Chapter 8
Surgical Ablative Treatment of Head and Neck Cancers

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Introduction

Head and neck anatomy centers on function and aesthetics. Structures such as the mandible and the larynx, while millimeters in separation, serve vastly disparate occupations. As such, tumor extirpation can be particularly morbid.

Transoral excision of superficial tumors in the oral cavity was reported as early as the fifth century. In the 1800s, Billroth and Von Langenbeck described the lower lip split and mandibulotomy for access to elaborate tumors [1]. Kocher then pioneered the submandibular resection, allowing proximal vascular control and reduced need for mandibulotomy. A great advancement in surgical visualization came when Garcia refined the indirect laryngoscopy by experimenting on his own larynx. In 1873, Billroth initiated the first laryngectomy for cancer, albeit with profound mortality rates due to aspiration and sepsis [2].

The forefather of modern head and neck surgery was George Crile, who published his extensive experience in the early 1900s. After reviewing his cases from 1899 to 1906, Crile advocated for en bloc resection of neck lymphatics, improving survival rates from 19% to 75% [3, 4]. Martin added the level I–V modified radical neck dissection for metastatic neck disease.

Towards the late twentieth century, new technological advances have allowed for decreased morbidity. In rapid succession, Jako and Kleinsasser developed microlaryngoscopy [5], Polanyi invented the CO2 laser [6], and Jako and Strong reported using the two in combination [7].

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While techniques have flourished, the principles are steadfast. Tumor ablation is the primary modality to prevent progression and metastasis. Resection with clean margins must weigh multi-functional morbidities of the head and neck. Perhaps paramount of which is lengthy discussion with the patient regarding individual goals. Ninety percent of head and neck cancers are squamous cell carcinomas (SCC) [8]; thus the focus of this chapter will be the ablative management of head and neck SCC, upon which resection of other malignancies are often mirrored.

General Principles

Elective Tracheostomy

Aspiration and airway edema, risking loss of airway, are serious sequelae of head and neck cancer resection. Guidelines for elective tracheotomies are controversial. Grading systems exist such as the clinical assessment scoring system for tracheostomy (CASST) including a variety of surgical and patient factors (Table 8.1) [9].

Generally, those with increased secretions such as patients with chronic aspiration, patients with posterior tongue tumors with potential of tongue fall, and those with a free or pedicle flaps for airway reconstruction will require prolonged airway control with a tracheotomy. Those with large tumors encroaching on the airway will often need an urgent tracheotomy or urgent surgical resection with elective tracheotomy in anticipation of postoperative swelling. Generally speaking, the most common indication for tracheostomy is in patients diagnosed with laryngeal cancer [10].

Tracheotomies are performed prior to tumor resection. An open tracheotomy is performed, and an endotracheal tube is advanced for ventilation during the

Table 8.1 Gupta et al. developed the CASST grading system to predict the need for tracheostomy with a sensitivity of 95.5% and a negative predictive value of 99.3% [9]

Major criteria	**Points**
Previous radiation in same region of surgery	2
Resection of two more sub-site of oral cavity or oropharynx	2
Bilateral neck dissection	2
Extended hemi- or central-arch mandibulectomy	2
Bulky flap used for reconstruction	2
Flap causing compression (e.g., use of a reconstruction plate, intact mandibular rim)	2
Minor criteria	
Age > 65 years	1
Previously operation at the same site	1
Trismus	1
Pathological CT chest findings (e.g., COPD, emphysema)	1
Total score < 6	No need for tracheostomy
Total score > 7	Likely need for tracheostomy

procedure. Decannulation rates are high, studies reporting up to 88.5%, and should be carried out when secretions are controlled and mechanical ventilation is no longer required [11].

Feeding

High rates of dysphagia exist after head and neck cancer surgery, further compounded by treatment- and disease-related cachexia. Malnutrition complicates curative goals and increases morbidity with each treatment step. Thus, many clinicians opt for prophylactic feeding tube placement at the time of surgical resection or at the onset of swallowing compromise [12].

One review from Moffitt Cancer Center identifies body mass index below 25, tumor stage three or greater, and a cumulative cisplatin dose great than 200 mg/m^2 as the factors most associated with percutaneous endoscopic gastrostomy tube placement [13]. As high as 60% of patients undergoing chemoradiation for head and neck cancer undergo feeding tube placement which remain for a median of 9 months. However, most studies fail to find significant improvements in morbidity or survival with feeding tube placement [14–19].

There is little consensus among institutions regarding practices for prophylactic feeding tube placement. At this juncture, authors do not recommend prophylactic placement without identified patient comorbidities. National Comprehensive Cancer Network (NCCN) guidelines currently identify (i) severe weight loss, (ii) symptomatic patients, (iii) risk for aspiration, and (iv) high-dose radiation as strong considerations for percutaneous endoscopic gastrostomy (PEG) placement (Table 8.2). The ease of modern endoscopic placement allows swift enteric feeding once malnutrition is identified. Likewise, open discussion should ensue prior to surgical resection to determine patient preference for feeding.

Reconstruction

Head and neck reconstruction principles are complex and beyond the scope of this chapter, and it is been covered in the subsequent chapter in this volume. In general, surgical principles follow the reconstructive ladder. Small defects in the alveolar arch or hard palate can be allowed to granulate by secondary intention as scar contracture is negligible. On the opposite spectrum, the free fibula flap has arisen as the work horse of mandibular reconstruction, with excellent aesthetic results and minimal donor site morbidity.

A plastic surgery team should be involved early in surgical planning. Aesthetic and functional goals must be discussed thoroughly as final reconstruction may take years to complete.

Table 8.2 Taken from the NCCN guidelines for head and neck cancer. With a copyright permission, the content adopted from [125]

Global nutrition recommendations for patients receiving (chemo)radiotherapy	
Utilize oral intake as much as possible when maintaining safety Monitor for the lifetime of the patient even well after therapy	
Factors predicting limited enteral feeding requirement	**Factors suggesting strong consideration of prophylactic PEG**
Very good performance status as measured by the Eastern Cooperative Oncology Group (ECOG/WHO/Zubrod) score No significant Pretreatment weight loss 5% past 1 month 10% past 6 months Airway obstruction Dysphagia	Severe weight loss prior to treatment 5% past 1 month 10% past 6 months Symptoms includes Ongoing dehydration Severe dysphagia Anorexia Odynophagia interfering with oral intake Significant comorbidities requiring good oral intake for health maintenance Severe aspiration in any patient Any aspiration in an elderly patient or patients with compromised cardiopulmonary function Patients anticipating high-dose radiation

Neck Dissection

Neck dissections are either comprehensive (radical and modified radical) or selective. The radical neck dissection is characterized by unilateral removal of lymph nodes in regions I–V, sacrifice of the spinal accessory nerve, internal jugular vein, and sternocleidomastoid, and is rarely used today.

In patients without palpable neck disease or concerning findings on imaging, elective treatment of the neck is pursued based on the probability of occult metastatic disease. In general, if the risk of metastases is greater than 20%, treatment is considered [20, 21]. In particular, patients with nasopharyngeal, pyriform sinus, and base of tongue lesions with propensity for early lymphatic spread should be considered for elective neck treatment [22, 23]. The neck is managed by surgery or radiation depending on the primary tumor management. Glottic tumors T1-2 are generally safe to defer any neck treatment; however, patients with advanced T3-4 tumors are recommended to undergo neck dissections or radiotherapy. Oropharyngeal, hypopharyngeal, or supraglottic laryngeal tumors T2-4 often spread to the neck without palpable signs and should receive lateral neck dissections or radiation.

Patients with clinically positive neck disease are recommended to undergo comprehensive dissection. Those without adenopathy in level V can be considered for selective neck dissection as level V involvement is often rare. If extracapsular extension is present, adjuvant radiotherapy is delivered concurrently with chemotherapy. Individualized neck management will be discussed for each tumor type separately.

Cutaneous Malignancies

Basal Cell Carcinoma (BCC)

Low-risk BCC are categorized by primary tumors of nodular or superficial subtype, less than 10 mm on the cheek, forehead, scalp, or neck, without perineural invasion, and without history of radiation [24–26]. Resection involves 4 mm margins and Mohs micrographic salvage for positive margins. Curettage and electrodesiccation is an in-office alternative, but cannot evaluate for histologic margins.

High-risk BCC are of the morpheaform, basosquamous, sclerosing, mixed infiltrative, or micronodular subtype, are greater than or equal to 10 mm, and involve the periorbita, eyebrows, nose, lips, chin, mandible, peri-auricular region, or temple and recurrent or history of immunosuppression/radiation. High-risk disease is managed upfront with Mohs surgery, which boasts lower recurrence rates and increased tissue sparing than traditional resection.

Squamous Cell Carcinoma (SCC)

SCC arise from premalignant actinic keratosis and are further stratified into low- and high-risk categories [27]. Low-risk SCC is a primary disease; less than 10 mm diameter on the cheek, forehead, scalp, or neck; less than 2 mm in depth; and is Clark levels I–III, with well-defined border, without structural invasion, and in patients without prior radiation. Actinic keratosis and SCC in situ can be treated with in-office cryotherapy, topical 5-FU, imiquimod, and other topicals. Lesions with a diagnosis of low-risk SCC is generally recommended for surgial excision with 4–6 mm margins, with Mohs micrographic surgery reserved for positive margins.

A diagnosis of high-risk SCC includes lesions that are recurrent, are poorly defined, have more than 2mm in depth, Clark levels IV-V, demonstrate rapid growth, show structural invasion, involve the periorbita, eyebrows, nose, lips, chin, mandible, peri-auricular region, or temple, and are histologically aggressive. High-risk SCC is initially treated with Mohs surgery or can receive standard surgical excision.

Melanoma

Following standard punch or incisional biopsies, head and neck melanomas are managed standardly with wide local excision [24, 25]. These include 1 cm margins for tumors with Breslow depth less than 1 mm, 1–2 cm margin for lesions 1–2 mm thick, and 2 cm margins for tumors more than 2 mm thick.

Special considerations exist based on anatomic location. In general, melanomas of the face are resected to the facial muscles, barring invasion of muscle and

underlying bone. Melanomas of the ear are considered for partial or total auriculectomy, while those of the ear canal may require resection of temporal bone. Scalp melanomas are resected to the periosteum, and those that abut the periosteum may indicate outer table resection.

Neck Dissection

BCC has very low rates of neck metastases and dissection is reserved for positive nodal disease [25–27]. SCC, on the other hand, can be considered for sentinel node biopsy in high-risk disease. Lesions that (i) are larger than 2 cm, (ii) have a depth greater than 4 mm, (iii) are on the lip or ear, (iv) have presence of perineural invasion or poor differentiation, or (v) are in immunosuppressed patients have an increased risk of metastasis. Palpable disease warrants therapeutic neck dissection. Posterior scalp and neck SCC warrants posteriolateral neck dissection, involving suboccipital and retroauricular nodes.

Melanomas are relatively more complex to manage [24]. Patients with T2-3 tumor, Clark levels IV–V, or ulcerative melanomas are treated with a sentinel node biopsy. Therapeutic neck dissection is indicated for palpable neck disease or positive sentinel nodes. Anterior scalp, temple, ear, and facial melanomas with positive sentinel nodes indicate superficial parotidectomy, as disease commonly metastasizes to the parotid nodes. Posterior scalp and retroauricular melanomas also indicate suboccipital and retroauricular dissection.

Oral Cavity

Surgery is the primary modality of oral cancer ablation. Adjuvant radiation or chemoradiation supplements resection of advanced tumors. Early-stage oral tumors T1-2 often undergo transoral resection. Access to advanced or posterior tumors generally can be performed through a combined transcervical and transoral approach and is rarely facilitated by mandibulotomy.

Lip

While basal cell carcinomas are most prevalent in the lip, SCC comprise 30% [28, 29]. The lip is the most common site for cancer of the oral cavity. Lip resection poses an obvious cosmetic challenge, and concurrent reconstruction is always required.

In situ lesions are managed more conservatively with shave excision, topical 5-fluorouracil, or imiquimod. Invasive lesions generally require formal excision,

with exception to select early stage commissure lesions that may be managed with radiation only, due to the complexity of reconstructing the oral commissure. All lesions should be assessed for mandibular or mental nerve involvement prior to excision. Neck metastases are rare (10%) and elective neck dissections for node negative disease are generally not recommended in T1-2 tumors; however should be considered in T3-4 disease [30].

Tongue

Cancers of the tongue are not limited by anatomical barriers and are often more invasive, requiring comprehensive resection with 1 cm margins [31]. T1-2 lesions can be ablated with transverse wedge excisions or wide local excision with frozen sections [32, 33]. Large T2 lesions and posterior lesions classically mandated pull-through or mandibulotomy, particularly for segmental resections. Extensive local disease mandates near-total or total glossectomy.

Resections limited to the oral tongue that encompass less than one quarter of the tongue volume can be closed primarily or skin grafted [34]. When more than one third of the tongue is resected, fasciocutaneous free flap reconstruction should be considered to restore tongue bulk and maintain mobility and is considered mandatory for patients with >50% tongue resection. Reconstruction is also dependent on the degree of floor of mouth involvement which can cause significant tongue tethering. Unfortunately for large T3-4 lesions, even with reconstruction, total glossectomies are complicated by chronic aspiration and breathing difficulties, and laryngectomy is occasionally indicated.

Mandible

SCC can invade directly from the oral cavity into the mandible. Tumors extending to the superficial gingiva are resected with periosteum only. Those with periosteal invasion require at least a marginal mandibulectomy [35, 36]. Generally, if a tumor extends from the alveolar ridge below the level of the mandibular canal, a segmental mandibulectomy is required over a marginal mandibulectomy. Discussion of mandibular resection will be elaborated for each type of tumor later in this chapter.

The mandible, even uninvolved, inhibits proper tumor access and may rarely mandate mandibulotomy. Current guidelines are moving towards more mandibular sparing, particularly with the popularity of the pull-through technique for tumors that do not grossly involve the mandible. In general, mandibulotomies for access alone are avoided due to complications such as nonunion, temporomandibular joint disease, ankyloglosis, or even osteoradionecrosis [37, 38].

Floor of the Mouth

Proper resection of these tumors in proximity to the mandible can involve marginal mandibulectomy with 1 cm margins [39]. Early-stage tumors can be treated with transoral resection or pull-through technique [40]. Tumors that abut the mandible without obvious invasion past the periosteum can be limited to marginal mandibulectomy. Those tumors that have radiologic cortical involvement will require complete segmental mandibulectomy with bone cuts 1 cm from the malignant margins. Large tumors that are purely soft tissue with appropriate distance from the mandible can be accessed transcervically and resected en bloc with the neck dissection.

Alveolar Ridge

Primary tumors at this site are rare and share subunit management with floor of mouth tumors. Cases where the tumor does not invade the periosteum, a subperiosteal resection is possible [41, 42]. Small tumors can be addressed with marginal mandibulectomy or maxillectomy, while larger ones generally require segmental mandibulectomy or maxillectomy.

Retromolar Trigone

Mucosa of the retromolar trigone abuts the mandible, and even early-stage malignancies often involve mandible resection by L-shaped coronal marginal mandibulectomy, segmental, or hemimandibulectomy [43].

Hard Palate

Although SCC are the majority of hard palate malignancies, one third of tumors in this area arise from minor salivary glands. Resection involves 1 cm margins. Small tumors can be accessed per-orally [44]. Fortunately, the palatal periosteum bars tumor spread. Periosteal involvement requires removal of a portion of the bony palate with an infrastructure maxillectomy. Large tumors that extend into the pterygoid plates and masticator space benefit from superoanterior exposure of the nasal cavity, a maxillary sinus attained via a transverse-vertical Weber-Ferguson approach. In advanced tumors, en bloc maxillary resections may remove the inferior orbital rim. Thus, reconstructions must address separation of the oral and nasal cavities, replacing the nasal lining, and reconstruction of the orbit. Often a dental prosthesis can supplement rehabilitation of speech and swallowing.

Buccal Mucosa

Small superficial lesions with minimal depth of invasion are excised transorally without muscle resection [45, 46]. However, tumor that has any palpable thickness should have resection of the underlying buccinator muscle. If there are concerns about the depth of invasion, an MRI scan can give critical information about the involvement of the buccinator or extension towards the external skin. Tumors that extend posteriorly towards to retromolar trigone should be assessed for involvement of the masticator space. Lip-split incisions are generally avoided with a careful combined transoral and transcervical approach.

Neck Dissection

Oral cancers often metastasize to nodal basins I, II, and III [47]. Elective treatment of the clinical N0 neck is achieved with a supraomohyoid neck dissection including these three levels [48, 49]. Level IIb can generally be spared in elective neck dissections which may decrease the incidence of spinal accessory nerve weakness. Those with clinically apparent nodal disease undergo a comprehensive dissection followed by adjuvant radiation. If extracapsular extension is present in the lymph nodes, chemotherapy is given concurrently with radiation therapy.

Odontogenic Cysts and Tumors

Odontogenic cysts, regardless of histology, are standardly treated by enucleation; unilocular cysts do not require curettage, while multilocular, scalloped, or recurrent cysts are recommended to be curettage [50–52]. The necessity of tooth extraction is dependent on the histology.

Similar principles of enucleation and curettage apply to odontogenic tumors [20]. This strategy includes but is not limited to adenomatoid odontogenic tumors, ameloblastic fibromas, calcifying cystic odontogenic tumors, odontomas, and squamous odontogenic tumors. Notable exception is the keratocystic odontogenic tumor (KCOT) with high recurrence rate and should always be curettage with careful removal of the entire cyst lining [53, 54]. Pindborg tumors (i.e., calcifying epithelial odontogenic tumors) are resected with a small margin of bone. Odontogenic myxomas have a gelatinous appearance and 0.5–1 cm medullary bone should be removed with the specimen.

Ameloblastomas are the most aggressive benign tumor [55]. Treatment is controversial, but generally ameloblastomas in the mandible are often resected with 1 cm bony margins including periosteum [56]. Maxillary ameloblastomas are recommended to have 1–2 cm margins, and particular care should be taken intraoperatively with resection radiographs to ensure clean margins.

Oropharynx

Oropharyngeal cancers are an area of significant research and changing treatment paradigms due to the rapid increase in HPV-associated oropharyngeal cancer. HPV-positive disease has dramatically better outcomes than HPV-negative disease, and new protocols are investigating whether de-escalation of therapy can maintain excellent outcomes while minimizing morbidity. In general, T1 and T2 lesions can be primarily managed with surgery or radiation therapy depending on their ease of resectability and the extent of involvement of the neck [57]. When moving into more advanced T3 and T4 lesions, surgical resection would leave patients with significant morbidity and most institutions pursue upfront chemoradiotherapy.

The transoral approach is the most common surgical approach utilized. Tumors easily accessible with the direct transoral approach include small tumors of the soft palate, tonsils, and pharyngeal walls. Modifications to the transoral approach to reach larger tumors of the tongue base or retromolar trigone include transoral laser microsurgery (TLM) and transoral robotic surgery (TORS), the latter of which is mainly approved for T1-2 lesions [58–60]. Laser microsurgery proceeds with sequential piecemeal resection and is aided by frozen sections for confirmation of margins. TORS is currently under further development, including adaptation with the single port robotic novel robotic da Vinci [61], and many argue that the cost and difficult setup make it inferior to TLM. Research is underway to develop more flexible robotic arms, allowing it to follow the nonlinear anatomic path.

If transoral access is inadequate, often in inferior lesions, a pharyngotomy is the next step. Multiple variations exist with the traditional being the lateral approach sparing the hypoglossal and superior laryngeal nerve. The transhyoid pharyngotomy enters the vallecula medially, with care taken to close the pharyngotomy judiciously to prevent fistulae. Select extensive lesions may warrant a combined transoral and transcervical approach.

Soft Palate

Stage I and II tumors can be treated with radiation and stage III and IV tumor with chemoradiation to limit velopharyngeal insufficiency [62, 63]. Surgery is generally not recommended for tumors in this location given the superior functional outcomes of radiation therapy [64].

Tonsils

Tonsils and tonsillar pillars are the most common primary carcinoma site. Tonsillar tumors follow the typical treatment algorithm for oropharynx cancers described above. Anatomical access is challenging and aided by TLM or TORS for early-stage cancers and mandibulotomy for more extensive invasion [60, 65, 66]. Large tumors involving the mandible and multiple subunits mandate an en bloc resection with posterior mandibulectomy.

Tongue Base

Tongue base tumors are treated as other oropharyngeal cancers. If surgery is indicated, access can be attained from least to most invasive via transoral excision, lateral pharyngotomy, supra-/transhyoid pharyngotomy, lip split, or paramedian mandibulotomy. Small primaries T1-2 are managed with TLM or TORS [67, 68]. Tumors abutting or involving the mandible will be managed with marginal or segmental mandibulectomy. If total glossectomy is necessary in patients at high risk of aspiration, laryngectomy may prevent aspiration [60].

Posterior Wall

While early oropharyngeal wall tumors are treated with surgery or radiation, most late lesions should be treated with radiation with or without chemotherapy [69, 70]. Despite the deep location, appropriate retraction allows for resection of early tumor using transoral, TLM, or TORS. Lateral tumors are proximal to the internal carotid artery, and care must be taken to anatomic orientation particularly if performing micro or robotic surgery to protect it from injury. Unique to posterior wall tumors and soft palate, the retropharyngeal lymph nodes are most common. Dissection is difficult but can be reached via the transoral or transmandibular approach.

Neck Dissection

Oropharyngeal cancers often present at an advanced stage, half of which have nodal involvement. Node metastasis occurs commonly along levels 2–4, with occasional involvement of retropharyngeal nodes [71, 72]. Of note, oropharyngeal SCC which arise from HPV classically present with cystic lymph nodes.

Given the likelihood of early occult metastasis (40–50% of patients without clinical evidence had metastases), elective neck dissection or radiation is recommended. Those with extracapsular lymph node spread should receive primary chemoradiation. Soft palate cancers metastasize bilaterally, and bilateral neck dissections or radiation should be pursued as indicated.

Hypopharynx

Hypopharyngeal cancers report the poorest long-term survival among head and neck cancers, owing to high probability of distant metastases [73]. Anatomically, these tumors are in close proximity to the larynx, and even barring involvement, resection would compromise laryngeal function. While conventional management was total laryngopharyngectomy, recent advances involve chemoradiation in attempts to preserve the larynx, and transoral laser surgery. Due to the rarity of this disease, management guidelines are highly variable per institution (Table 8.3).

Table 8.3 General management guidelines of hypopharyngeal carcinomas

Procedure	T Stage	Reconstruction
Partial pharyngectomy	1, 2	Primary closure
Supracricoid hemilaryngectomy	1, 2, 3	Primary closure
Partial laryngopharyngectomy	1, 2, 3	Regional or free flap
Endoscopic carbon dioxide laser resection/ transoral robotic surgery	1, 2 (possibly 3 and 4)	Secondary intention
Total laryngectomy with partial/total pharyngectomy	3, 4	Primary closure vs regional or free flap
Total pharyngolaryngoesophagectomy	4	Gastric pull-up

Adapted from Cummings Otolaryngology [20]

In general, the majority treat T1 lesions and select T2 lesions with radiation alone or surgical resections [74, 75]. T2 lesions and above are managed with radiation therapy; however if there is significant laryngeal involvement and dysfunction of the laryngeal structures, a radical resection followed by radiation is preferred [76]. Stage III/IV can be considered for chemotherapy and radiation alone to limit laryngeal resection with surgery as secondary salvage.

Early-Stage Tumors

Generally, these patients are consented for a tracheotomy as pharyngeal edema postoperatively can cause airway compromise. Early T1/2 tumors with posterior or lateral extent can be considered for partial pharyngectomy with lateral pharyngotomy [77, 78]. More extensive tumors may necessitate a lateral transthyroid pharyngotomy, and posterior tumors may be approached with an anterior transthyroid pharyngotomy.

Tumors of the medial piriform sinus without involvement of the piriform apex, extension to the postcricoid, vocal cord paralysis, or invasion of the cricopharyngeus can be managed with a partial laryngopharyngectomy [79]. A supracricoid hemilaryngopharyngectomy expands upon this to include the ipsilateral supracricoid hemilarynx and piriform sinus [80].

Outside of the traditional open approaches, the management of early-stage tumors is moving towards tissue preserving surgeries such as transoral laser microsurgery (TLM). Minimized tissue resection translates to better functional swallowing postoperatively. The tumor is removed piecemeal with 1 cm margins, confirmed with frozen sections. This technique may eliminate the need for tracheostomy and significantly shorter perioperative course.

Late-Stage Tumors

In large lesions not suitable for conservation or those that fail chemoradiation, a traditional laryngectomy or total laryngopharyngectomy are necessary, respectively. These are plagued with pharyngocutaneous fistula rates as high as 40% [81, 82].

Those with tumors extending into the cervical esophagus will need a total pharyngolaryngoesophagectomy. This procedure involves bilateral neck dissections, total thyroidectomy, parathyroid autotransplantation, total laryngopharyngectomy, and transhiatal pull-through esophagectomy with gastric pull-through reconstruction [83].

Neck Dissection

Up to 75% of patients have palpable neck metastases upon presentation, owing to the abundant lymphatics in this region. The broad generalization is that elective neck dissections of levels II-IV should be pursued for N0 stages and therapeutic dissections for N+ necks [84].

Larynx

Laryngeal cancer treatment is focused on functional preservation. The larynx is poised for vocal production, swallowing, and breathing. Each of these three must be considered individually when recommending an optimal treatment for patients. Treatment is divided anatomically based on the three sections of the larynx:

Supraglottis

40% of laryngeal cancers originate in the supraglottis. Early-stage tumors are treated with single-modality therapy, and advanced stage disease is treated with multiple modalities. Smaller tumors are eligible for surgical resection [85]; however, as tumors extend to areas outside of the supraglottic region, or more deeply into the vocal cords, non-surgical management is preferred [86, 87]. Surgical resection can be performed by TLM which has largely replaced open partial laryngectomy approaches given the lower morbidity. TORS is limited by narrow exposure through the oral cavity but has similarly reported similar functional and oncologic outcomes to TLM [88, 89].

Stage III/IV tumors can be treated differentially with total laryngectomy and radiation or chemoradiation alone [33]. Tumors that compromise the cartilage or have extralaryngeal spread are favored for resection. Surgery is always the initial option for salvage. Surgically, the traditional option has been total laryngectomy and bilateral neck dissections, which presents significant morbidity. Supracricoid partial laryngectomy preserves the hyoid and cricoid cartilage and resects all true and false vocal cords, paraglottic spaces, thyroid cartilage, and epiglottis. This is often closed with a cricohyoidopexy. Supracricoid partial laryngectomy is indicated for T3 tumors with fixation of the true vocal cords or invasion of the pre-epiglottic space and T4 tumors with minimal involvement of the thyroid cartilage without extension to the extralaryngeal space [90].

Glottis

59% of laryngeal cancers originate in the glottis. Glottic tumors often present early with persistent hoarseness, allowing for better outcomes. T1 glottic tumors have great control rates with surgery and radiation alone, with the former being slightly preferred due to voice outcomes [91–93]. T2 tumors require more extensive resection of the vocal cord, which impairs voice outcomes, and more deeply invasive tumors have a higher risk of recurrence. TLM is the preferred method for resecting tumors over open approaches when feasible [88]. Voice prognosis from early tumors depends directly on muscular invasion. The exception is anterior commissure tumors which often recur. Open surgical resection may be the best option as radiation often underdoses tumors in this location and TLM has poor visualization in this anatomic region [94].

Stage III/IV tumors, similar to supraglottic tumors, can be treated with surgery and radiation or chemoradiation alone, with surgery for salvage. T3/T4 tumors were classically treated with total laryngectomy with adjuvant radiation; however, numerous trials have demonstrated the feasibility of using concurrent chemoradiation therapy for organ preservation and equivalent survival outcomes. Tumors that cause a dysfunctional larynx prior to treatment, in particular due to destruction of the laryngeal cartilage or cricoid invasion, are preferentially treated with an upfront laryngectomy. Tumors with more than 1 cm subglottic extension or palpable thyroid disease warrant hemithyroidectomy for likely invasion.

Subglottis

1% of laryngeal cancers originate in the subglottis [95]. While rare, these tumors are highly invasive, often spreading distally along the trachea and posteriorly towards the esophagus. Unfortunately, resection must be aggressive, yet survival is poor [96, 97]. Similarly, Stage I/II tumors receive radiation alone, while Stage III/IV tumors are treated with surgery or possibly radiation alone in non-surgical candidates. Surgery for all tumors is total laryngectomy to control the spread. Tracheal involvement requires low tracheal resection and manubrium removal.

Neck Dissection

Supraglottic tumors are highly metastatic and often involve bilateral lymph nodes [98]. Early T1 lesions can avoid elective neck dissection. N0/1 disease is recommended for bilateral selective neck dissection of levels 2–4 [99, 100]. Ipsilateral comprehensive neck dissection levels 1–5 and contralateral selective dissection are warranted for N2/3 disease.

Glottic tumors have lower rates of nodal metastasis; thus early T1/2 glottic tumors can exclude elective neck dissection. Majority of T3 tumors do not necessitate neck management, while T4 tumors are recommended to undergo neck management [101]. This includes dissection of paratracheal nodes levels 2–4.

Subglottic tumors often spread via abundant lymphatics to the pretracheal, paratracheal, inferior jugular, and mediastinal nodes. Thus, bilateral neck dissection with paratracheal node dissection is the standard of care.

Nasopharynx

Nasopharyngeal tumors are heavily susceptible to chemoradiation (generally radiation for stage I/II and chemoradiation for stage III/IV); thus surgery is reserved for local or regional disease recurrence [102, 103]. Contraindications to resection include internal carotid artery involvement, skull base erosion, and intracranial extension.

Surgical approaches can be open or endoscopic, depending on the location and extent of tumor. Challenging access is evident from the posterior location of the nasopharynx and the narrow gateway nasal vestibule, and open approaches require significant exposure from a transpalatal, transmaxillary, transcervical approach, extended osteoplastic maxillotomy, or "maxillary swing" [104]. Endoscopic and robotic nasopharyngectomies are becoming more popular for small central recurrences [105]. These approaches can resect the posterior nasal septum, roof of the nasopharynx, and the medial maxillary wall. Regional recurrence in the neck mandates a modified radical or radical neck dissection.

Nasal Cavity

Nasal cavity tumors are generally treated surgically. Resection must take into consideration involvement of the sinuses, nose, orbit, and cranial base.

Paranasal Sinus

Paranasal sinus tumors are particularly challenging given their insidious progression and advanced disease at time of presentation. General management involves surgical resection and postoperative radiation or chemoradiation. Early T1/2 tumors localized to a single region, such as the nasal cavity, septum, or maxillary sinus, can be managed with surgical resection alone. Increased stage tumors are supplemented by postoperative radiation, and chemotherapy is reserved for unresectable tumors.

Surgical Techniques

The choice of open versus endoscopic resection depends upon the intrinsic tumor properties and surgeon training. Open resection enables comprehensive exposure and should be pursued for involvement of the hard palate requiring maxillectomy, involvement of the orbit requiring orbital exenteration, anterior involvement of the nasal bone, and involvement of the external skin.

The endoscopic approach provides higher definition, allowing careful dissection around critical structures such as the orbit, dura, and carotids while avoiding unnecessary bony/soft tissue ablation [106, 107]. For most sinonasal malignancies, the endoscopic approach is now used whenever feasible [108]. Endoscopic endonasal/sinonasal resection occurs segmentally from the inferior nasal floor superiorly towards the skull base until clear margins are secured. Endoscopic partial maxillectomy removes the medial maxilla with inferior tubinate, the uncinate process, and, if involved, the orbital lamina. Endoscopic transcribriform resection expands the partial maxillectomy to include the anterior cranial base. Tumors that spread into the pterygopalatine or infratemporal fossa can be reached with coronal plane extension following medial maxillectomy. Contraindications to endoscopic resection include involvement of the soft tissue of the face or forehead, frontal sinus, palate, dura of the lateral orbit, brain invasion greater than two centimeters, mandible, cavernous sinus, significant orbit involvement requiring exenteration, or internal carotid total encasement.

Salivary Gland

Benign

The focus of this chapter is on resection of head and neck malignancies; however, given the prevalence of benign parotid tumors and their predominant surgical management, we will discuss them briefly. The majority (85%) of benign salivary tumors are parotid [52, 109, 110].

The approach to the majority of benign lesions is surgical excision with a cuff of healthy tissue, including myoepitheliomas, canalicular adenomas, oncocytomas, and lipoadenoma [111]. Large tumors in the superficial lobe can be resected with a superficial parotidectomy. Otherwise, deep tumors indicate total parotidectomy with facial nerve preservation. Facial nerve involvement indicates some degree of nerve sacrifice. If function is preserved, nerve branches can be selectively removed and reconstructed. Total paralysis on presentation requires facial nerve resection.

Pleomorphic adenomas are the most common benign parotid tumor and make up 75% of benign salivary gland tumors [112, 113]. As 90% arise superficial to the facial nerve, they are treated operatively with superficial or total parotidectomy depending on their location with dissection and sparing of the facial nerve. Transoral

resection or enucleation leads to unacceptably high recurrence rates. These often have a substantial recurrence rate of 2–7%, often as a complication of incomplete resection. Treatment is reoperation and adjuvant radiotherapy for multinodular recurrence. Repeat resection carries increased risk of facial nerve damage. Patients who are not good surgical candidates can achieve successful local control with neutron radiotherapy.

Warthin tumors are the second most common benign parotid tumor, found almost exclusively within the parotid. These tumors are slow growing, often asymptomatic. Smoking is a notable risk factor [114], and smoking cessation often significantly decreases risk. Treatment is observation, with resection for symptomatic disease – occasionally are painful or inflamed – or cosmetically desired. Parotidectomies are preferred as recurrence is common with inadequate excision.

Benign submandibular gland tumors involve gland removal with preservation of the marginal mandibular and hypoglossal nerve. Similarly, minor salivary gland tumors should be excised with a cuff of normal tissue, and enucleation should be discouraged. Management of malignant submandibular gland tumors is discussed below.

Parapharyngeal salivary gland tumors are resected via a transcervical incision and exposure of the major neurovascular structures of the upper cervical region. Hemangiomas, similar to those of other anatomical sites, are initially treated with steroids or beta-blockers with surgery or laser therapy reserved or select cases.

Malignant

Tumors that arise in the sublingual glands and minor salivary glands are most often malignant, while those in the parotid are more often benign. These include mucoepidermoid carcinomas, adenoid cystic carcinomas, acinic cell carcinomas, and polymorphous adenocarcinoma. Pleomorphic adenomas have a 10% risk for malignant transformation to carcinomas ex pleomorphic adenoma. Squamous cell carcinoma arising in the parotid gland are assumed to arise as metastases from frontotemporal scalp cutaneous carcinoma. Occasionally, skip lesions occur in the upper neck, and treatment of these should still involve a parotidectomy for presumed occult disease. Lymphomas are one exception and are treated by chemoradiation primarily.

Parotid

The parotid is bordered by the masseter anteriorly, sternocleidomastoid muscle posteriorly, zygomatic arch superiorly, and mandibular ramus inferiorly [115, 116]. While not anatomically separate, surgeons tend to refer to the deep (20%) and superficial lobes (80%) of the parotid which are separated by the plane of the facial nerve. Lymph nodes are located intra- and peri-glandular.

Malignant parotid tumors should be managed with a parotidectomy [109, 117]. Current guidelines are moving towards less aggressive resections when indicated. A total parotidectomy is indicated for high-grade tumors with high metastatic profile, tumors with lymph node metastasis, or any primary deep lobe tumors. Small, encapsulated malignancies in the lateral lobe can be managed with a superficial parotidectomy, and larger tumors can be considered for a partial deep lobe resection.

Parotidectomies are approached via the modified Blair incision, taking care to identify the main trunk of the facial nerve laterally, and the marginal mandibular branch inferiorly [118]. Deep lobe and parapharyngeal space tumors can warrant transcervical resection with possible mandibulotomy. If the facial nerve is involved, general principles apply and resection with negative margins should be pursued. Proximal extension may require mastoidectomy to achieve a negative margin. Facial nerve reconstruction can be completed by neurorrhaphy or interposition graft. However, if no nerve invasion is present and a plane can be surgically developed between the parotid tissue and nerve, preservation is important for improved morbidity.

Facial nerve paresis or paralysis may result from manipulation and traction during dissection, fortunately with full recovery in most cases. Approximately 20% of superficial parotidectomies can result in Frey syndrome, or auriculotemporal nerve syndrome. This is classified by gustatory sweating as a result of sympathetic fibers of transected auriculotemporal nerve branches aberrantly reinnervating the parotid. Treatment for refractory cases can be topical scopolamine or Botox injection.

Submandibular Gland

The submandibular gland is bordered superiorly by the mandible and inferiorly by the anterior and posterior bellies of the digastric muscle [119, 120]. Lymph nodes are all located peri-glandular.

Malignancies require gland excision in continuity with the level Ib nodes (submandibular nodes), present at the inferomedial location on the mandible [69]. Care should be taken to identify the marginal mandibular nerve, which should be reflected superiorly for preservation. The hypoglossal nerve should similarly be protected deep to the digastric muscles. The facial artery and vein can be ligated, and the submandibular ganglion and Wharton duct are the final structures to be sacrificed.

Sublingual and Minor Salivary Glands

The sublingual glands are located superior to the mylohyoid muscle, opposite of the lingual frenulum. Malignancies must be resected via a transcervical or, more popularly, a transoral approach, with a wide local excision often involving the tongue, mylohyoid, mandible, and possibly lingual nerve.

Neck Dissection Palpable or radio-apparent nodes in the neck should undergo ipsilateral radical neck (Levels 1–5) dissection with adjuvant radiation [121, 122]. Such aggressive treatment is necessary as salivary gland cancers often metastasize to any of the nodal basins.

Armstrong and colleagues demonstrated that 3 out of 30 patients (10%) had metastases in level I, 8 of 30 (27%) in level II, 7 of 30 (23%) in level III, 6 of 30 (20%) in level IV, and 1 of 30 (3%) in level V [123, 124]. They showed that dissection of levels I through IV would have detected all occult metastases. The one patient with a positive level V node also had node-positive disease in levels II through IV.

The guidelines for management of the clinically node-negative neck are under investigation. In general, elective neck dissection can be considered for high-grade or stage III/IV disease, extra-glandular extension, or facial nerve involvement.

Conclusion

Head and neck surgery is a formidable field to master. Each cancer type and anatomic location possesses different management algorithms and unique challenges. Proper comprehensive discussion would mandate a textbook for every tumor category. The importance of an involved radiation oncology team cannot be emphasized enough, as management almost always extends past surgical resection alone. There furthermore remains much to innovate in the field of head and neck surgery. Minimal surgical treatment has allowed great improvements in functional morbidity, significantly limiting the need for tracheostomies. As the field continues to grow, we anticipate improved resection outcomes with decreased aesthetic and functional deficits.

References

1. Nelson WR. In search of the first head and neck surgeon. Am J Surg. 1987;154(4):342–6.
2. Folz BJ, Silver CE, Rinaldo A, et al. An outline of the history of head and neck oncology. Oral Oncol. 2008;44(1):2–9.
3. Crile GW. On the surgical treatment of cancer. Transact Southern Surg Gynecol Assoc. 1906;18:108.
4. Crile G. Excision of cancer of the head and neck: with special reference to the plan of dissection based on one hundred and thirty-two operations. JAMA. 1987;258(22):3286–93.
5. Kleinsasser O. Mikrolaryngoskopie und endolaryngeale Mikrochirurgie: Technik und typische Befunde: Schattauer Verlag; 1991.
6. Polanyi TG, Bredemeier H, Davis T. A CO 2 laser for surgical research. Med Biol Eng. 1970;8(6):541–8.
7. Strong MS, Jako GJ. Laser surgery in the larynx early clinical experience with continuous CO2 laser. Ann Otol Rhinol Laryngol. 1972;81(6):791–8.

8. Mork J, Lie AK, Glattre E, et al. Human papillomavirus infection as a risk factor for squamous-cell carcinoma of the head and neck. N Engl J Med. 2001;344(15):1125–31.
9. Gupta K, Mandlik D, Patel D, et al. Clinical assessment scoring system for tracheostomy (CASST) criterion: objective criteria to predict pre-operatively the need for a tracheostomy in head and neck malignancies. J Cranio-Maxillofac Surg. 2016;44(9):1310–3.
10. Crosher R, Baldie C, Mitchell R. Selective use of tracheostomy in surgery for head and neck cancer: an audit. Br J Oral Maxillofac Surg. 1997;35(1):43–5.
11. Adoga AA, Kirfi AM, Bature IF, Bakari AA. Retrospective analysis of tracheostomy in patients with tumors of the aerodigestive tract. Ann Med Health Sci Res. 2018;8(6)
12. Wiggenraad R, Flierman L, Goossens A, et al. Prophylactic gastrostomy placement and early tube feeding may limit loss of weight during chemoradiotherapy for advanced head and neck cancer, a preliminary study. Clin Otolaryngol. 2007;32(5):384–90.
13. Hardy S, Haas K, Vanston VJ, Angelo M. Prophylactic feeding tubes in head and neck cancers# 318. J Palliat Med. 2016;19(12):1343–4.
14. Atasoy BM, Yonal O, Demirel B, et al. The impact of early percutaneous endoscopic gastrostomy placement on treatment completeness and nutritional status in locally advanced head and neck cancer patients receiving chemoradiotherapy. Eur Arch Otorhinolaryngol. 2012;269(1):275–82.
15. Rutter CE, Yovino S, Taylor R, et al. Impact of early percutaneous endoscopic gastrostomy tube placement on nutritional status and hospitalization in patients with head and neck cancer receiving definitive chemoradiation therapy. Head Neck. 2011;33(10):1441–7.
16. Salas S, Baumstarck-Barrau K, Alfonsi M, et al. Impact of the prophylactic gastrostomy for unresectable squamous cell head and neck carcinomas treated with radio-chemotherapy on quality of life: prospective randomized trial. Radiother Oncol. 2009;93(3):503–9.
17. Chen AM, Li B-Q, Lau DH, et al. Evaluating the role of prophylactic gastrostomy tube placement prior to definitive chemoradiotherapy for head and neck cancer. Int J Radiat Oncol Biol Phys. 2010;78(4):1026–32.
18. Silander E, Nyman J, Bove M, Johansson L, Larsson S, Hammerlid E. Impact of prophylactic percutaneous endoscopic gastrostomy on malnutrition and quality of life in patients with head and neck cancer—a randomized study. Head Neck. 2012;34(1):1–9.
19. Strom T, Trotti AM, Kish J, et al. Risk factors for percutaneous endoscopic gastrostomy tube placement during chemoradiotherapy for oropharyngeal cancer. JAMA Otolaryngol–Head Neck Surg. 2013;139(11):1242–6.
20. Flint PW, Haughey BH, Robbins KT, et al. Cummings otolaryngology-head and neck surgery e-book. In: Elsevier health sciences; 2014.
21. Wei WI, Ferlito A, Rinaldo A, et al. Management of the N0 neck—reference or preference. Oral Oncol. 2006;42(2):115–22.
22. D'Cruz AK, Vaish R, Kapre N, et al. Elective versus therapeutic neck dissection in node-negative oral cancer. N Engl J Med. 2015;373(6):521–9.
23. Robbins KT, Clayman G, Levine PA, et al. Neck dissection classification update: revisions proposed by the American Head and Neck Society and the American Academy of Otolaryngology–Head and Neck Surgery. Arch Otolaryngol–Head Neck Surg. 2002;128(7):751–8.
24. Ow TJ, Grethlein SJ, Schmalbach CE, Head ECotA, Society N. Do you know your guidelines? Diagnosis and management of cutaneous head and neck melanoma. Head Neck. 2018;40(5):875–85.
25. Chan Y. KJ Lee's essential otolaryngology head & neck Surgery. 11th ed. New York: McGraw-Hill Education; 2016.
26. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Basal Cell Carcinoma. 2018;V1. www.nccn.org.
27. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Squamous Cell Carcinoma. 2018. www.nccn.org.
28. Raskob GE, Zitsch IIIRP, Park CW, Renner GJ, Rea JRJL. Outcome analysis for lip carcinoma. Otolaryngol–Head Neck Surg. 1995;113(5):589–96.

29. Vukadinovic M, Jezdic Z, Petrovic M, Medenica LM, Lens M. Surgical management of squamous cell carcinoma of the lip: analysis of a 10-year experience in 223 patients. J Oral Maxillofac Surg. 2007;65(4):675–9.
30. Zitsch RP III, Lee BW, Smith RB. Cervical lymph node metastases and squamous cell carcinoma of the lip. Head Neck J Sci Special Head Neck. 1999;21(5):447–53.
31. Goldenberg D, Ardekian L, Rachmiel A, Peled M, Joachims HZ, Laufer D. Carcinoma of the dorsum of the tongue. Head Neck J Sci Special Head Neck. 2000;22(2):190–4.
32. Ganly I, Patel S, Shah J. Early stage squamous cell cancer of the oral tongue—clinicopathologic features affecting outcome. Cancer. 2012;118(1):101–11.
33. Lydiatt DD, Robbins KT, Byers RM, Wolf PF. Treatment of stage I and II oral tongue cancer. Head Neck. 1993;15(4):308–12.
34. Bokhari WA, Wang SJ. Tongue reconstruction: recent advances. Curr Opin Otolaryngol Head Neck Surg. 2007;15(4):202–7.
35. Marchetta FC, Sako K, Murphy JB. The periosteum of the mandible and intraoral carcinoma. Am J Surg. 1971;122(6):711–3.
36. Tei K, Totsuka Y, Iizuka T, Ohmori K. Marginal resection for carcinoma of the mandibular alveolus and gingiva where radiologically detected bone defects do not extend beyond the mandibular canal. J Oral Maxillofac Surg. 2004;62(7):834–9.
37. Dai T-S, Hao S-P, Chang K-P, Pan W-L, Yeh H-C, Tsang N-M. Complications of mandibulotomy: midline versus paramidline. Otolaryngol Head Neck Surg. 2003;128(1):137–41.
38. Eisen MD, Weinstein GS, Chalian A, et al. Morbidity after midline mandibulotomy and radiation therapy. Am J Otolaryngol. 2000;21(5):312–7.
39. Shaha AR, Spiro RH, Shah JP, Strong EW. Squamous carcinoma of the floor of the mouth. Am J Surg. 1984;148(4):455–9.
40. Rodgers LW Jr, Stringer SP, Mendenhall WM, Parsons JT, Cassisi NJ, Million RR. Management of squamous cell carcinoma of the floor of mouth. Head Neck. 1993;15(1):16–9.
41. Eicher SA, Overholt SM, El-Naggar AK, Byers RM, Weber RS. Lower gingival carcinoma: clinical and pathologic determinants of regional metastases. Arch Otolaryngol–Head Neck Surg. 1996;122(6):634–8.
42. Overholt SM, Eicher SA, Wolf P, Weber RS. Prognostic factors affecting outcome in lower gingival carcinoma. Laryngoscope. 1996;106(11):1335–9.
43. Huang CJ, Chao KC, Tsai J, et al. Cancer of retromolar trigone: long-term radiation therapy outcome. Head Neck J Sci Special Head Neck. 2001;23(9):758–63.
44. Yorozu A, Sykes AJ, Slevin NJ. Carcinoma of the hard palate treated with radiotherapy: a retrospective review of 31 cases. Oral Oncol. 2001;37(6):493–7.
45. Jing J, Li L, He W, Sun G. Prognostic predictors of squamous cell carcinoma of the buccal mucosa with negative surgical margins. J Oral Maxillofac Surg. 2006;64(6):896–901.
46. Diaz EM Jr, Holsinger FC, Zuniga ER, Roberts DB, Sorensen DM. Squamous cell carcinoma of the buccal mucosa: one institution's experience with 119 previously untreated patients. Head Neck J Sci Special Head Neck. 2003;25(4):267–73.
47. Lin HW, Bhattacharyya N. Survival impact of nodal disease in hard palate and maxillary alveolus cancer. Laryngoscope. 2009;119(2):312–5.
48. Civantos FJ, Moffat FL, Goodwin WJ. Lymphatic mapping and sentinel lymphadenectomy for 106 head and neck lesions: contrasts between oral cavity and cutaneous malignancy. Laryngoscope. 2006;116(S109):1–15.
49. Montes DM, Carlson ER, Fernandes R, et al. Oral maxillary squamous carcinoma: an indication for neck dissection in the clinically negative neck. Head Neck. 2011;33(11):1581–5.
50. Wendt JR, Gardner VO, White JI. Treatment of complex postoperative lumbosacral wounds in nonparalyzed patients. Plast Reconstr Surg. 1998;101(5):1248–53.
51. Eversole L, Sabes W, Rovin S. Aggressive growth and neoplastic potential of odontogenic cysts. With special reference to central epidermoid and mucoepidermoid carcinomas. Cancer. 1975;35(1):270–82.
52. Regezi J, Kerr D, Courtney R. Odontogenic tumors: analysis of 706 cases. J Oral Surg (American Dental Association: 1965). 1978;36(10):771.

53. Chapelle KA, Stoelinga PJ, de Wilde PC, Brouns JJ, Voorsmit RA. Rational approach to diagnosis and treatment of ameloblastomas and odontogenic keratocysts. Br J Oral Maxillofac Surg. 2004;42(5):381–90.
54. Brøndum N, Jensen VJ. Recurrence of keratocysts and decompression treatment: a long-term follow-up of forty-four cases. Oral Surg Oral Med Oral Pathol. 1991;72(3):265–9.
55. Carlson ER, Marx RE. The ameloblastoma: primary, curative surgical management. J Oral Maxillofac Surg. 2006;64(3):484–94.
56. Gardner D. Critique of the 1995 review by Reichart et al. of the biologic profile of 3677 ameloblastomas. Oral Oncol. 1999;35(4):443–9.
57. Oliver R, Clarkson JE, Conway D, et al. Interventions for the treatment of oral and oropharyngeal cancers: surgical treatment. Cochrane Database Syst Rev. 2007;(4):CD006205.
58. Bhayani MK, Holsinger FC. Lai SY. A shifting paradigm for patients with head and neck cancer: transoral robotic surgery (TORS). Head Neck. 2010;24(11)
59. Haughey BH, Hinni ML, Salassa JR, et al. Transoral laser microsurgery as primary treatment for advanced-stage oropharyngeal cancer: a United States multicenter study. Head Neck. 2011;33(12):1683–94.
60. Grant DG, Salassa JR, Hinni ML, Pearson BW, Perry WC. Carcinoma of the tongue base treated by transoral laser microsurgery, part one: untreated tumors, a prospective analysis of oncologic and functional outcomes. Laryngoscope. 2006;116(12):2150–5.
61. Chan JY, Wong EW, Tsang RK, et al. Early results of a safety and feasibility clinical trial of a novel single-port flexible robot for transoral robotic surgery. Eur Arch Otorhinolaryngol. 2017;274(11):3993–6.
62. Har-El G, Shaha A, Chaudry R, Hadar T, Krespi YP, Lucente FE. Carcinoma of the uvula and midline soft palate: indication for neck treatment. Head Neck. 1992;14(2):99–101.
63. Calais G, Alfonsi M, Bardet E, et al. Stage III and IV cancers of the oropharynx: results of a randomized study of Gortec comparing radiotherapy alone with concomitant chemotherapy. Bull Cancer. 2000;87:48.
64. Parsons JT, Mendenhall WM, Stringer SP, et al. Squamous cell carcinoma of the oropharynx: surgery, radiation therapy, or both. Cancer: Interdisciplin Int J Am Cancer Soc. 2002;94(11):2967–80.
65. Schneider I, Thumfart WF, Eckel HE, Volling P, Ebeling O. Transoral laser surgery for oral carcinoma. Lasers Otorhinolaryngol Head Neck Surg. 1995;49:185–90. Karger Publishers
66. Hicks WL Jr, Kuriakose MA, Loree TR, et al. Surgery versus radiation therapy as single-modality treatment of tonsillar fossa carcinoma: the Roswell Park Cancer Institute experience (1971–1991). Laryngoscope. 1998;108(7):1014–9.
67. Steiner W, Ambrosch P. Endoscopic laser surgery of the upper aerodigestive tract: with special emphasis on cancer surgery. Stuttgart – New York: Thieme; 2000.
68. Steiner W, Fierek O, Ambrosch P, Hommerich CP, Kron M. Transoral laser microsurgery for squamous cell carcinoma of the base of the tongue. Arch Otolaryngol–Head Neck Surg. 2003;129(1):36–43.
69. Spiro RH, Kelly J, Vega AL, Harrison LB, Strong EW. Squamous carcinoma of the posterior pharyngeal wall. Am J Surg. 1990;160(4):420–3.
70. Meoz-Mendez RT, Fletcher GH, Guillamondegui OM, Peters LJ. Analysis of the results of irradiation in the treatment of squamous cell carcinomas of the pharyngeal walls. Int J Radiat Oncol Biol Phys. 1978;4(7–8):579–85.
71. Werner JA, Dünne AA, Myers JN. Functional anatomy of the lymphatic drainage system of the upper aerodigestive tract and its role in metastasis of squamous cell carcinoma. Head Neck J Sci Special Head Neck. 2003;25(4):322–32.
72. Shah MN, Kane AA, Petersen JD, Woo AS, Naidoo SD, Smyth MD. Endoscopically assisted versus open repair of sagittal craniosynostosis: the St. Louis Children's Hospital experience. J Neurosurg Pediat. 2011;8(2):165–70.
73. Wahlberg PC, Andersson KH, Biörklund AT, Möller TR. Carcinoma of the hypopharynx: analysis of incidence and survival in Sweden over a 30-year period. Head Neck J Sci Special Head Neck. 1998;20(8):714–9.

74. Pingree TF, Davis RK, Reichman O, Derrick L. Treatment of hypopharyngeal carcinoma: a 10-year review of 1, 362 cases. Laryngoscope. 1987;97(8):901–4.
75. Hoffman HT, Karnell LH, Shah JP, et al. Hypopharyngeal cancer patient care evaluation. Laryngoscope. 1997;107(8):1005–17.
76. CHEEVER DW. Cancer of the tonsil: removal of the tumor by external incision (a second case). Boston Med Surg J. 1878;99(5):133–9.
77. CRACOVANER AJ, CHODOSH PL. The lateral approach to the larynx and hypopharynx. AMA Arch Otolaryngol. 1960;71(1):8–15.
78. Holsinger FC, Motamed M, Garcia D, Brasnu D, Ménard M, Laccourreye O. Resection of selected invasive squamous cell carcinoma of the pyriform sinus by means of the lateral pharyngotomy approach: the partial lateral pharyngectomy. Head Neck J Sci Special Head Neck. 2006;28(8):705–11.
79. Ogura JH, Jurema A, Watson RK. Partial laryngopharyngectomy and neck dissection for pyriform sinus cancer: conservation surgery with immediate reconstruction. Laryngoscope. 1960;70(10):1399–417.
80. Laccourreye H, St Guily JL, Fabre A, Brasnu D, Menard M. Supracricoid hemilaryngopharyngectomy: analysis of 240 cases. Ann Otol Rhinol Laryngol. 1987;96(2):217–21.
81. Laccourreye O, Garcia D, Ishoo E, Kania R, de Mones E, Hans S. Supracricoid hemilaryngopharyngectomy in patients with invasive squamous cell carcinoma of the pyriform sinus: part I: technique, complications, and long-term functional outcome. Ann Otol Rhinol Laryngol. 2005;114(1):25–34.
82. Kraus DH, Harrison LB, Zelefsky M, et al. Salvage laryngectomy for unsuccessful larynx preservation therapy. Ann Otol Rhinol Laryngol. 1995;104(12):936–41.
83. Harrison DF. Surgical management of hypopharyngeal cancer: particular reference to the gastric pull-up operation. Arch Otolaryngol. 1979;105(3):149–52.
84. Buckley M, Tulloch J, White R Jr, Tucker M. Complications of orthognathic surgery: a comparison between wire fixation and rigid internal fixation. Int J Adult Orthodon Orthognath Surg. 1988;4(2):69–74.
85. Mcdonald TJ, Desanto LW, Weiland LH. Supraglottic larynx and its pathology as studied by whole laryngeal sections. Laryngoscope. 1976;86(5):635–48.
86. Scola B, Fernández-Vega M, MartÍNez T, Fernández-Vega S, Ramirez C. Management of cancer of the supraglottis. Otolaryngol Head Neck Surg. 2001;124(2):195–8.
87. Sessions DG, Lenox J, Spector GJ. Supraglottic laryngeal cancer: analysis of treatment results. Laryngoscope. 2005;115(8):1402–10.
88. Ambrosch P. The role of laser microsurgery in the treatment of laryngeal cancer. Curr Opin Otolaryngol Head Neck Surg. 2007;15(2):82–8.
89. Ambrosch P, Kron M, Steiner W. Carbon dioxide laser microsurgery for early supraglottic carcinoma. Ann Otol Rhinol Laryngol. 1998;107(8):680–8.
90. Brasnu DF. Supracricoid partial laryngectomy with cricohyoidopexy in the management of laryngeal carcinoma. World J Surg. 2003;27(7):817–23.
91. Myers EN, Wagner RL, Johnson JT. Microlaryngoscopic surgery for T1 glottic lesions: a cost-effective option. Ann Otol Rhinol Laryngol. 1994;103(1):28–30.
92. Fein DA, Mendenhall WM, Parsons JT, Million RR. T1–T2 squamous cell carcinoma of the glottic larynx treated with radiotherapy: a multivariate analysis of variables potentially influencing local control. Int J Radiat Oncol Biol Phys. 1993;25(4):605–11.
93. Thomas JV, Olsen KD, Neel HB, DeSanto LW, Suman VJ. Early glottic carcinoma treated with open laryngeal procedures. Arch Otolaryngol–Head Neck Surg. 1994;120(3):264–8.
94. Cellai E, Frata P, Magrini SM, et al. Radical radiotherapy for early glottic cancer: results in a series of 1087 patients from two Italian radiation oncology centers. I. The case of T1N0 disease. Int J Radiat Oncol Biol Phys. 2005;63(5):1378–86.
95. Stell P, Tobin K. The behavior of cancer affecting the subglottic space. Can J Otolaryngol. 1975;4(4):612–7.

96. Hong WK, Lippman SM, Wolf GT. Recent advances in head and neck cancer—larynx preservation and cancer chemoprevention: the Seventeenth Annual Richard and Hinda Rosenthal Foundation Award Lecture. Cancer Res. 1993;53(21):5113–20.
97. Goguen LA, Posner MR, Tishler RB, et al. Examining the need for neck dissection in the era of chemoradiation therapy for advanced head and neck cancer. Arch Otolaryngol–Head Neck Surg. 2006;132(5):526–31.
98. Chiu RJ, Myers EN, Johnson JT. Efficacy of routine bilateral neck dissection in the management of supraglottic cancer. Otolaryngol Head Neck Surg. 2004;131(4):485–8.
99. Yang CY, Andersen PE, Everts EC, Cohen JI. Nodal disease in purely glottic carcinoma: is elective neck treatment worthwhile? Laryngoscope. 1998;108(7):1006–8.
100. Brentani RR, Kowalski LP, Soares JF, et al. End results of a prospective trial on elective lateral neck dissection vs type III modified radical neck dissection in the management of supraglottic and transglottic carcinomas. Head Neck. 1999;21(8):694–702.
101. Greene RM, DeWitt AI, Otto RA. Management of T3 N0 and T4 N0 glottic carcinomas: results of a national survey. Otolaryngol Head Neck Surg. 2003;128(2):191–5.
102. Wei WI, Sham JS. Nasopharyngeal carcinoma. Lancet. 2005;365(9476):2041–54.
103. Chen MY, Wen WP, Guo X, et al. Endoscopic nasopharyngectomy for locally recurrent nasopharyngeal carcinoma. Laryngoscope. 2009;119(3):516–22.
104. Wei WL, Lam KH, Sham JS. New approach to the nasopharynx: the maxillary swing approach. Head Neck. 1991;13(3):200–7.
105. Wei WI, Ho WK. Transoral robotic resection of recurrent nasopharyngeal carcinoma. Laryngoscope. 2010;120(10):2011–4.
106. Patel MR, Stadler ME, Snyderman CH, et al. How to choose? Endoscopic skull base reconstructive options and limitations. Skull Base. 2010;20(6):397.
107. Lee JY, Ramakrishnan VR, Chiu AG, Palmer J, Gausas RE. Endoscopic endonasal surgical resection of tumors of the medial orbital apex and wall. Clin Neurol Neurosurg. 2012;114(1):93.
108. Lund VJ, Stammberger H, Nicolai P, et al. European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base. Rhinol Suppl. 2010;(22):1–143.
109. Witt RL. The significance of the margin in parotid surgery for pleomorphic adenoma. Laryngoscope. 2002;112(12):2141–54.
110. Pogrel MA. Benign non odontogenic lesions of the jaws. Peterson's Principles Oral Maxillofac Surg. 2004;1:597–616.
111. Avelar RL, Antunes AA, Carvalho RW, Bezerra PG, Neto PJO, Andrade ES. Odontogenic cysts: a clinicopathological study of 507 cases. J Oral Sci. 2009;51(4):581–6.
112. Jansisyanont P, Blanchaert R Jr, Ord RA. Intraoral minor salivary gland neoplasm: a single institution experience of 80 cases. Int J Oral Maxillofac Surg. 2002;31(3):257–61.
113. Tanimoto H, Kumoi K, Otsuki N, Hirayama Y. Multiple primary pleomorphic adenomas in a single parotid gland: report of a new case. Ear Nose Throat J. 2002;81(5):341–5.
114. Pinkston JA, Cole P. Cigarette smoking and Warthin's tumor. Am J Epidemiol. 1996;144(2):183–7.
115. Berg DH. Working memory and arithmetic calculation in children: the contributory roles of processing speed, short-term memory, and reading. J Exp Child Psychol. 2008;99(4):288–308.
116. Thackray AC, Lucas RB. Tumors of the major salivary glands. Washington, DC: Armed Forces Institute of Pathology; 1974.
117. Beahrs OH, Woolner LB, Carveth SW, Devine KD. Surgical management of parotid lesions: review of seven hundred sixty cases. AMA Arch Surg. 1960;80(6):890–904.
118. Terris DJ, Tuffo KM, Fee WE. Modified facelift incision for parotidectomy. J Laryngol Otol. 1994;108(7):574–8.
119. Bhattacharyya N. Survival and prognosis for cancer of the submandibular gland. J Oral Maxillofac Surg. 2004;62(4):427–30.
120. Da-Quan M, Guang-Yan Y. Tumours of the minor salivary glands: a clinicopathologic study of 243 cases. Acta Otolaryngol. 1987;103(3–4):325–31.

121. Gold DR, Annino DJ. Management of the neck in salivary gland carcinoma. Otolaryngol Clin N Am. 2005;38(1):99–105.
122. Terhaard CH, Lubsen H, Rasch CR, et al. The role of radiotherapy in the treatment of malignant salivary gland tumors. Int J Radiat Oncol Biol Phys. 2005;61(1):103–11.
123. Armstrong JG, Harrison LB, Thaler HT, et al. The indications for elective treatment of the neck in cancer of the major salivary glands. Cancer. 1992;69(3):615–9.
124. Kelley DJ, Spiro RH. Management of the neck in parotid carcinoma. Am J Surg. 1996;172(6):698–700.
125. Schoeff SS, et al. Nutritional management for head and neck cancer patients. Pract Gastroenterol Series 121. 2013;37(9):43–51.