vector in which the SMASectomy is performed is oriented parallel to the nasolabial fold, thereby producing improvement of the nasolabial fold
  - The mobile anterior SMAS is then sutured securely to the fixed portion of the superficial fascia overlying the parotid in a posterior-superior fashion

Hamra's Deep Plane Rhytidectomy

The SMAS represents a fascial extension of the platysma muscle beneath the cheek fat of the midface and thins prior to reaching the zygomatic major muscle. Traction placed on the SMAS, as in traditional SMAS rhytidectomy approaches, is not transmitted to the melolabial fold and as a result does not improve the fold. The SMAS is effectively anchored by the osseous attachments of the mimetic muscles it invests. Hence, the investments of the SMAS in the region of the midface must be released in order to move the SMAS and the overlying malar fat pad superiorly, thereby improving the melolabial fold and the appearance of the midface.

- The sub-SMAS dissection is advanced superiorly at the inferior cheek, sharply cutting through the SMAS peripherally.
- Essentially, the plane of dissection transitions from a sub-SMAS plane in the inferior cheek to a supra-SMAS plane in the superior medial cheek remaining just superficial to the zygomatic major and minor muscles.
- This releases the SMAS from its superomedial investments of the midface, permitting the SMAS and the overlying skin and subcutaneous fat pad to advance upward as a single tissue flap.
- The dissection extends medially and can proceed beyond the melolabial fold, totally releasing all SMAS attachments to the dermis of the upper lip, creating a thick musculocutaneous flap composed of skin, subcutaneous fat of the cheek, and the platysma.
- Shifting the dissection sharply to a more superficial plane from beneath the platysma of the lower cheek to a plane superficial to the SMAS superior and anterior to the zygomatic major muscle in the superomedial cheek places the zygomatic branch of the facial nerve at risk to injury.
- **Hamra's Composite Rhytidectomy**
  – Modified the deep plane rhytidectomy to incorporate the orbicularis oculi in the rhytidectomy flap, thereby connecting the facelift flap with a lower blepharoplasty dissection to achieve improvement in the malar crescents

Supra-SMAS Technique

- Advantages:
  – Corrects ptotic cheek fat of midface aging and mitigates the nasolabial fold
- Drawbacks:
  – Extended preauricular skin flap via lengthy anterior dissection, leads to large dead space where hematoma may accumulate
  – Does not provide as much improvement of the jowl compared with employing SMAS flap of the inferior cheek

Technique key points

- Subcutaneous tissue dissection extended anteriorly beyond the parotid gland toward the midface.
- However, this dissection is performed at a deeper level than the standard subcutaneous facelift plane and is immediately superficial to the SMAS and mimetic muscles of the face.
- The resulting thick cutaneous flap consisting of the cheek fat and the overlying attached facial skin.
- **Owsley's Extended Supra-SMAS Rhytidectomy**
  – The dissection is carried anteriorly to the upper lip to release all of the dermal attachments of the SMAS to the nasolabial crease.
  – The cutaneous flap is then suspended under considerable tension posterosuperiorly to the fascia overlying the zygoma and parotid gland.
  – The goal of this technique is to displace the cheek fat of the midface superiorly correcting the ptotic cheek fat, thus softening the nasolabial fold.

Subperiosteal Rhytidectomy

- Lifting of the midface tissues with a subperiosteal plane of dissection over the maxilla and zygoma
- All midface soft tissues are lifted including skin, fat, and muscle
  – Elevators of the lip, zygomatic major and minor, and orbicularis oculi
- Elevating the origin of the zygomatic musculature to a higher position on the zygoma improves elevation of the upper lip and oral commissure resulting in an aesthetically pleasing shape to the mouth
- Procedure also typically includes an endoscopic subperiosteal forehead lift

- Tri-plane rhytidectomy combines subperiosteal dissection with sub-SMAS approach to achieve improvement in both midface and jowls
- Advantages:
  - Overall safety with less risk of injury to the zygomatic branch of the facial nerve with the subperiosteal approach compared with the deep plane or extended supra-SMAS facelift
  - Rejuvenating the midface without placing unnatural tension on the skin in the temporal area
  - Enhancing malar eminence due to increased horizontal width of the face by displacing the origin of the zygomatic major muscle to a more superior and lateral position
  - No disruption of the blood supply to the skin of the midface
  - Does not require a long cheek flap extending anteriorly compared to the deep plane and extended supra-SMAS facelifts
- Drawbacks:
  - Protracted recovery time due to increased edema compared to other techniques
  - Subperiosteal midface lifts do not significantly correct the jowl and have no influence on the upper neck
  - Increase the horizontal width of the face by displacing the origin of the zygomatic major muscle to a more superior and lateral position
  - Risk to the temporal branch of the facial nerve with elevation of the periosteum from the anterior portion of the zygomatic arch
  - Risk to the buccal branch of the facial nerve during dissection of the periosteum off the inferior zygoma requiring dissection over the masseter muscle tendon

Technique key points

- The key is to release the periosteum from the lateral and inferior bony orbital rim and from the entire zygoma and maxilla
- Four surgical approaches used:

– (1) Transtemporal usually using an endoscope
  Incision behind the hairline in the temple
  Endoscopic dissection deep to the temporoparietal fascia of the anterior lateral scalp, i.e., plane of dissection is immediately superficial to superficial layer of deep temporal fascia. Temporal branch is protected in a plane superficial to the plane of dissection
  Transition made to a subperiosteal plane as dissection continues inferiorly over the zygoma and zygomatic arch
  Subperiosteal dissection extended medially in the midface releasing the soft tissues from their attachment to the maxilla
  Requires some dissection of the upper portion of the masseter muscle
  Disadvantage: difficulty releasing the periosteum from the medial maxilla due to poor visualization, even when an endoscope is used

– (2) Transorbital through a lower eyelid or transconjunctival incision
  Advantage: direct access to the midface without the need for an endoscope
  Subperiosteal dissection under direct visualization
  Midface soft-tissue suspension to the inferior bony orbital rim or to the anteroinferior temporalis fascia
  Disadvantage: transient distortion of the lateral canthal area from bunching of redundant soft tissue and risk for lower eyelid malposition

– (3) Transoral through an upper gingival buccal incision
  Combined with transorbital or transtemporal incisions for a combined surgical approach
  Allows the periosteum to be easily lifted from the inferior aspects of the maxilla and zygoma via oral access
  Advantage: ease of dissection and direct visualization without the need for an endoscope

Disadvantage: risk of wound infection via bacteria in the oral cavity

– (4) Combined using two more of the previously listed approaches

Midface Lift

The midface lift can be performed alone or as an adjunct to rhytidectomy in treating the aging face. The various planes of dissection and surgical approaches to the midface are found in Tables 28.4 and 28.5, respectively.

Threadlift

- A minimally invasive technique that gained popularity due to shorter operating time and opportunity for performance of surgery in office-based setting. Marketed to patients that are willing to trade a more modest degree

Table 28.4 Midface lift: Planes of dissection

	Advantages	Disadvantages
Subperiosteal	• Avoids preauricular incision/skin flap • Does not impair vascular supply of facial skin • Avoids risk to zygomatic branch of facial nerve • Lifting orbicularis oculi of lower eyelid • Lifting of oral commissure	• Increases horizontal width of face • Risk to temporal and buccal branches of facial nerve and infraorbital nerve • Greater postoperative edema • May cause hypesthesia of malar eminence
Supra-SMAS	• Less postoperative edema • Does not reposition zygomatic musculature • Avoids risk to temporal and buccal branches of facial nerve	• Long preauricular cutaneous flap • Reduces skin vascularity of face • Risk to zygomatic branch of facial nerve • Does not lift orbicularis oculi

Table 28.5 Surgical approaches to the midface

Surgical approach	Dissection plane	Advantages	Disadvantages
Transfacial	Supra-SMAS	• Avoids risk to temporal and buccal branches of facial nerve • Less post-op edema	• Preauricular incision and long skin flap • Requires some blind dissection • Does not lift orbicularis oculi
Transtemporal	Subperiosteal	• No preauricular incision • Simultaneous lateral brow lift	• Risk to temporal and buccal branches of facial nerve • Requires endoscope • Poor access to periosteal dissection of maxilla
Transorbital	Subperiosteal/ supraperiosteal	• Direct access for dissection and suspension of midface • More vertical vector for suspension of midface soft tissues	• Risk to buccal branch of facial nerve • Risk to infraorbital nerve • Risk of lower lid malposition
Transoral	Subperiosteal	• Direct access for dissection of midface • Ease in elevating periosteum of maxilla	• Risk to buccal branch of facial nerve • Does not provide access for suspension of midface tissues • Greater risk of infection • Risk to infraorbital nerve
Combined	Subperiosteal usually transoral combined with transtemporal or transorbital	• Direct visualization of entire dissection • Ease of suspension of midface tissues	• More postoperative edema • Greater risk of infection if transoral route used

of cosmetic improvement for supposed decreased morbidity
- To counteract the descent and laxity of the facial tissues, **barbed sutures** are placed under the skin of the neck and face
- Suspension of ptotic facial soft tissues via the subcutaneous plane
- Advantages:
  - Avoids large incisions and substantial undermining
  - Reduced recovery time
- Drawbacks:
  - Repositions the soft tissues in a superficial plane without addressing excess skin
  - Barbed wire—breakage and **extrusion**, skin dimpling, superficial hemorrhages, mild asymmetry, ecchymosis, erythema, edema, and persistent pain
  - Not easily reversible
  - Revision rate as high as 20 %
  - Short-lived results and decline in patient satisfaction

Standard Rhytidectomy Incisions

Factors that influence incision design: gender, hairline, hairstyle, history of previous facelift surgery, and facial and cervical skin redundancy

Temporal Incision

- Extends above the auricle into the hair, curving upward and forward to end 1 or 2 cm above the level of the eyebrow
- Often a horizontal incision **(sideburn incision)** is added beneath the temporal tuft of hair to enable removal of vertically elevated facial skin without raising the temporal hairline to an abnormal height
- Preservation of temporal hair tuft is critical in all facelift patients and poorly designed incisions in this area can lead to significant alopecia in this area that is difficult to correct and may necessitate hair grafting to correct this sequela of facelift

Preauricular Incision

- Follows curve of the root of the helical crus to the level of the tragus
- The incision may then continue posterior to the tragus or in the pretragal crease to the inferior aspect of the earlobe.
- Post-tragal incision should be used in women
  - In men this can result in the tragus being covered with hair-bearing skin, although electrolysis and laser hair removal in this area can be used as adjunctive measures to remove unwanted hair
- Advantages of the retrotragal incision:
  - Incision is hidden behind the posterior border of the tragus
  - Should be used in women
- Disadvantages of the retrotragal incision:
  - Obliteration of the pretragal crease and scar contraction that may pull the tragus forward, with an unnatural visibility of the external auditory canal
  - If a retrotragal incision is utilized, the pretragal hollow must be reestablished with a dermal stitch, recreating the normal preauricular contour
- Unnatural contours in the peri-tragal area are prevented by thinning the portion of skin flap immediately anterior to the tragus and trimming the flap with a minor redundancy of skin covering the tragus

Earlobe Incision

- Fashioned so the lobe is separated from the skin flap, with a 2 mm cuff of facial skin at its base
- Ensures the preservation of the sulcus between the lobe and the facial skin
- Complication: **satyr's ear/pixie ear deformity**

- Due to excessive tension on the ear lobe postoperatively causing the ear lobe to gradually become pulled down or stretched down onto the face. This unnatural-appearing earlobe is a giveaway for facelifting
- Litton stitch—mattress suture placed at cut edge of ear lobe secured to underlying tissue can assist in minimizing risk of satyr's ear deformity

Retroauricular Incision

- Positioned 2–3 mm anterior to the postauricular sulcus (AKA cephaloauricular groove) on the medial surface of the auricle. Addresses the potential for some posterior migration of the retroauricular scar, so that the scar will remain hidden by the auricle

Posterior Scalp Incision

- Extends from the retroauricular incision across the postauricular sulcus at the level of the tragus or where the helix meets the hairline to best conceal incision
- The straight line from the auricle to the hair-bearing scalp can be altered with a small superiorly based triangular flap in the mastoid area
- This dart of skin helps prevent straight-line scar contracture and hypertrophic scarring
- The scalp incision is directed into the hair, curving slightly inferiorly and parallel to the postauricular hairline
- The incision should not be made along the inferior border of the postauricular hairline as incisions designed along the hairline can become obvious rendering patients unable to wear their hair up to due visible scarring in this location
- In younger patients with only mild elastosis, the skin does not need to be elevated from the postauricular area and neck dissection may not be necessary. Therefore the retroauricular incision may be limited only to a short vertical incision behind the ear with no posterior scalp incision

Male Rhytidectomy

Special Considerations

- The approach to the male rhytidectomy patient is different due to fundamental differences in their motivation, expectations, support systems, and adaptability to changes in appearance compared to women.
- Anatomically men have a higher degree of descent of the midface leading to increased hollowing and more accentuated nasolabial folds.

Incisions

Specific pattern and distribution of facial and temporal hair influence incision design. Additionally, males who wear their hair short or shave their head may need to be advised to grow their hair out to better camouflage the peri-auricular facelift incisions.

- **Temporal Incision**—most important consideration is to minimize alterations in the hairline and maintain the temporal tuft of hair
  - *Full growth of hair and no temporal recession*: no significant modification of the incision is necessary and the sideburn incision is not necessary
  - *Thinning hair with temporal recession or significant male-pattern baldness*: requires modifications of the temporal incision
    - Superior incision may be shortened to prevent it from extending into the area of recessed hair
    - Alternatively a *sideburn incision (see above)* with a horizontal extension, inferior to the temporal hairline, helps maintain the temporal tuft and prevents its recession or elevation. It also permits bearded hair to be moved superiorly to recreate the sideburn

- **Preauricular Incision**—A balance between preserving the non-hair-bearing skin in the preauricular area and maintaining the proper location of sideburns
  - *Preauricular incision placed just posterior to sideburn*
    Curvilinear incision following the root of the helical crus and then transitioning into the pretragal crease
    Potential for more conspicuous scar
  - *Incision in the preauricular sulcus with a posttragal extension*:
    Less obvious scar, but may move hair-bearing skin onto the tragus, eliminating the natural area of hairlessness in the preauricular area

- **Earlobe incision**—A 2-mm cuff of tissue should be preserved around the earlobe, preventing displacement of hair-bearing skin into the preauricular sulcus, creating issues when shaving
- **Retroauricular incision**—Standard incision (see above) used for women may result in transfer of hair-bearing skin onto the posterior aspect of the ear, necessitating shaving
  - Optimal to place the incision **within** the postauricular sulcus (AKA cephaloauricular groove) although posterior migration of the incision may occur with this design and the possibility of a visible postauricular incision should be discussed with the patient at the time of the preoperative visit
- **Posterior scalp incision**—incision (see above) used for women with extension of the posterior incision into the hairline may result in displacement of the hairline as well as contour irregularities
  - To reduce posterior and superior hairline displacement and stair stepping in the male patient, to place the incision in a pretrichial position along the inferior aspect of the hairline
  - More inferiorly located incisions reduce the height of the hair-bearing flap behind the ear and the need for shaving in the superior postauricular sulcus

Male Rhytidectomy Pearls

- Deep plane technique is the procedure of choice for men; however facelift should be tailored to the patient's needs
- Hair follicles in the midface and neck skin of men carry a more robust subdermal plexus, with the potential for increased bleeding:
  - More difficult to develop appropriate plane of dissection
  - Higher rate of hematoma formation in men
  - Allow for more subcutaneous fat on the undersurface of the flap to preserve hair follicles
- Before any trimming, skin should be redraped and the postauricular hairline reestablished to minimize step deformities
- Superior advancement of the skin flaps often results in redundant tissue and standing cone deformities at the temporal tuft
  - The redundant skin inferior to the temporal tuft is excised and relationship between the sideburns and the temporal hairline is preserved
- To prevent the shift of bearded skin into the hairless preauricular area noted with the pretragal incision, the hair follicles on the undersurface of the flap can be excised or cauterized

Adjunctive Procedures and Treatment

The Aging Neck

The presentation and etiology of the aging neck are described at the beginning of this chapter (Table 28.6). Ellenbogen and Karlin describe

Table 28.6 Ellenbogen and Karlin—visual criteria for the aging neck

(5) Youthful neck features
• Distinct, smooth inferior mandibular border with no jowl overhang
• Small subhyoid depression at the cervicomental angle
• Visible thyroid cartilage convexity
• Distinct anterior border of the sternocleidomastoid muscle from mastoid to sternum
• Cervicomental angle between 105 and 120°

youthful attributes of the neck, while (Table 28.7) Dedo offers a classification schema for the aging neck. Table 28.8 describes various approaches for the management of the aging neck.

Fat Transfer

- Fat transfer can be used as an adjunct to rhytidectomy or primary treatment to restore age-related facial contour changes.

Attractive, youthful, heart-shaped facial features
- Strong, well-projected chin with a straight jawline
- A slight hollowing of the buccal area
- A full anterior and lateral cheek

Aged, hollowed, square-shaped facial features
- Loss of volume in periorbital region with a hollowed-out, cachectic appearance
- Loss of volume in the midface and temple accentuates the squaring of the upper face
- Jowl and buccal fat descent with gravity
- Volume loss in the chin and perioral region, especially at the prejowl sulcus
- Lateral jawline volume loss
- Lower face jowls promote a squaring of lower face appearance

Areas of fat augmentation
- Periorbital areas, nasojugal groove, malar eminence, buccal area, prejowl sulcus

Other adjunctive treatments
- Skin resurfacing with laser treatments or chemical peel
- Forehead-lift
- Blepharoplasty
- Rhinoplasty
- Midfacial implants and/or chin augmentation

Table 28.7 Dedo aging neck classification

Class	Description
Class I (youthful neck)	Well-defined cervicomental angle, good platysmal tone, and no submental fat
Class II	Simple skin laxity only
Class III	Skin laxity with excess of submental fat
Class IV	Appreciable platysmal banding
Class V (bone structure)	Retrognathic/hypoplastic mandible
Class VI (bone structure)	Low hyoid bone

Rhytidectomy Complications

Parotid Injury

- More common with sub-SMAS dissection
- If gland parenchyma is violated, it should be cauterized to seal ductules
- Injury may result in **sialocele** or **fistula formation**

Table 28.8 Rejuvenation of the aging neck

Excess skin	Subcutaneous fat	Subplatysmal fat	Low hyoid	Platysmal banding	Deficient chin
Direct excision or Lower facelift with or without platysmal tightening or Extended platysmaplasty with suspension suture	Suction-assisted lipectomy or Laser-assisted liposuction or Judicious direct excision	Direct excision of subplatysmal fat with platysmal tightening (+/−) Digastric muscle plication and/or reduction if indicated (+/−) Submandibular gland excision	Suspension suture	Midline platysmal plication Botulinum toxin A treatment of platysmal bands (nonsurgical)	Osseous or alloplastic genioplasty or Chin augmentation using fat grafting or Orthognathic surgery if indicated

  - Treated with drainage, pressure dressing, and anticholinergic agent (glycopyrrolate)
  - Botulinum toxin injection
  - Large sialocele greater than 3 cm and persistent salivary fistulas should be treated with closed suction drainage
- **Parotid duct injury**
  - May occur along the anterior border of the masseter on a line from the external auditory canal to the upper lip
  - Treated with retrograde cannulation and repair under magnification
  - Catheter removed after 2 weeks

Facial nerve branch injury

- 0.3–2.6 % risk
- Spectrum of mild paresis to complete paralysis
- See section on ***Facial Nerve Anatomy for the Rhytidectomy Surgeon***
- If the nerve branch is inadvertently injured repaired with 10-0 nylon perineural (if possible) or epineural sutures placed under magnification
- Assymetry due to injury of frontal branch may be addressed with neuromodulator (Botox) on the contralateral side for mild cases, or may require ipsilateral brow lift for gross asymmetry after permanent injury

Auricular nerve and jugular vein injury

- The great auricular nerve is the most frequently injured nerve in rhytidectomy, 1–7 % risk
  - Originating from second and third cervical nerves (C2 and C3)
  - Supplies sensation to the upper lateral neck and ear lobule
  - Emerges at the posterior border of the SCM at Erb's point approximately 6–6.5 cm inferior to the external auditory canal. It circumscribes this border, and ascends in the neck in a sub-platysmal plane
  - Distally it imparts a small postauricular branch and penetrates the parotid gland to provide its sensory innervation
- Care is taken to avoid exposing the fascia overlying the sternocleidomastoid muscle and risking injury to the great auricular nerve and accompanying external jugular vein, which is located anterior to the nerve
- If injured, perform direct repair of nerve and suture ligature of vein

Spinal accessory nerve injury

- May be injured with extensive elevation of the postauricular skin flap into the posterior superior cervical triangle
- Injury is very rare although it may be injured during dissection posterior to the SCM as it lies in a fairly superficial location (with coverage only by a thin layer of subcutaneous fat and fascia) where it exits from the posterior border of the sternocleidomastoid muscle within 1–2 cm superior to **Erb's point**
- Injury is associated with constant, deep pain, limitation of shoulder abduction and cosmetic defect resulting from unilateral trapezius atrophy
- Management includes conservative measures including analgesics, physical therapy, electrophysiologic studies, and consideration of nerve exploration with repair

Hematoma

- Typically occurs in first 24 h after surgery
- Most common postoperative complication 3–8 %
- Associated with hypertension (post-op nausea/vomiting, coughing, agitation, poorly controlled pain)
- More common in men
- See section on ***Facial Surgery Perioperative Care and Anesthesia***
- Warning signs include increasing facial edema, bruising, and pain out of proportion to procedure
- Important early detection and treatment within a few hours to avoid skin flap necrosis and subsequent scarring
- *Minor hematomas* (2–10 mL)

  - Most commonly in the infra-auricular and postauricular region of the neck and amenable to evacuation in the office followed by placement of compression dressing with reexamination in 24 h
- *Major hematoma* (actively expanding)
  - 1.9–3.6 % require immediate evacuation and control of hemorrhage in the OR
- **Seroma formation**
  - Usually presents 5–7 days postoperatively
  - Treated with percutaneous aspiration and placement of pressure dressing
- **Postoperative vacuum drains**—decrease seroma formation but has not been shown to have statistical impact on hematoma formation
- **Fibrin glue**—improved flap adherence with controversial reduction in hematoma or seroma formation
  - Disadvantage: Increased cost

Infection

- Unusual following rhytidectomy (<1 %)
- *Staphylococcus* and *Streptococcus* species

Skin Flap Necrosis

- Etiology
  - Untreated hematoma (vascular congestion and arterial compromise)
  - Ischemia due to tobacco use *(risk increases 12-fold)*; stop tobacco at least 2 weeks before and after rhytidectomy
  - Subdermal plexus injury during dissection
  - Closure of incisions with excessive tension
- Most common at the postauricular region where skin flap is thinnest, wound tension is greatest, and blood supply is most tenuous *Partial-thickness injury* (superficial epidermolysis) heals with limited sign of scarring and/or hypopigmentation
- Full-thickness injury may lead to hypertrophic scar
- Conservative management is mainstay with topical application of nitropaste or DMSO two to three times daily, and local wound care
  - Area of concern is allowed to declare fully into eschar acting as a biological dressing, with conservative serial excision
  - Judicious use of steroid injection

Scarring

- Usually due to inappropriate incision placement or excessive wound closure tension
- **Hypertrophic scar**
  - Most commonly in the retroauricular incision where skin is thinnest at the mastoid with even moderate closure tension results in scar thickening
  - Responds well to serial intralesional injections of triamcinolone
- **Satyr's ear/pixie ear**
  - Downward traction and displacement of the earlobe with obliteration of the sulcus between earlobe and cheek
  - Due to poorly placed earlobe incision (see ***Standard Rhytidectomy Incisions***)
  - Mild deformity can be repaired with V-Y advancement as soon as 6 months although this can leave a visible suture line in the infra-auricular area
  - Severe deformity should be repaired in a delayed fashion and requires undermining of peri-auricular cheek skin, scar excision, and advancement of infra-auricular skin

Hair Loss

- Up to 8 % of rhytidectomy with hair loss
- Follicle damage due to electrocuatery, excess traction/tension on skip flaps
- *Telogen effluvium* (up to 8 % of rhytidectomy)
  - Regrowth occurs within 4–6 months
  - Can treat with minoxidil to shorten duration

- If persistent after 12 months consider micrografting
- **Distortion of natural hairline**
  - Insufficient anterior pivoting of postauricular flap to realign hairline
- **Inadvertent elevation/elimination of temporal hair tuft or hairline**
  - Can be prevented with the use of horizontal sideburn incision below the level of the tuft
- **Stair stepping deformity** of the postauricular hairline with marked advancement of the cervical skin
  - More noticeable with short hair and certain hairstyles

Pigmentary Changes

- Posinflammatory hyperpigmentation
  - More commonly affects Fitzpatrick skin types IV–VI
  - May persist for months but eventually dissipates
  - Aggravated with sun exposure
  - May consider treatment with hydroquinone or other bleaching cream
- Hypopigmentation
  - Affects all Fitzpatrick skin types
  - Excessive skin tension on incision closure
  - Dermal electrocautery
  - Areas of partial- or full-thickness necrosis
- Telangiectasias
  - Patients with premorbid tendency for telangiectasias have higher occurrence postoperatively in areas of skin undermining
  - Usually resolve spontaneously in 1–2 months following rhytidectomy

    If persistent, can be treated with vascular laser (e.g., KTP or diolite lasers, both 532 nm)

Contour Deformity

- **Cobra deformity**—hollow depression above the hyoid with overly aggressive liposculpting of submentum and neck
  - Worse when platysma muscles are not sutured at midline
- Nodules and skin puckering
  - May be due to organization of localized hematomas not aspirated or unrecognized contour deformities of the underlying deeper tissue layers prior to skin redraping
  - Small deformities resolve over months with faster recovery with massage and steroid injection
  - Dermal filler or autologous fat injection can be used to smooth irregularities

Systemic Complications

- 0.1–0.5 % risk
- DVT, PE, need for blood transfusion, major anesthetic complication, death
- Events more likely with general anesthesia compared with local anesthesia with IV sedation

Depression

- Short-term depression can occur in up to 30 % of women after rhytidectomy
- More likely in patients with pre-existing depression
- Duration usually 1 month after surgery
- Reassurance/emotional support and occasional short course of antidepressant may be warranted

Rhytidectomy Questions

- What is the definition of glabella?
- What is the Frankfort line?
- What are normative values of SN—A and SN—B?
- What are the extrinsic processes responsible for microscopic skin changes in aging?
- What is elastosis?
- What are the skeletal changes that contribute to orbit shape in periorbital aging?
- Describe the tear trough deformity and its etiology.
- Describe peri-oral changes in aging.
- What is the Witch's chin deformity?

- Describe the SMAS and its relationship with the facial retaining ligaments?
- In a sub-SMAS dissection what vessel is encountered inferior to the malar eminence that indicates close proximity to the zygomaticus major muscle?
- Describe the danger zone of the frontal branch of the facial nerve?
- What are the safe planes of dissection along the anterior zygomatic arch?
- What branch of the facial nerve is at risk in the deep plane rhytidectomy approach?
- What branch of the facial nerve is at risk with the subperiosteal approach for midface lift?
- The patient should refrain from tobacco use for how long prior to/after rhytidectomy surgery?
- Tobacco increases the risk of flap necrosis by how much compared to the typical nonsmoker?
- What are favorable features in prospective candidates for rhytidectomy?
- What are unfavorable features in prospective candidates for rhytidectomy?
- What are the standard photographic views for a facelift patient?
- What herbal supplements should be stopped prior to rhytidectomy? How long before surgery?
- Describe the indications, advantages, and drawbacks of short flap rhytidectomy.
- Describe Baker’s strip SMASectomy?
- Describe the deep plane rhytidectomy and its distinction from a composite rhytidectomy?
- Describe the extended supra-SMAS rhytidectomy?
- What are the different approaches to midface lifting?
- What are the drawbacks of the subperiosteal rhytidectomy?
- What is a threadlift? What are its limitations and drawbacks?
- What is the utility of a horizontal sideburn incision at the temple in rhytidectomy?
- What are the benefits and disadvantages of the retrotragal incision?
- What is the Satyr’s ear deformity? How is it corrected?
- Where is the optimal position of the retroauricular incision?
- What is difference in the temporal incision of male compared to female rhytidectomy?
- What are the criteria for the youthful-appearing neck?
- What is the Dedo aging neck classification?
- How does one address a low hyoid?
- Contrast the youthful heart-shaped face with the aged square-shaped face.
- What is the management of post-rhytidectomy parotid fistula?
- What are short-term and long-term treatment options for frontal branch injury in rhytidectomy?
- Describe the management of hematoma after rhytidectomy.
- What is the benefit of vacuum drains and fibrin glue in rhytidectomy?
- What are the ramifications of full-thickness skin flap necrosis and its management?
- Where is the most common location of hypertrophic scar after rhytidectomy? Why?
- How common is hair loss after rhytidectomy? What medication can be used to potentially shorten the duration of alopecia?
- Which Fitzpatrick skin types are more prone to hypopigmentation after rhytidectomy? Hyperpigmentation?
- What is the cobra deformity?

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