Reconstructive Surgery in Oral and Maxillofacial Region

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Reza Tabrizi and Parsa Behnia

The reconstruction of oral and maxillofacial defects can be both challenging and satisfying. The orofacial defects most often result from trauma or pathologic lesions surgery and congenital problems. The aims of reconstructing orofacial defects consist of the restoration of complex functional, anatomic, and aesthetic characteristics. The decision-making in reconstruction surgery depends on patients and defects status, which should be considered case by case. This chapter discusses the significant options in soft tissue and bone reconstruction.

Evaluation of Patients with Orofacial Defects

The first step in a comprehensive patient evaluation is taking a history. The time and etiology of defects are essential. If the patient's health condition permits, the reconstruction should be done as soon as possible. Also, there are few exceptions in immediate reconstruction: (1) acute infection and (2) uncertainty in safe margin following cancer resection.

The etiology of defects can affect treatment planning. In traumatic patients, primary care is the treatment priority. For example, immediate reconstruction in gunshot patients is advocated if the patients' condition is stable [1]. Immediate reconstruction is necessary for through-and-through defects, covering vital anatomical structures and facial defects that affect patients' appearance.

Treatment planning can be modified according to the patient's health condition. A simple reconstruction option with a short operation duration is desirable for patients in American Society of Anesthesiologists (ASA) III or IV. In particular, the use of reconstruction plate or pre-fabricated titanium mandible in compromised patients following segmental mandibular resection without continuity is recommended.

Radiographic Assessment

In hard tissue defects, a CT scan is beneficial. A three-dimensional CT scan can help estimate the size of defects and make 3D models. Studies showed that 3D models and the use of patient-specific pre-bent plates significantly decrease operation time and provide precise surgery [2, 3]. Furthermore, CT models can help surgeons determine any vital anatomical structure in proximity to defects.

Soft Tissue Defects in the Oral and Maxillofacial Region

Accurate preoperative planning, including flap design, is important than the technique of harvest flap harvesting. The "right" flap selection is essential, as otherwise, if an incorrect flap is chosen, the entire reconstructive attempt is downfallen to failure, despite how meticulously the surgical technique is done.

Regional Soft Tissue Flaps

Generally, regional flaps are the most common techniques used for the reconstruction of oral and maxillofacial defects. These techniques have the advantage of the donor site proximity to the recipient site and mostly depend on an "arc of rotation" as a limiting factor for regional flaps. Other benefits of such flaps are easy harvesting, reliability, short operation time, and requirement of no special instruments. The main

R. Tabrizi (✉)
Department of Oral and Maxillofacial Surgery, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran
e-mail: rtabrizi@sbmu.ac.ir

P. Behnia
Department of Oral and Maxillofacial Surgery, Shahid Beheshti University of Medical Sciences, Tehran, Iran
e-mail: Parsabehnia1@sbmu.ac.ir

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disadvantages of local flaps are limited application due to the arc of rotation and a limited soft tissue for reconstruction. To overwhelm these limitations, free flap transportation should be considered as an alternative treatment option. A local flap is preferable when it is available to avoid the risks of a free tissue transfer.

Forehead and Scalp

The forehead and scalp defects have familiar characters: an inherent resistance to tissue distension, cosmetically noticeable areas such as the brows and hairline, and the potential involvement of neurovascular structures [4]. Defects can be of various sizes, from a small skin defect to a full-thickness defect.

The scalp defects may be large that the reconstruction is challenging due to relative scalp immobility. Tissue quality and coverage aims can differ in patients based on previous surgery, radiation, or other comorbidities. Surgical planning should provide function and aesthetics related to adjacent tissues to prevent overlooking. The knowledge of the scalp and forehead anatomy is essential to reach an acceptable outcome.

Secondary Intention Healing

A secondary intention is a nonsurgical technique that can be suitable for selected patients. In the absence of intrinsic wound-healing problems, particularly heavy smoking or a history of local radiation, the granulation tissue will form and secondary healing occurs. It is a good option for non-hair-bearing areas of the scalp (the temple or vertex) when defects consist of a partial-thickness wound. Patients who cannot tolerate a surgical procedure or are medically compromised are candidates for secondary intention healing. However, it is associated with significant scar formation and is not advocated for visible aesthetic zoon, such as the frontal. Smaller defects (less than 2 cm) with a vascularized bed wounds heal in a few weeks, whereas more extensive wounds may last a few months to completely close. Although secondary intention healing is associated with contraction (up to 60%), it should be noted that it can distort adjacent tissues [5].

Primary Wound Closure

Subcutaneous undermining around defects can decrease wound tension. Primary closure is useful for small defects less than 1–2 cm. It should be cautioned that the use of primary closure does not distort anatomic landmarks (Fig. 45.1a, b). For temple defects with size 3 cm or less, reconstruction with a distensible tissue is recommended. The surface anatomy relationships of the forehead, the hairline, and brow should be considered [6].

Tissue Expansion

Tissue expansion is a preferred approach for large defects in the scalp and frontal. Gradual tissue expansion depends on the phenomenon of biologic creep, which leads to permanent

Fig. 45.1 (**a**) Traumatic injuries in the left eyebrow, frontal, and the perioral area, which were repaired by primary closure; (**b**) the patient's view 6 months after repair

elongation of tissues due to tan external force. The biological effect concept in tissue expansion includes the adjacent skin movement, enhanced mitotic activity, cell proliferation, and endorsed angiogenesis [7]. The complications of tissue expansion consist of infection, implant or port exposure, hematoma, seroma implant leak, skin necrosis, and neurosensory disturbance overlying the implant. These complications can be prevented by correct placement of the implant, antibiotic prophylaxis for 2–3 weeks, and post-operative drain.

Skin Grafting

The skin has a dual role as a graft and recipient in reconstruction. It was used for resurfacing superficial defects in the scalp and frontal. Full-thickness skin grafts are useful in patients with tight skin and large defects that adjacent tissue transfer is difficult or result in distortion surface anatomy. Skin grafts often reduce the need for additional facial skin incisions; however, they are vulnerable to the formation of a "patch-like" appearance because of a mismatch of color, contour, or texture if not meticulously planned. Skin grafts should be used with caution. The skin graft is recommended in cases that cannot be reconstructed with local flaps or significant distortion [8].

Local Flaps

When primary closure is not possible, the local soft tissue flap is the workhorse for forehead and scalp reconstruction. Local flaps are not only advocated for small or medium defects, but they may also reconstruct select large defects. In general, local flaps can be characterized as advancement, transposition, or rotation flaps. The forehead region is cosmetically essential, and any alteration of the adjacent anterior hairline or brow position can lead to aesthetic disharmony and patient dissatisfaction. Furthermore, critical neurovascular structures cross the forehead and temporal regions and should not be injured to make reconstruction more convenient [9]. The unilateral or bilateral advancement flaps can reconstruct small (less than 3 cm) forehead defects. These flaps rely on random blood supply in the dermal and subdermal plexus. Advancement flaps should be designed with a length-to-width ratio of at least 4:1 [10].

Nose Reconstruction

The nasal pyramid locates in the middle face. Nasal prominence and central location are often associated with behavior and personal identity [11]. The local and regional flap reconstruction has advantages over skin grafts or free flaps in certain situations.

The restoration of the nasal mucosal lining is challenging. The ideal donor site should be similar to the nasal lining in vascularity and pliability. Skin grafts, free mucosal grafts, and local mucoperichondrial flaps are applied for restoration of the nasal lining.

Bone and cartilage graft replacement prevent soft tissue from collapsing under the forces of scar contracture. Moreover, they maintain airway patency during inspiration. Any reconstruction without restoration of cartilage and bony components results in scar contracture or soft tissue collapse and nasal deformity. Three donor sites are recommended for cartilage replacements: auricular cartilage, costal cartilage, and nasal septum. Cartilage grafts depend on the vascularity of the recipient site and the overlying flap. It is advocated that grafts should be placed in the early reconstruction stage before scar formation, which compromises the final aesthetic outcome. Reconstruction of the bony nasal pyramid or dorsum needs autogenous bone grafts. Different donor sites have been used for nasal bone reconstruction: calvaria graft, rib, iliac crest, the lateral ramus.

Skin coverage is the final stage of nasal reconstruction and is essential to achieve a desired aesthetic result. Local and distant flaps are used to restore soft tissue in nasal defects. The flap selection primarily depends on anatomic location, defect size, defect location, and the adjacent skin's quality. If soft tissue defects are in an area with thin and smooth and mobile skin, particularly the nasal dorsum, primary closure may be possible. In larger defects, a skin graft may be suitable. The skin and cartilage composite grafts may be used in a one-stage reconstructive for the alar rim defects. A sandwich graft of skin and cartilage from the root of the auricular helix is commonly used to restore full-thickness defects. The paramedian forehead flap is a gold standard for the reconstruction of extensive defects of the nose (Fig. 45.2a–d). It is an axial flap that relies on the supratrochlear artery [11].

Periorbital Reconstruction

Reconstruction aims in the periorbital region consist of providing ocular surface lubricity with an internal layer in the smooth mucus membrane structure to prevent corneal irritation. Forming tars that restore the lid's shape and hardness with fixed lid edges are essential for lashing out corneal contact. Restoration of eyelid defects with thin skin are necessary to allow lid movement and enough levator movement to permit the upper lid lifting. The periorbital aesthetic is another crucial issue that should be considered in treatment planning [12]. The defect zone, size, and type of defect (the full or partial layer thickness) are the significant factors that should be considered in treatment planning (Fig. 45.3a–c).

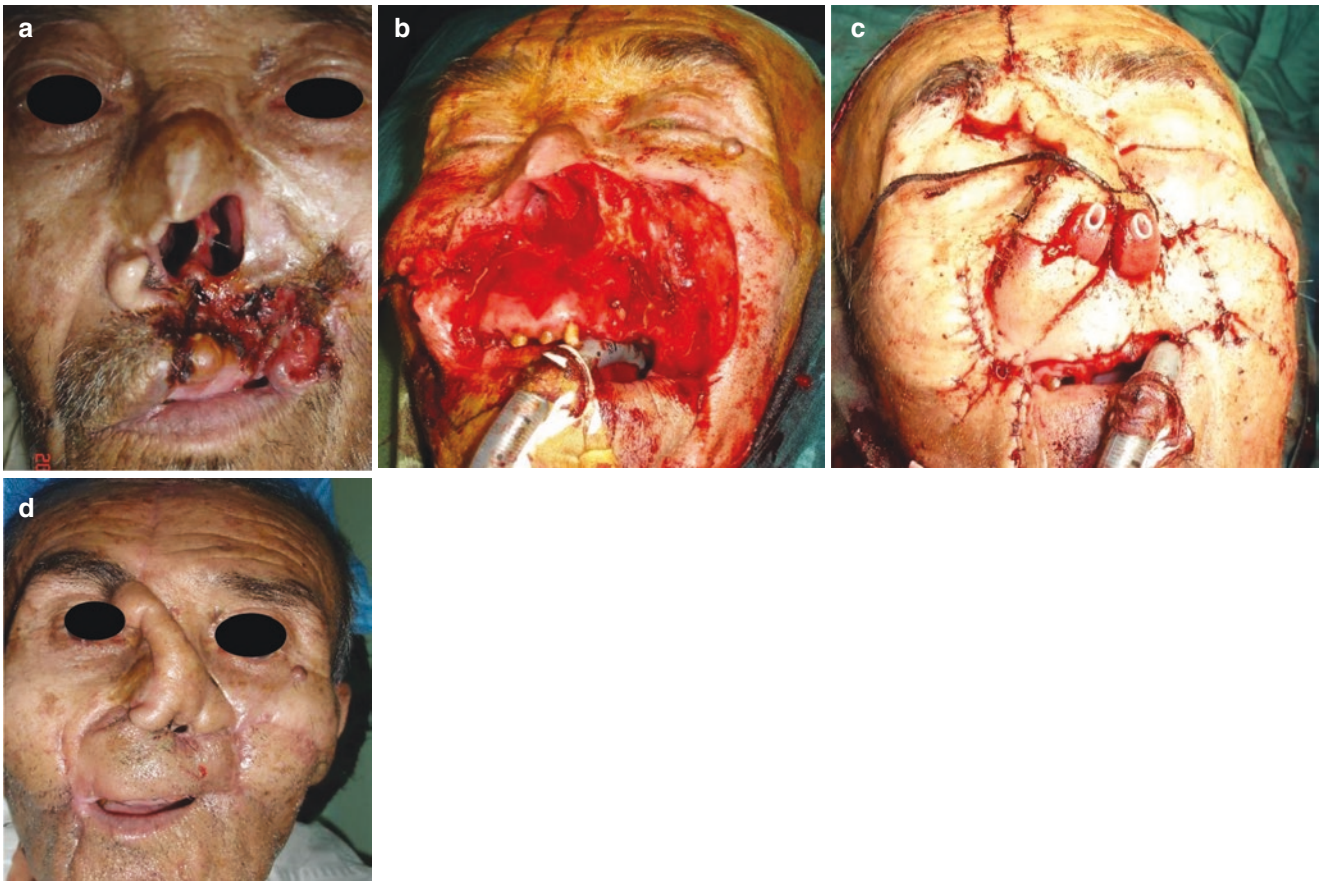

Fig. 45.2 (**a**) A patient with a massive basal cell carcinoma in the nasal and upper lip. (**b**) The nasal and perioral area's defect due to the tumor resection (**c**). A paramedian forehead flap for nose reconstruction and Kazanjian flap for closing the upper lip flap. (**d**) The patient 4 weeks after reconstruction

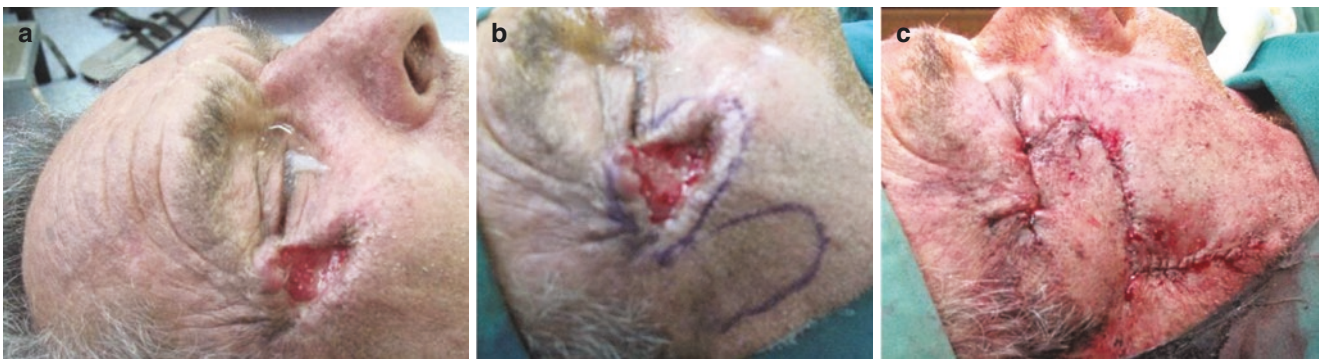

Fig. 45.3 (**a**) Ulcerative lesion (basal cell carcinoma) in the lateral of the left orbit. (**b**) The design of rotational flap for closure of the defect. (**c**) Reconstruction of the defect

The standard methods used in the reconstruction of periorbital defects include the split-thickness skin grafting, lid switch flap, Tenzel rotational flap, Cutler-Beard flap, forehead flap, Tripier flap, transconjunctival advancement (Hughes), and Mustarde's lid switch flap.

Lip Reconstruction

Lips are one of the essential components in a facial structure which maintains oral competence. Furthermore, lips have a role in mastication, communication, facial expression, and

also beauty. Phonation of various sounds needs the advanced function of the lips and surrounding musculature. Defects of the lips are most often acquired, which are secondary to traumatic injuries or oncologic excision. The vermilion superficial defects usually heal by secondary intention. Minimal distortion occurs in this way. However, contraction should be expected in all wound healing.

Lip vermilion is a particular tissue that is different from any other soft tissue in the body. Furthermore, lip vermilion covers the orbicularis muscles, important to maintaining a proper sphincteric function of the lip. If vermillion defects are small, lateral, and superficial, the secondary intention healing may have an acceptable outcome. If such defects locate medially, primary closure is suitable. Anatomic landmarks, mainly the vermilion border and the white roll, should be marked and aligned with sutures. Three-layer closure of the buccal mucosa, orbicularis oris, and skin must be done. Mucosal closure should be performed using a fast absorbable suture, while the muscle layer is approximated with a slowly absorbable suture. Precise re-approximation of the orbicularis oris muscle prevents lips incompetency. The skin defects that include less than 50% of the philtrum can often be closed primarily when the philtrum is wide enough. This technique is mainly useful for the small skin defects of the lower philtrum that permits a wedge excision and local advancement. In partial-thickness defects in this area, preauricular full-thickness skin grafts have good clinical results [13].

Large defects of the vermilion need more advanced procedures such as vermilion switch flaps or vermilion advancement flaps. Vermilion advancement flaps are advocated in repairing midline vermilion defects. These flaps rely on the labial artery.

Larger defects in the central area of lips can also be closed primarily in men that can grow facial hair and conceal otherwise unappealing scars and asymmetry. In defects more significant than 50% of the philtrum that involves both skin and vermilion, an Abbe flap is the best choice [14].

Cheek Reconstruction

The cheek consists of four anatomic subunits: medial, lateral, buccal, and zygomatic. Inferiorly and laterally, the cheek abuts the mandible's inferior border, the preauricular crease, and the temporal hairline. The central subunits form the superior and medial borders: the lower eyelid, nasal sidewall and ala, the lip and oral commissure, and nasolabial fold. The size, shape, and subunit location of the defect are important factors in cheek reconstruction [15]. Small defects, particularly in concave areas, can heal by secondary intention. On convex regions such as the central expanse of the cheek, secondary healing is not suitable. The exception is the preauricular area that large defects can be left to granulate with acceptable aesthetic results. The nasofacial groove is also a desirable location in which to hide scars due to secondary intention. The secondary intention healing should be avoided in juxtaposition to the lower eyelid because scar contracture can lead to ectropion.

As significant elasticity and laxity inherent in the cheek skin with extensive subcutaneous fatty tissue lead in primary closure of relatively large wounds of the cheek. It is preferred that the closure be placed in peripheral subunit borders of the cheek or Relaxed skin tension lines (RSTLs). Medially, repairs should be paralleled to the nasofacial sulcus or nasolabial fold. Laterally, the closure should follow RSTLs. Long, linear closures of the cheek from the superomedial to inferolateral should be located parallel to both the nasolabial fold and RSTLs. Several regional and distant flaps can be used to restore extensive and composite defects in the cheek area, such as nasolabial flap, submental flap, and pectoralis major flap (Figs. 45.4 and 45.5).

Fig. 45.4 (**a**) A buccal defect due to tumor resection and post-op radiotherapy. (**b**) The use of pectoralis major flap for reconstruction of the defect

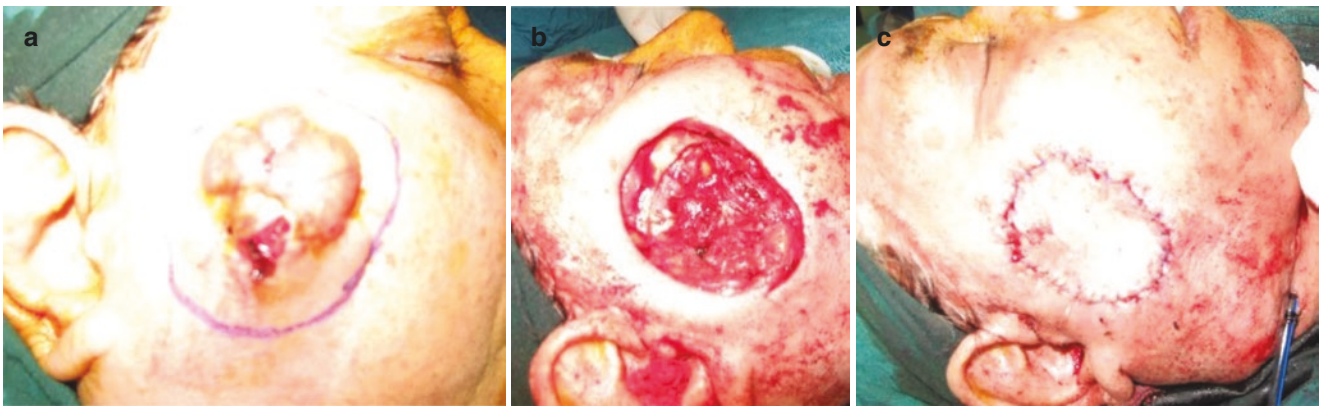

Fig. 45.5 (**a**) A tumoral lesion (basal cell carcinoma) in the malar area. (**b**) The defect of the malar area after tumor resection. (**c**) The reconstruction of the defect using a submental flap

Bone Defects in Maxillofacial Reconstruction

Frontal Defects

Reconstruction of the frontal bone defects aims to restore the normal contour and aesthetics. Various reconstruction options are available for frontal reconstruction. An ideal reconstruction material should be biocompatible, malleable, stable, and cost-effective. Alloplastic materials do not need a donor site and can be individually customized according to defects' size and shape. Furthermore, the use of alloplastic materials can reduce operation time and is associated with acceptable clinical results. Foreign body reaction and infection are the main disadvantages of alloplastic material applications. Autogenous sources such as calvaria grafts and iliac bone grafts can be used to restore the frontal defects. The second surgery in the donor site, unpredictable bone resorption, and difficulty forming grafts are disadvantages of using autogenous grafts [16].

Zygomatic Defects

The defects of zygoma can be due to traumatic injuries or oncologic surgeries. Zygomatic defects can compromise the patient's aesthetic. The use of customized alloplastic prosthesis is advocated for extensive zygomatic defects. The evidence advocates overall acceptable survival rates for the use of zygomatic implants [17]. Autogenous bone is another treatment option for zygomatic reconstruction.

Maxillary Defects

The maxilla is an anatomical structure connecting the skull base to the occlusal plane, anchors the maxillary dentition, resists the forces of mastication, separates the oral and nasal cavities, and is a prominent part of the orbit floor supporting the facial musculature [18]. The midface and maxillary defects may range from an oroantral fistula to a large defect from the skull base to the oral cavity.

The maxillary reconstruction aims include the restoration of the bone defect to provide a recipient site for dental implants, separation of the oral and nasal cavities, support of the orbital contents, and retorsion of facial contours.

Brawn and Shaw have classified the maxillary and midface defect as follows [19] – Vertical type: I. maxillectomy does not lead to an oronasal fistula; II. no orbital involvement; III. the orbital adnexae are involved with orbital retention; IV. maxillectomy with orbital enucleation or exenteration; V. orbitomaxillary defect; VI. nasomaxillary defect; Horizontal classification: (a) Palatal defect only, not involving the dental alveolus; (b) less than or equal to 1/2 unilateral; (c) less than or equal to 1/2 bilateral or transverse anterior; (d) greater than 1/2 maxillectomy.

Several techniques are available to reconstruct maxillary defects according to the patient's health condition, defect size, and location (Fig. 45.6). Historically, maxillary defects were reconstructed with a skin graft to provide a mucosal barrier and followed by an obturator [20]. Nowadays, free flaps are extensively used in the reconstructive field, and free flaps have successfully restored restoration function, quality of life, and improved cosmetics [21]. Limited maxillectomy defects that include a palatal defect without the orbital floor, cranial base, cheek involvement can be applied as an obturator. Obturators have many advantages: the treatment cost is cheaper than complex reconstruction procedures, a simple procedure without any operation, which is preferred in patients with a compromised health condition.

In using an obturator, surgeons should consider the size and location of the defect and may perform adjuvant procedures such as (1) removing the inferior turbinate to permit a sufficient space to accommodate the prosthesis, (2) coronoidectomy to prevent the obturator from getting dislodged in mandibular movement, or (3) skin grafting inside the

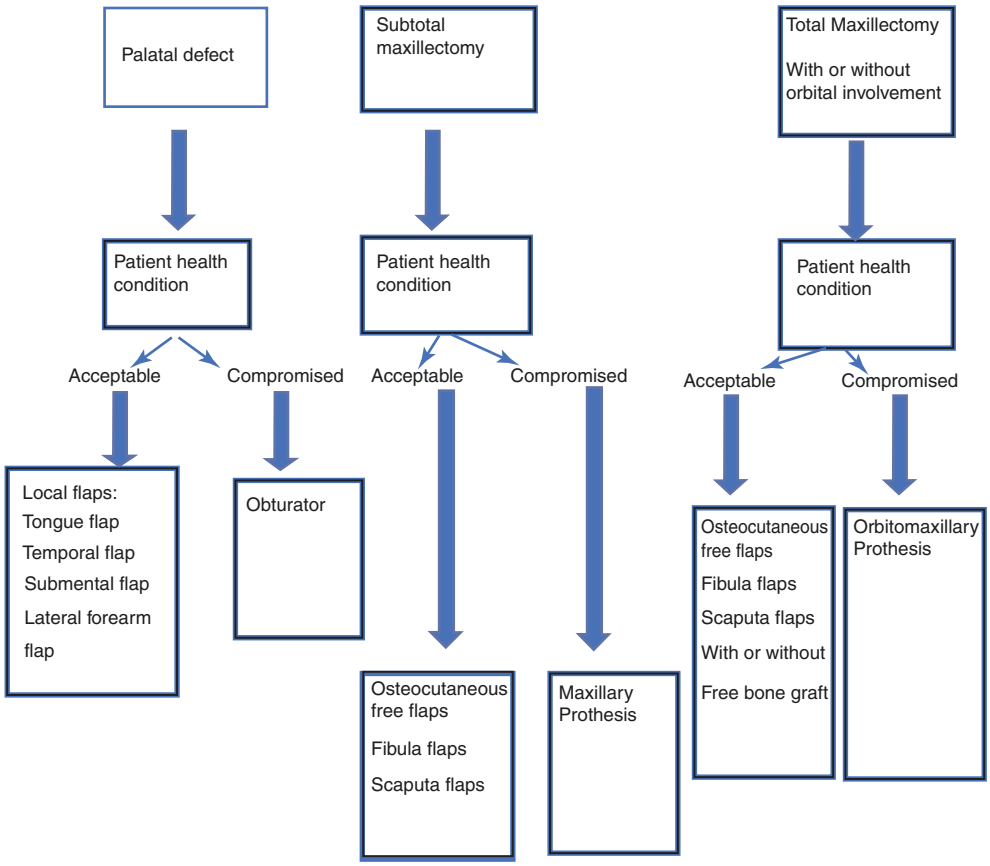

Fig. 45.6 The algorithm of reconstruction in the maxillary defects

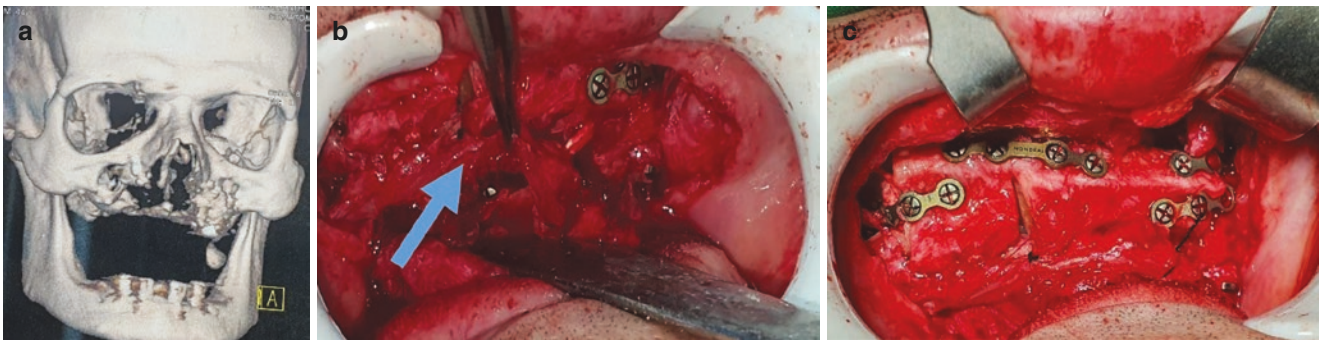

Fig. 45.7 (**a**) A maxillary defect due to a previous tumor surgery. (**b**) A pedicle of vascular fibula graft. (**c**) Reconstruction of the maxillary defect using a vascular fibular graft

defect to provide a scar band to aid in retention. Many free flaps have been used in the reconstruction of hard and soft tissues in the maxillary region. The radial forearm free flap is a workhorse in head and neck reconstructions; it could be relatively easily harvested, has a reliable and long pedicle, can be harvested simultaneously with maxillofacial cancer ablation, and often provides acceptable skin color match for maxillofacial reconstruction. The disadvantages of radial forearm flap include donor site morbidity, the risk of tendon exposure, and requirement of a split-thickness skin graft by the donor site for closure [22]. Osteocutaneous free flaps are used to restore soft tissue components and bone defects simultaneously (Fig. 45.7a–c). The common free osteocutaneous flaps include the fibular free flap, scapular flap, radial forearm, and iliac crest free flap.

Mandibular Defects

Defects of the mandible following ablative surgery or traumatic injuries can be disfiguring and disabling. There are several reconstructive techniques for the reconstruction of

mandibular continuity as well as oro-mandibular function. Soft tissue reconstruction should be considered before hard tissue reconstruction. Perioral soft tissue defects are challenging because of functional and aesthetic concerns (Fig. 45.8a–c). Early attempts for mandibular reconstruction relied on using non-vascularized, autogenous bone grafts (Fig. 45.9a–c). The risk of graft infection and soft tissue dehiscence was high due to salivary contamination and adjuvant radiation, leading to bone loss or bone resorption. It is advocated for mandibular defects whose sizes are more than 5 cm; pedicled osteomyocutaneous flaps should be used [23]. Today, osteocutaneous free tissue transfer is the gold standard for mandibular reconstruction (Fig. 45.10a–c).

A simple classification of mandibular defects includes total mandibular defects, subtotal hemimandibular defects, mandibular defects with continuity and without continuity, and concomitant soft tissue (buccal or lingual) defects.

The mandibular reconstruction goals are to restore the lower third of the face and reestablish the patient's function (mastication, speech).

The tongue defect due to cancer resection affects the patient's prognosis for recovery of oral function. If patients have tongue defects with mandibular defects, the reconstruction approach should start by addressing the tongue. In most cases, restoration of tongue bulk and improvement of mobility are more important in the post-operative functional recovery than simple management of the bony defect. Loss of oral mucosa in the mouth floor is critical in evaluating whether to reconstruct it with non-native tissue. Restoration of tongue bulk and preservation of mobility permit palatoglossal contact, which is essential for improving articulation during speech and manipulating bolus during swallowing. Dentition and occlusion are two crucial factors in treatment planning for mandibular reconstruc-

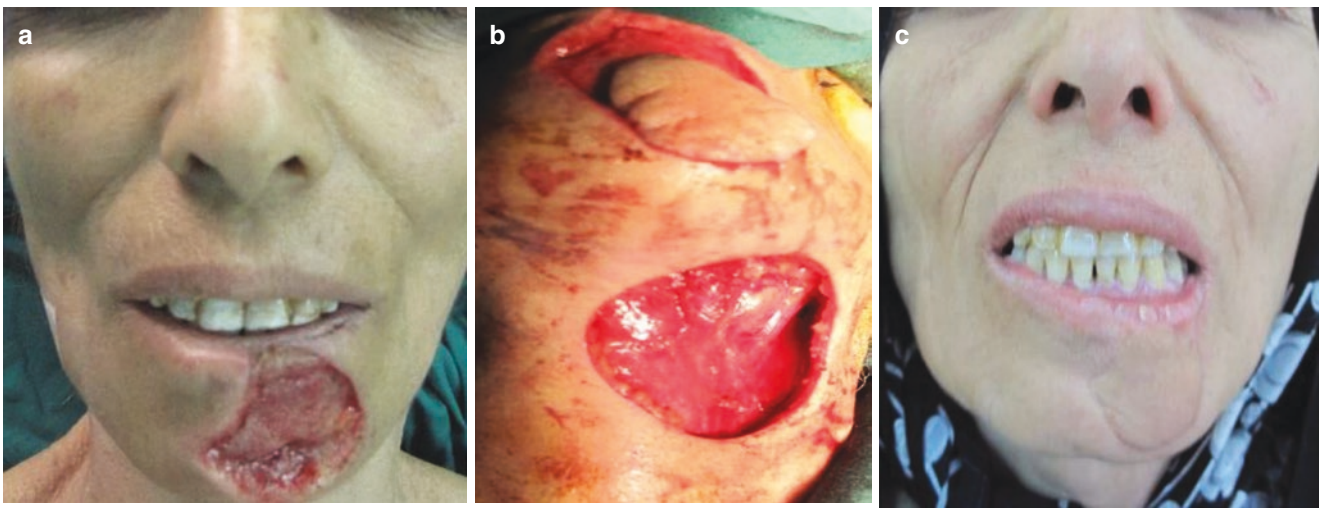

Fig. 45.8 (**a**) The defect of the lower lip and submental area due to human bite. (**b**) The reconstruction of the defect using a submental flap. (**c**) The patient 2 months after reconstruction

Fig. 45.9 (**a**) The soft tissue and hard tissue defects of the mandible and lower lip. (**b**) The defect after debridement. (**c**) The reconstruction of the mandible and lower lip using an osteocutaneous fibula graft

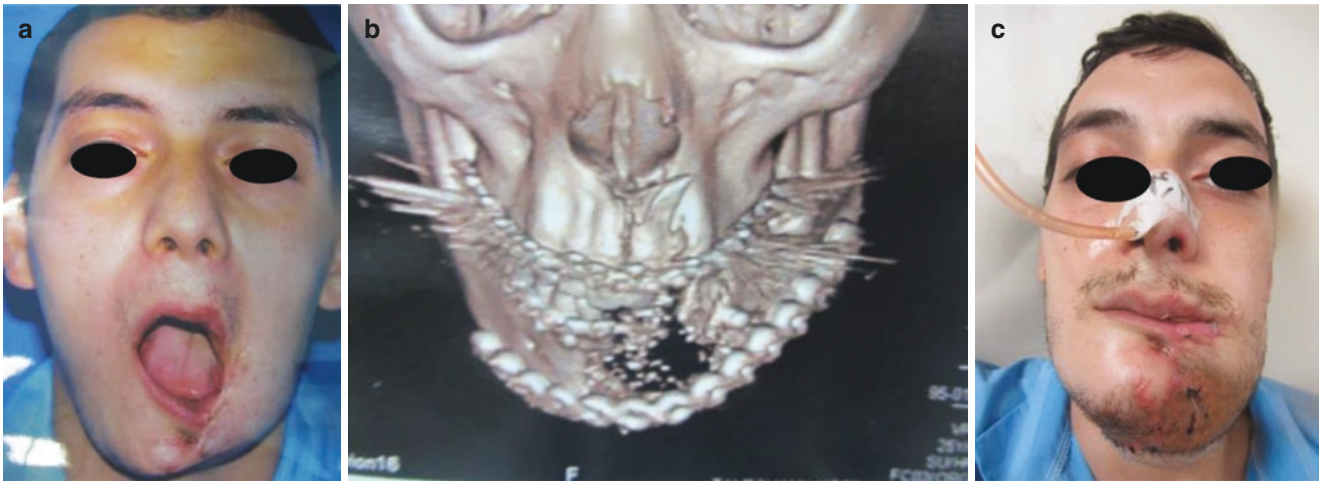

Fig. 45.10 (**a**) A mandibular and soft tissue defect due to a gunshot injury. (**b**) The primary reconstruction with a reconstruction plate before referring to our department. (**c**) The defects were restored with an osteocutaneous fibula graft

tion. The final aim of mandibular reconstruction is the restoration of oral function and dentition.

A free bone graft is advocated for small bone defects (<5 cm) with sufficient soft tissue coverage. It can be used in mandibular defects with or without continuity. Rigid fixation with a reconstruction plate is essential for achieving good clinical results. In mandibular defects with continuity, miniplates can be applied for rigid fixation.

It is essential to preserve mandibular symmetry by using the mirror technique and individually customized plates. Simultaneously, tumor resection and reconstruction, construction of a three-dimensional mandibular model, and mirror technique help receive a desirable result. The placement reconstruction plate before resection can prevent the condylar segment (proximal segment) displacement.

In extensive bone defects (>5 cm) or small bone defects with concomitant soft tissue defects, osteocutaneous free flaps are the gold standard. Free osteocutaneous fibula graft is the right choice for such defects, which restore hard and soft tissues. The vascular pedicle supplying the fibula flap is relatively long, and 20–26 cm of bone may be harvested in adults, sufficient for total mandibular defects. The fibula flap's pedicle can reach vessels in the inferior and the contralateral neck in mandibular reconstruction. The fibular bone quality is ideal for mandibular reconstruction, and dental implants can be placed with reliable results. The major drawback of using the fibula graft in mandibular reconstruction is the restoration of mandibular height. The alveolar height of a normal dentate mandible is more than the diameter of the fibular bone. For restoring the alveolar height, the double-barrel technique is recommended [24] (Fig. 45.11a–e).

The iliac crest flap is another flap for mandibular reconstruction. It has advantages such as sufficient bone volume, good shape, and height, making it an optimal choice for plate fixation and implant placement for dental restoration [25]. The harvested bone is mainly cancellous. The iliac bone can be contoured to restore segmental mandibular defects. The hemimandible defect can be reconstructed from the ipsilateral ilium. The internal oblique muscle can be harvested and intraoral mucosal defect can be repaired by including the deep circumflex iliac artery's ascending branch. The internal oblique muscle is pliable, thin, and can be manipulated independent of the bone and more reliably than the overlying skin flap.

Custom-Made Titanium Prosthesis for Mandibular Reconstruction

The gold standard in the restoration of large mandibular defects is free bone flaps. In a few conditions, free flaps are contraindicated, such as stenosis or a lack of good-quality cervical vessels, lupus anticoagulants, stenosis of the fibula flap pedicle, patient's health condition is not suitable for an extended surgery. The use of custom-made titanium prosthesis through 3D designing helps to restore the mentioned situations. The 3D design restores the anatomy of the mandible, and the operation is simplified with the use of the cutting guides and pre-drilling. There is no donor site morbidity. Long-term tolerance with use of custom-made titanium is not yet well known [26]. Custom-made titanium prosthesis can be used as a titanium mesh in combination with autogenous particle bone grafts. It allows placing dental implants after bone healing (Fig. 45.12a–c). The use of custom-made prostheses is advocated in older patients who cannot tolerate an extended operation for microvascular reconstruction. In the same condition, reconstruction with autografts (free or vascular) is prioritized on the use of alloplastic devices.

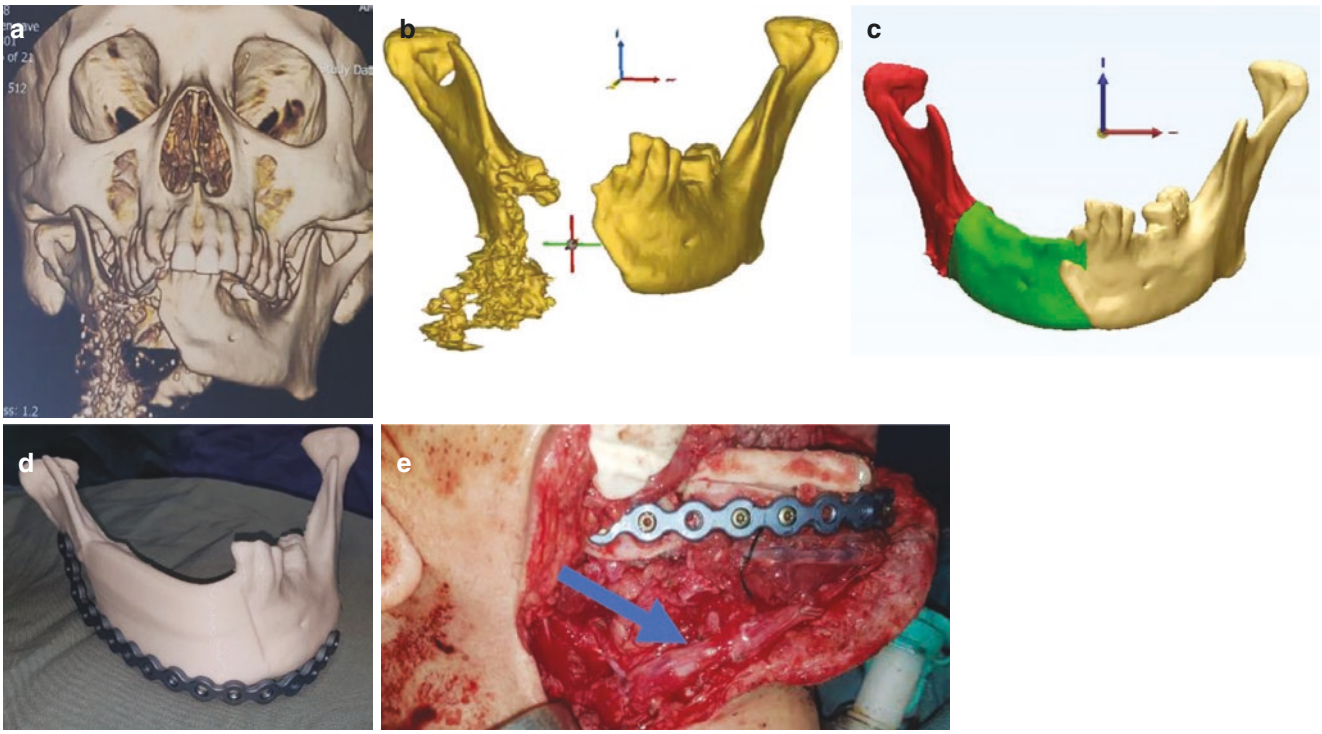

Fig. 45.11 (**a**) A mandibular defect due to a gunshot injury. (**b**) Three-dimensional models of the mandible show a collapse of mandibular segments. (**c**) The displaced segments were aligned in a computer model to demonstrate the actual size of the defect. (**d**) The mandibular model was reconstructed based on the computer model, and a reconstruction plate was bent on the model. (**e**) A double-barrel vascular fibula graft was used to reconstruct the mandible

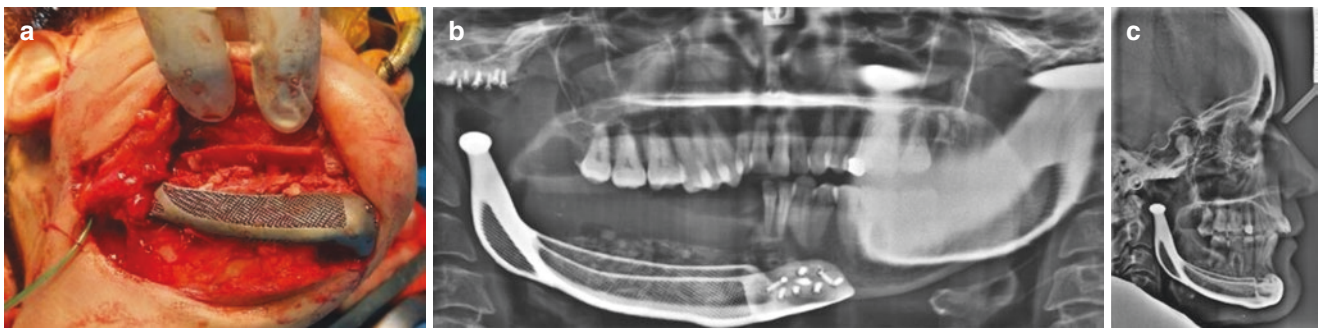

Fig. 45.12 (**a**) A custom-made titanium mesh, combined with autogenous particles from the iliac, was used to reconstruct the hemimandibular defect. (**b**) OPG view after reconstruction. (**c**) The lateral cephalometric view after reconstruction. (Courtesy of Hamed Kermani, DMD)

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