2 Surgical Reconstruction for Cancer of the Oral Cavity

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Introduction

The oral cavity marks the beginning of the upper aerodigestive tract. Anatomically, it is the region defined anteriorly by the lips and ending at the junction of the hard and soft palate superiorly, the anterior tonsillar pillars laterally, and the line of the circumvallate papillae inferiorly. The oral cavity is lined with squamous epithelium and interspersed with minor salivary glands. Squamous cell carcinomas make up the vast majority of oral cavity cancers with salivary gland malignancies and other rare pathologies making up the remainder. Cancers of the oral cavity are generally treated with primary surgery with adjuvant radiotherapy for advanced-stage tumors (Genden et al., 2010; Shah & Gil, 2009). Major ablative surgery for oral cavity cancers results in loss of mucosa, submucosa, and muscle and in some cases bone and external skin. These tissue deficiencies may also translate into the loss of core functions depending on the size and location of the tumor (Genden, 2012; Hutcheson & Lewin, 2013). There may also be significant aesthetic implications with ablative surgery such as the compromise of oral competence, as well as alterations of natural soft tissue and skeletal contours. These types of changes may create increases in distress, social withdrawal, and reduced quality of life overall (Bornbaum & Doyle, Chap. 5; Doyle & MacDonald, Chap. 27).

The ideal reconstruction attempts to restore form and function and is dependent on several factors including the location and size of the defect, types of tissue resected, pre- or postoperative radiation/chemotherapy, and patient-specific factors such as overall health and comorbidities (Genden, 2012; Neligan, Gullane, & Gilbert, 2003; Urken et al., 1991). Particularly in the oral cavity, the location and extent of post-surgical defects at different subsites can creat specific disabilities. Therefore, beyond issues of oncologic treatment, the goal of surgical reconstruction is to identify and anticipate these issues and address them before they manifest in the posttreatment period.

Restoration of ablative defects requires reconstitution of mucosal lining and rebuilding of lost elements. There are myriad reconstructive options available depending on the complexity of the defect and range from primary closure, local flaps, and regional flaps, to microvascular free tissue transfers. This chapter is, therefore, structured to provide a practical approach for addressing the most common defect using contemporary options.

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Relevant Anatomy and Functions of the Oral Cavity

The major subsites of the oral cavity include the lips, floor of mouth, anterior two-thirds of the tongue, buccal mucosa, upper and lower alveolar ridges, retromolar trigone, and hard palate. Somatosensory innervation is derived from contributions from the second and third divisions of the trigeminal nerve, while taste to the anterior tongue is derived from the lingual nerve. Branchial motor innervation is derived from the third division of the trigeminal nerve to the muscles of mastication, and the facial nerve supplies the buccinators and muscles of facial expression. The hypoglossal nerve innervates the intrinsic and extrinsic musculature of both the oral and oropharyngeal tongue. Although a comprehensive description of the complex neurosensory and neuromuscular anatomy is beyond the scope of this chapter, the outlined motor and sensory information provides a summary of the essential functions that may be lost in the process of surgical resection.

The oral cavity is critical for mastication, speech and articulation, respiration, and oral sensation. Different functional aspects are impacted depending on which subsites of the oral cavity are involved by the cancer resection. For example, the extent of lip resection leads to greater degrees of microstomia, thereby increasing the potential for impairments associated with food intake (Harris, Higgins, & Enepekides, 2012; Strong & Haller, 1996). Resecting the hard palate will leave a communication between the oral and nasal cavities, resulting in varied degrees of hypernasal speech and nasal regurgitation (Genden, Wallace, Okay, & Urken, 2004; Morlandt, 2016; Okay, Genden, Buchbinder, & Urken, 2001). Resections of the floor of mouth and ventral tongue, if not reconstructed, can leave the tongue tethered which may result in poor articulation and mastication (Hutcheson & Lewin, 2013). Because each subsite of the oral cavity plays a unique role in the function of the oral cavity, a clear understanding of the ablative functional deficits is the key to choosing the best option for reconstruction. These decisions are guided by a progressive level of surgical complexity that is referred to as the "reconstructive ladder," a topic that will be addressed in the subsequent section.

The Reconstructive Ladder

The armamentarium of reconstruction techniques is often referred to as the reconstructive ladder, a conceptual term that considers options ranging from simple techniques such as primary closure to progressively more complex procedures. The simplest technique that achieves the requisite goals of surgery should be utilized. Although many techniques may achieve defect closure, when larger resections are necessary, more sophisticated reconstructions are often required to achieve optimal function, appearance, and wound healing.

Under selected situations, the wound is allowed to heal without formal closure. This is known as *healing by secondary intention*; it is the simplest of all techniques, but this method should be used mainly for smaller defects because of wound cicatrization. With *primary closure*, the edges of the wound are approximated to one another, and sutures are used to keep the wound closed. The potential pitfall of primary closure is that it can create undue tension and distort the adjacent tissues with resulting functional consequences. *Skin grafts* are infrequently used in oral cavity reconstruction, but such use can mitigate some limitations that can result from primary closure or healing by secondary intention. A full-thickness skin graft incorporates both epithelium and dermis, while a split-thickness skin graft includes epithelium and various degrees of dermis. When used within the oral cavity, a split-thickness skin graft is preferred due to better take; that is, the graft will heal and merge with adjacent tissue. One example where a split-thickness skin graph is commonly used is in association with maxillectomy when the raw surface is skin grafted to better conform to obturator placement.

Pedicled flaps represent tissue transferred from its native bed (i.e., original site) to an adjacent area while retaining its native vascular supply. Flaps can incorporate varying components of tissue from skin, fascia, and/or muscle. In contemporary head and neck reconstruction, free tissue transfers or what is commonly referred to as *free flaps* have become the workhorse for most major surgical defects and have supplanted most pedicled flaps. The principle of free tissue transfer is to harvest tissue with its vascular pedicle, the tissue's primary blood supply, detach the blood supply, and then transplant the tissue from its native location to the new site of the ablative defect. The continuity of the blood vessels is restored by microvascular anastomosis to blood vessels near to the defect site. The enormous freedom to position the flap unencumbered by the pedicle connection, coupled with the near limitless capacity to harvest varying tissue types of different sizes to match the defect, has made free flaps the preferred reconstruction technique for major defects. Details of reconstructive techniques pertaining to each area of the head and neck will be addressed in the following sections.

Lip

The lips are often overlooked as an oral cavity subsite. However, they are crucial for proper oral function and maintenance of facial aesthetics. Achieving oral competency so as to maintain control of secretions, while maintaining adequate mouth opening, is the primary functional objective when reconstruction is required. The orbicularis oris muscle circumscribes the oral palpebrae and constitutes the major lip muscle. This muscle provides the sphincter function to maintain oral competence. Loss of orbicularis continuity results in oral incompetence. On the other hand, microstomia (reduction in size of the oral aperture) can occur as a consequence of lip resections and might inhibit oral intake; it can, in some instances, make denture placement difficult.

Numerous options exist for lip reconstruction, but the location and extent of the defect typically dictate the type of reconstruction utilized. In general, lip defects can be classified by their location and their relative width. In lip defects that encompass less than one-third of the lip, primary closure can be achieved without undue microstomia (Harris et al., 2012; Strong & Haller, 1996). Oral competence is maintained, and aesthetics are acceptable. However, as the defect size surpasses one-third of the lip length, the risk of microstomia and its functional implication increases.

Defects that are greater than one-third, but less than two-thirds the width of the lip, can be repaired by borrowing the opposite lip with a lip-switch procedure, referred to at the Abbe or the Estlander techniques (Harris et al., 2012). This involves using a portion of the upper or lower lip (half the defect size) to reconstruct the defect of the opposing lip. The flap is left pedicled on its native labial artery. The flap is elevated and sutured into the defect, while the donor site is closed primarily. The flap is divided in a delayed fashion. This reconstruction maintains excellent oral competence and aesthetics (Fig. 2.1). If the lip commissure is uninvolved, the Abbe flap can be used, whereas if the commissure is involved, the Estlander flap is used. Another option for defects greater than one-third but less than two-thirds the width of the lip is the Karapandzic flap (Harris et al., 2012). Using this flap, bilateral curved circumoral incisions are made at a distance equal to the vertical height of the remaining lip. The benefit of this type of reconstruction is that it mobilizes sensate lip with musculature innervation and with color match that is ideal. However, despite the aforementioned strengths, significant microstomia is an expected sequela of this procedure (Fig. 2.2).

In cases where greater than two-thirds of the lip is resected, reconstruction is achieved with more complex flaps or free tissue transfer. Inevitably, some degree of microstomia and reduced sensation, while achieving acceptable aesthetic outcome, is challenging. Classically, a radial forearm free flap with palmaris tendon flap can be employed for total lip reconstruction. The tendon helps to give support to the lip, while the fasciocutaneous tissue from the forearm recreates the skin of the lip and surrounding skin (Harris et al., 2012; Serletti, Tavin, Moran, & Coniglio, 1997). The disadvantage to this method of reconstruction is the loss of sensation (nerves are not microsurgically addressed), and it will have a

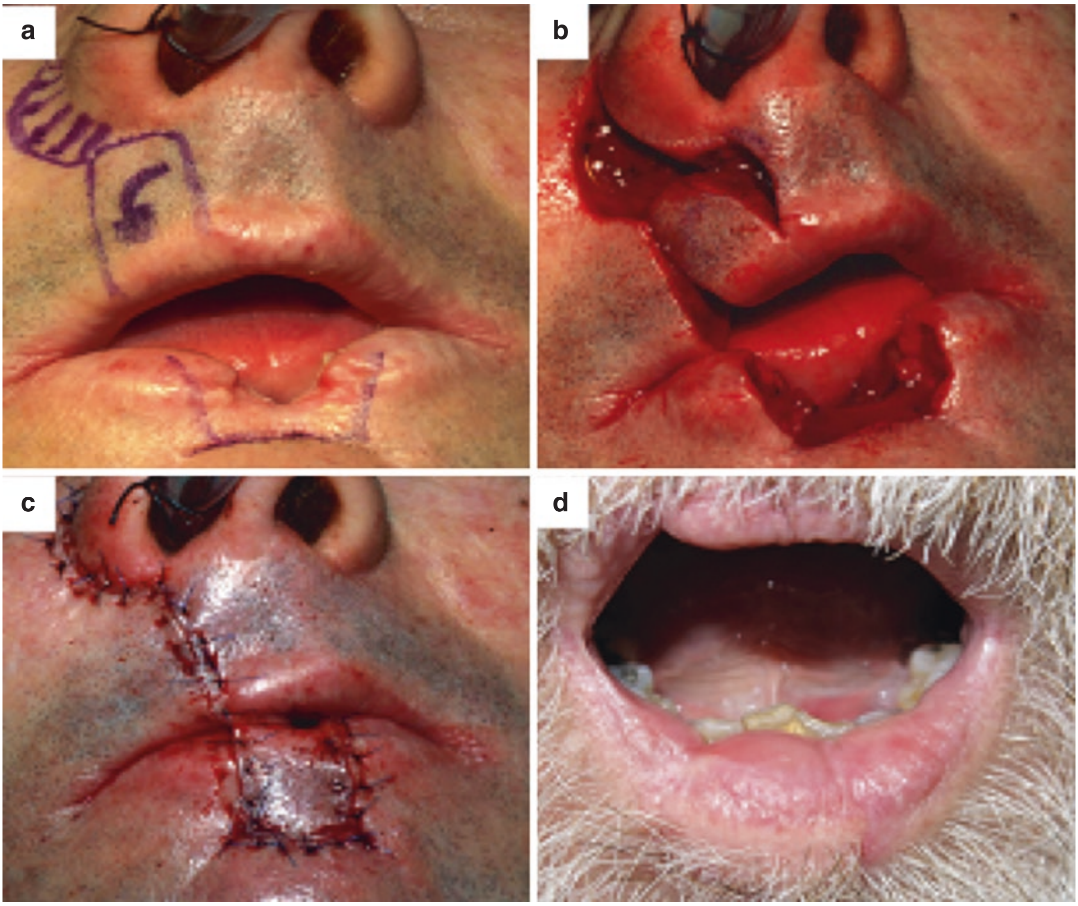

Fig. 2.1 Abbe flap for lip defect: (**a**) 1/3 lower lip defect with intraoperative markings. (**b**) Flap raised based in the labial artery. (**c**) Result of the first stage of the procedure with the pedicle undivided. (**d**) Remote postoperative picture with the pedicle already divided, showing a continent lip without microstomia

significant color mismatch. Despite these limitations, microstomia is not typically observed as a problem with these reconstructions.

Oral Tongue

The standard management of oral tongue cancer is surgical resection with clear tumor margins. After resection of the tumor, the need for surgical reconstruction depends on the location of the resection and size of the resulting defect. The goals of tongue reconstruction are to maximize tongue mobility, to limit tongue tethering, and to restore tongue volume (Chepeha et al., 2016; Hutcheson & Lewin, 2013; Pauloski, 2008). These objectives ensure that articulation, the ability to move food boluses, and the capacity to clear secretions are optimized. The ideal tongue reconstruction requires premaxillary and palate contact in order to ensure satisfactory speech production. Mobility of the tongue tip past the alveolar ridge helps to further ensure efficient tongue movement and to facilitate clearing of oral secretions (Riemann et al., 2016; Vos & Burkey, 2004).

Resections of less than 1/3 of the tongue may be closed primarily or left to heal by secondary intention. In fact, studies have shown that the functional outcomes of speech and swallowing are superior with primary closure of small tongue defects when compared with pedicled or free flap reconstruction (Vos & Burkey, 2004). For small

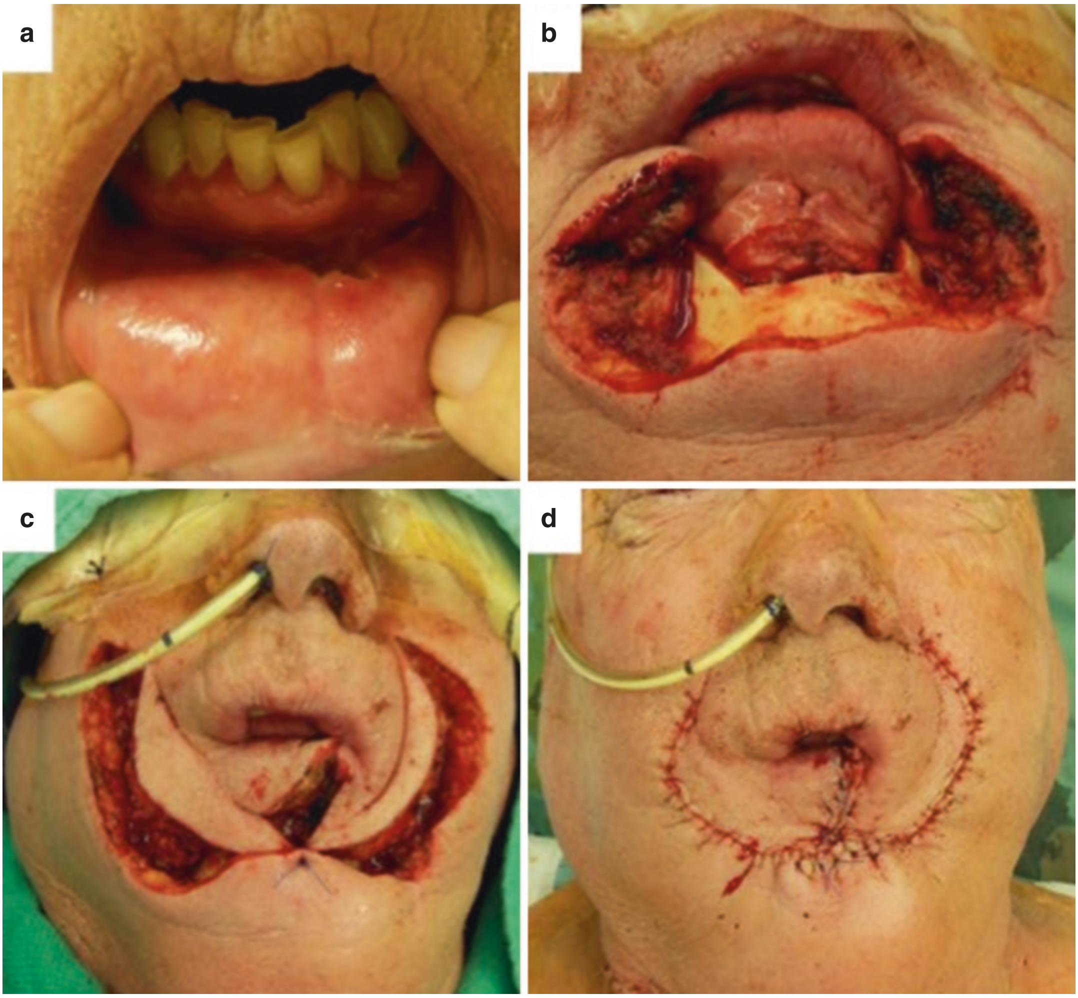

Fig. 2.2 Karapandzic flap for lip defect: (**a**) Carcinoma of the inferior alveolar ridge. (**b**) Postoperative defect consisting in a marginal mandibulectomy and a lip resection encompassing more than one-third but less than two-thirds of the lower lip. (**c**) Karapandzic flap with bilateral circumoral incisions to advance the remaining lower lip. (**d**) Oral continence is reestablished, with normal color match but with significant microstomia

superficial defects of the ventral tongue and floor of mouth, a split-thickness skin graft can be used to decrease tongue tethering (Vos & Burkey, 2004), and this is represented in Fig. 2.3. However, it must be emphasized that even small defects can lead to functional limitations, and, therefore, careful patient/reconstruction selection is required to optimize outcomes.

With larger resections of the tongue, bringing in additional tissue is necessary to achieve the reconstructive goals. If greater than one-third of the tongue is resected, options include pedicled flaps such as the buccinator-based myomucosal flap (Hayden & Nagel, 2013; Rigby & Taylor, 2013; Szeto et al., 2011), the submental island artery flap (Hayden & Nagel, 2013; Howard, Nagel, Donald, Hinni, & Hayden, 2014; Patel, Bayles, & Hayden, 2007; Rigby & Taylor, 2013), or the nasolabial flap represented in Fig. 2.4 (Napolitano & Mast, 2001; Rahpeyma & Khajehahmadi, 2016). In contemporary head and neck surgery, free tissue transfers have become the mainstay of reconstruction for most moderate sized and large tongue defects.

Free flaps are highly reliable and safe in experienced hands and are often the option of

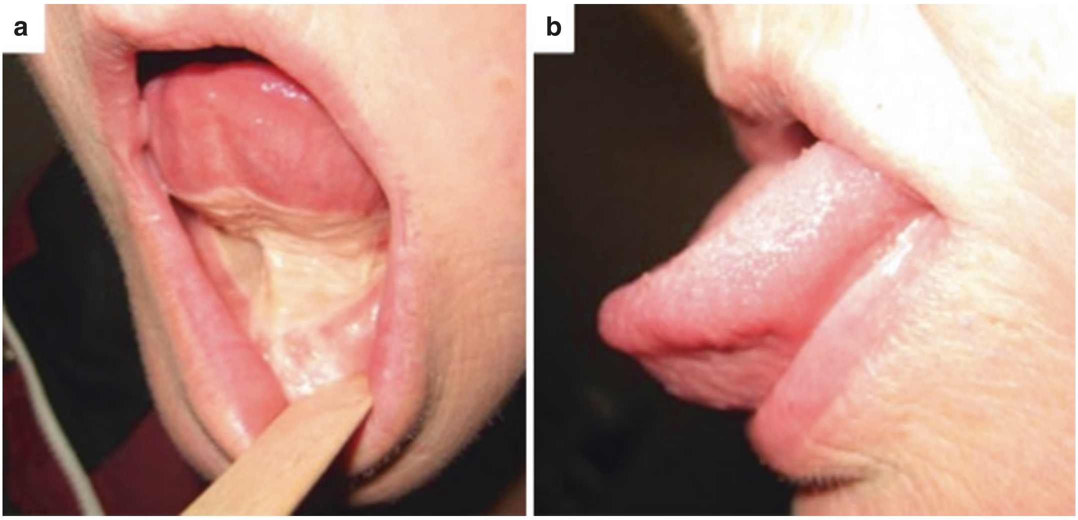

Fig. 2.3 Skin graft for ventral tongue/floor of mouth defect: (**a**, **b**) Remote postoperative picture after a ventral tongue and floor of mouth reconstruction with a skin graft, which obtained adequate tongue mobility and protrusion

choice for all but the simplest of oral cavity defects. Free flaps enable replacement of pliable tissue of ideal volume and surface area. The most common free flap used for tongue defects is the radial forearm free flap due its pliability, flexibility, and ease of elevation from the donor site as shown in Fig. 2.5 (Baas, Duraku, Corten, & Mureau, 2015; Kuriakose, Loree, Spies, Meyers, & Hicks, 2001; Rigby & Taylor, 2013). An additional perceived advantage of the radial forearm flap is its potential to be innervated in order to regain some sensation. Although appealing in concept, the benefits of direct reinnervation between the cutaneous nerve of the forearm and the lingual nerve have been difficult to demonstrate (Kuriakose et al., 2001; Namin & Varvares, 2016). When even greater volumes of tongue are lost such as with subtotal defects, the anterolateral thigh free flap has gained increasing popularity as the preferred reconstructive choice (Chana & Wei, 2004; Park & Miles, 2011; Rigby & Taylor, 2013; Vos & Burkey, 2004. Numerous other free flap options are available and have been used for various defects depending on size of defect and patient body habitus.

Floor of Mouth

The floor of mouth is critical for tongue protrusion, and undue scarring can limit mobility. After surgical resection of very small floor of mouth cancers, healing by secondary intention or through skin grafting may be acceptable options. However, in resections that include deeper musculature or involve significant portions of the ventral tongue, tethering and impaired mobility will occur without reconstruction. For that reason, pedicled flaps or free flaps (Fig. 2.6) are the standards of care with the greatest potential for successful outcomes (Rigby & Taylor, 2013; Vos & Burkey, 2004).

Buccal Mucosa

If resections that involve the buccal mucosa of the oral cavity are not reconstructed, scar contracture can lead to severe trismus, a reduction in jaw opening. Smaller buccal defects can be managed with primary closure, split-thickness skin graft, or pedicled soft tissue flaps such as the submental island artery flap (Genden, Buchbinder, & Urken,

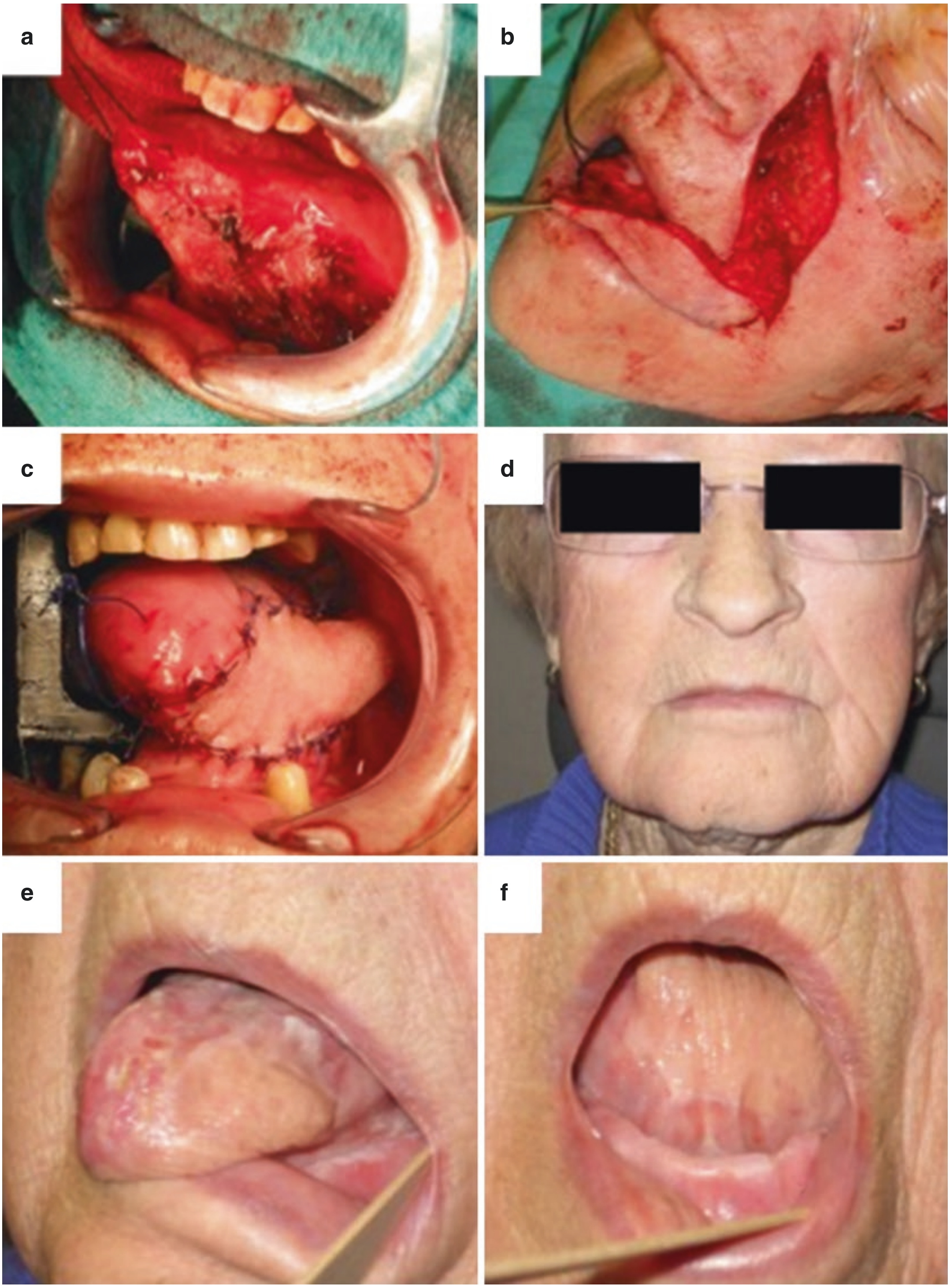

Fig. 2.4 Nasolabial flap for oral tongue defect: (**a**) Left lateral and ventral tongue defect. (**b**) Nasolabial pedicled flap raised showing good reach to the defect. (**c**) Inset of the flap, which is still attached to the pedicle from the skin. (**d**–**f**) Remote postoperative pictures depicting the scar placed in the nasolabial fold and excellent tongue mobility after the pedicle was divided in a second stage

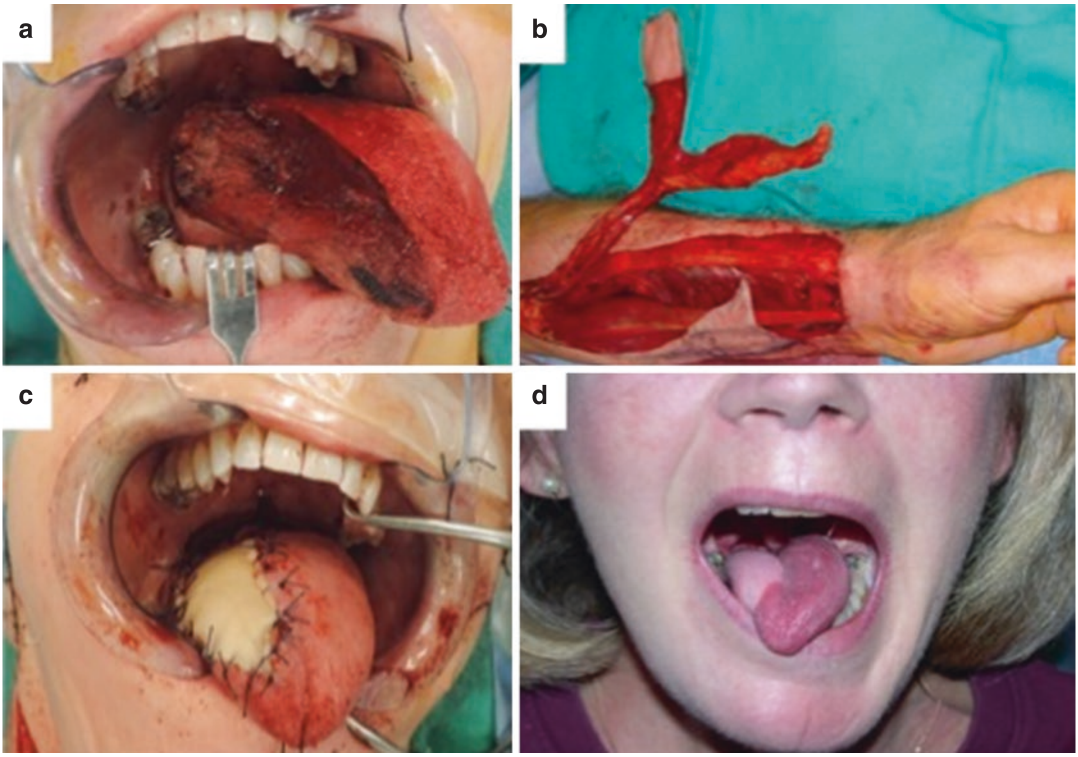

Fig. 2.5 Radial forearm free flap for oral tongue defect: (**a**) Left hemiglossectomy defect after carcinoma of the oral tongue resection. (**b**) Left radial forearm cutaneous free flap raised in situ with a fibroadipose component to add bulk to the reconstruction. (**c**) Immediate inset of the flap. (**d**) Remote picture showing good volume restoration and tongue protrusion

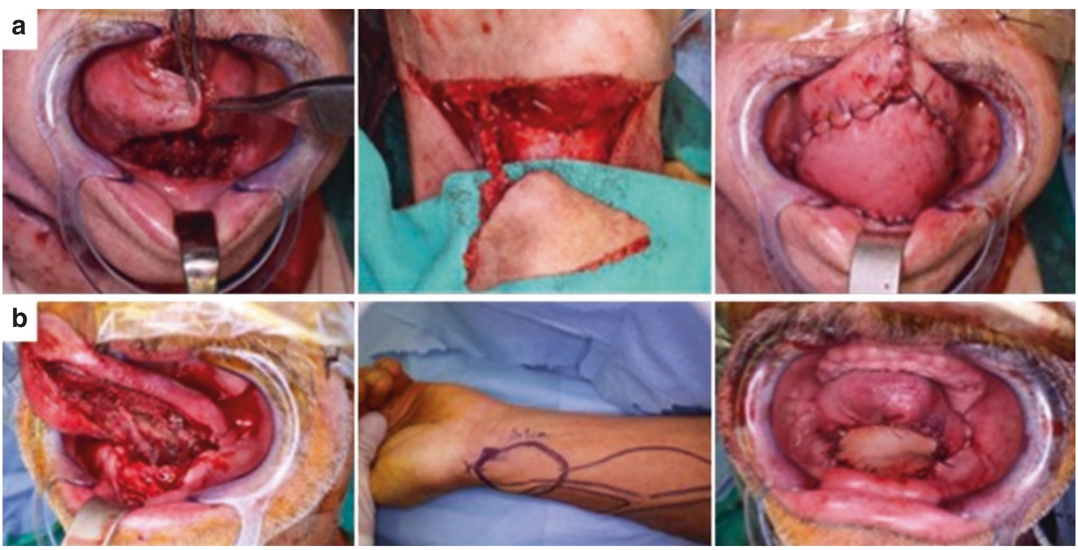

Fig. 2.6 Submental island flap and radial forearm free flap for floor of mouth defects: (**a**) Floor of mouth and ventral tongue defect reconstructed with a submental island flap. (**b**) Similar defect reconstructed with a radial forearm free flap. In both cases the paramount goal is to prevent tongue retraction and tethering, ensuring good mobility

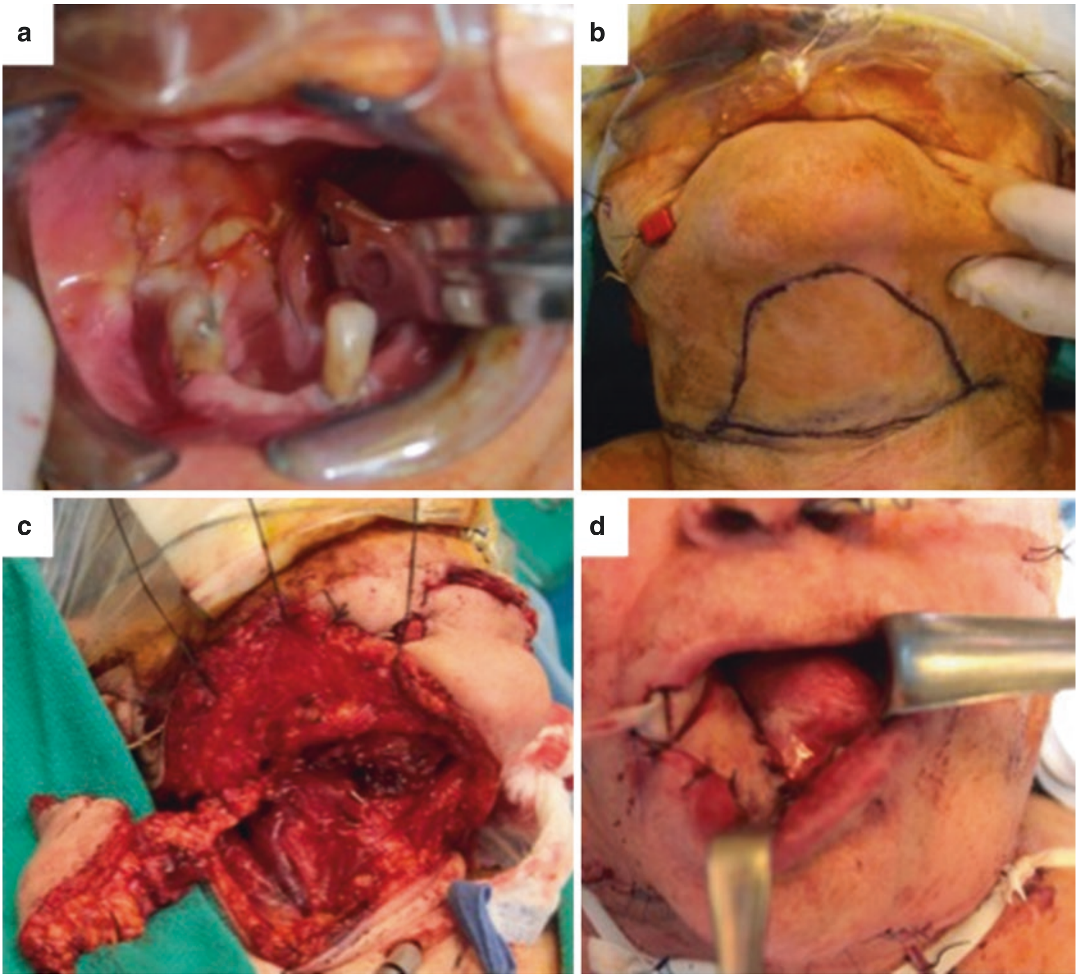

Fig. 2.7 Submental island flap for buccal mucosa defect: (**a**) Carcinoma of the right buccal mucosa which will require a reconstruction to prevent postoperative trismus. (**b**) Intraoperative design of a submental island pedicled flap and (**c**) flap elevation attached to the pedicle. (**d**) Immediate postoperative picture demonstrating good mouth opening

2004; Hayden, Nagel, & Donald, 2014) or the nasolabial flap (Napolitano & Mast, 2001; Rahpeyma & Khajehahmadi, 2016). If a split-thickness skin graft is used for reconstruction, it will require a bolster for several days to secure the graft in position. Otherwise, if the graft becomes displaced, contracture and trismus will result. With larger defects, even with the placement of a split-thickness skin graft, progressive contracture and scar formation can still result with an impact on functioning.

Therefore, for larger defects of the buccal mucosa, pedicled soft tissue flaps such as the submental island artery flap depicted in Fig. 2.7 (Hayden et al., 2014; Hayden & Nagel, 2013; Rigby & Taylor, 2013) or the nasolabial flap (Napolitano & Mast, 2001; Rahpeyma & Khajehahmadi, 2016) can be used to reline the defect. Compared with a split-thickness skin graft, local pedicled flaps are less likely to result in contracture and trismus. Soft tissue free flaps, in particular, the radial forearm free flap (Fig. 2.8), have excellent pliability and is well suited for large buccal reconstruction in order to reduce trismus (Rigby & Taylor, 2013; Vos & Burkey, 2004).

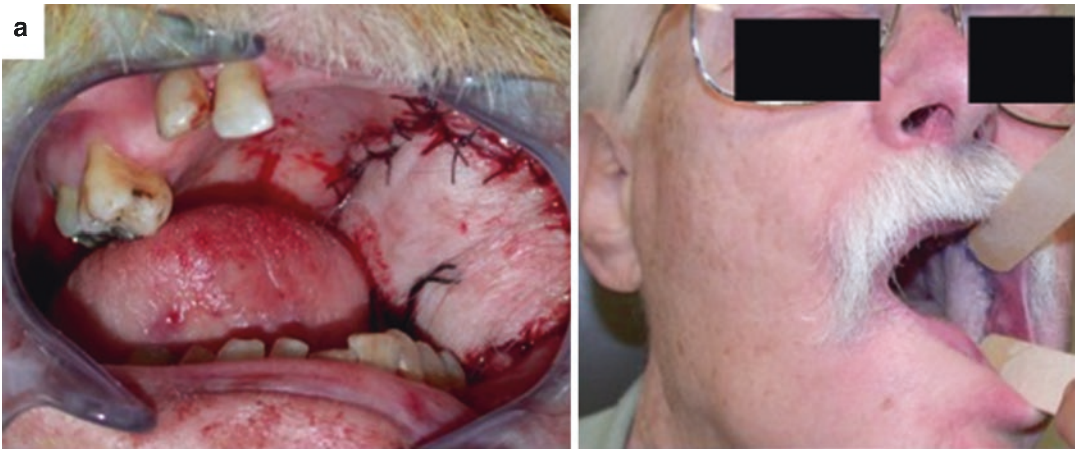

Fig. 2.8 Radial forearm flap for buccal mucosa defect: (**a**) Right buccal mucosa reconstructed with a radial forearm free flap, preventing trismus and scar retraction postoperatively (**b**) Post operative picture showing adequate mouth opening

Upper Alveolar Ridge/Maxilla and Hard Palate

The primary goals of reconstruction of the maxilla and the hard palate include supporting the orbital contents and maintaining separation of the oral and nasal cavities. Other important goals include reconstructing the palatal surface, reconstituting the patency of the lacrimal system, maintaining midface projection, and supporting dental rehabilitation. The extent and location of the defect will dictate the choice of reconstruction method. Reconstruction of the midface is among the most complex in head and neck surgery, and so with respect to this chapter, we will focus only on the hard palate.

The traditional approach for defects of the hard palate has been to employ prosthetic obturators for palatomaxillary defects and still remains an excellent option for many patients (Okay et al., 2001). However, numerous shortcomings were noted with this form of reconstruction especially with larger defects. For example, some limitations include poor retention and instability of the prosthesis, as well as loss of the oronasal prosthetic-tissue seal (see Cardoso & Chambers, Chap. 21). This leads to oronasal fistulae with resultant hypernasal speech and nasal regurgitation.

For non-tooth-bearing hard palate defects that constitute less than one-third of the hard palate, a prosthetic obturator or a local flap can be used for reconstruction. An obturator can be inconvenient for patients as it has to be removed and replaced regularly. The prosthesis-tissue seal can sometimes be a challenge to maintain and may not be acceptable for some patients (Okay et al., 2001). When there is remaining dentition, the prosthesis may be supported by clasps secured to the remaining teeth (Fig. 2.9). The alternative to prosthetic obturators includes pedicled or free flaps. In subtotal defects larger than one-third of the hard palate, either a prosthetic obturator or free tissue transfer with or without bone can be used (Genden et al., 2004). Local pedicled flaps are not large enough to reconstruct these defects. When the alveolar arch remains intact, bony reconstruction is not necessary. It should be noted that soft tissue reconstruction of the hard palate in edentulous patients may result in an inability to retain dentures making dental rehabilitation extremely difficult. In such cases, obturation may be the preferred rehabilitative option. Despite the challenges of these types of defects, functional outcomes are excellent if the oral cavity remains separated from the nasal cavity.

Maxillary defects that include the tooth-bearing alveolus can be reconstructed using a prosthetic obturator, a bone-containing free flap, or a soft tissue flap. With more extensive resections that involve more dentition, the

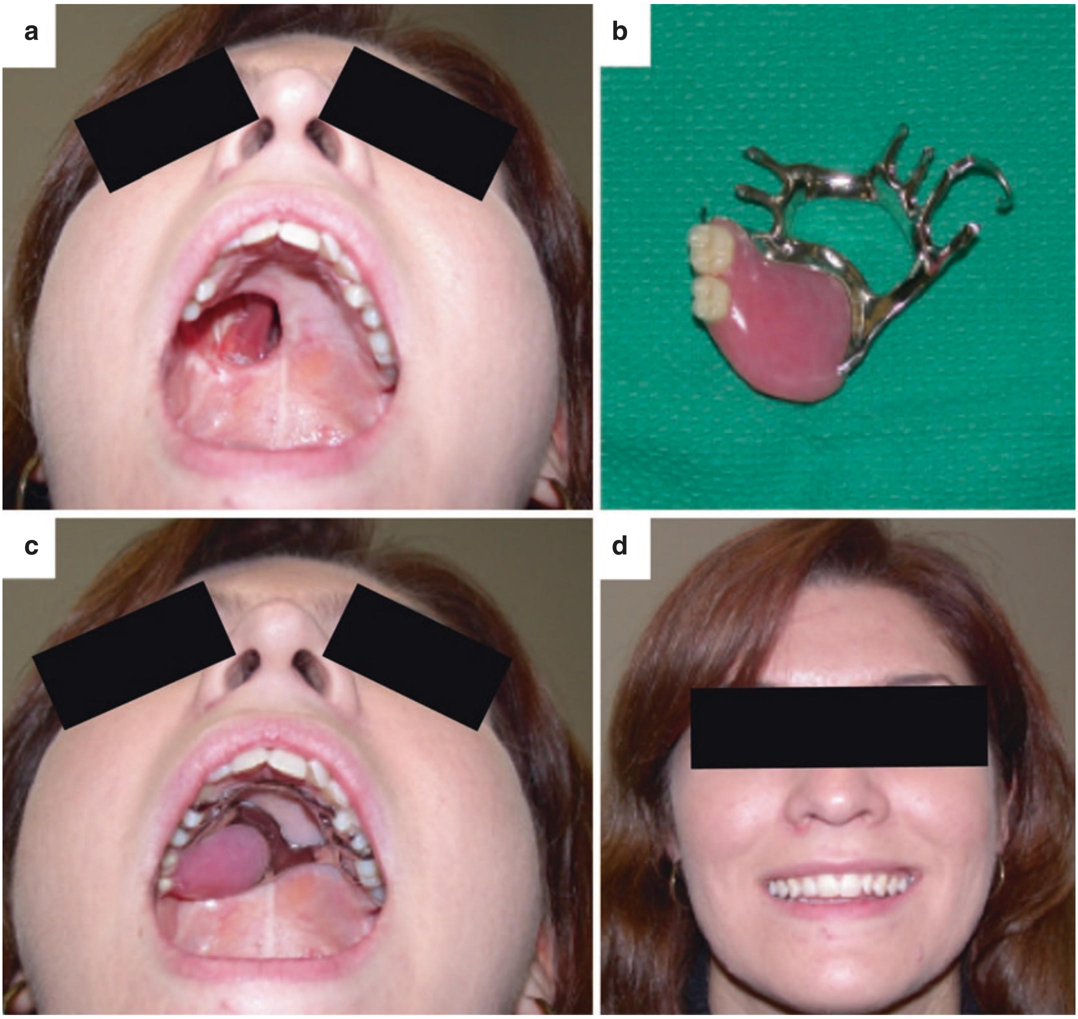

Fig. 2.9 Obturator for maxillary defect: (**a**) Hard palate defect showing communication an oroantral fistula in a non-edentulous patient. (**b**) Custom-made obturator with metal claps that will remain secured to the teeth. (**c**) Separation of the oral and nasal cavity preventing regurgitations and nasal voice with (**d**) cosmetic outcome

prosthetic obturator is less likely to stay in position, and, therefore, a free flap reconstruction may be necessary for successful oronasal separation (Morlandt, 2016). Soft tissue may only provide separation of the oral cavity from the paranasal sinuses and nasal cavity, but it may not provide optimal support for the facial soft tissue. Furthermore, dental rehabilitation is not possible.

Bone flaps may provide excellent facial musculoskeletal support and the potential for future dental rehabilitation through osteointegrated implantation. However, bone flap reconstructions of the midface are technically more challenging than soft tissue flaps and thus require considerable surgical expertise. Several options for bony reconstructions of the midface including the fibula (Fig. 2.10), scapula, and the iliac crest osteocutaneous free flap have all be well described with excellent results (Brown, Lowe, Kanatas, & Schache, 2017; Clark, Vesely, & Gilbert, 2008; Yoo, Dowthwaite, Fung, Franklin, & Nichols, 2013). Palatomaxillary reconstruction is a challenging aspect of head and neck reconstruction, and a thorough appreciation of biomechanics of the upper jaw and recognition of the critical

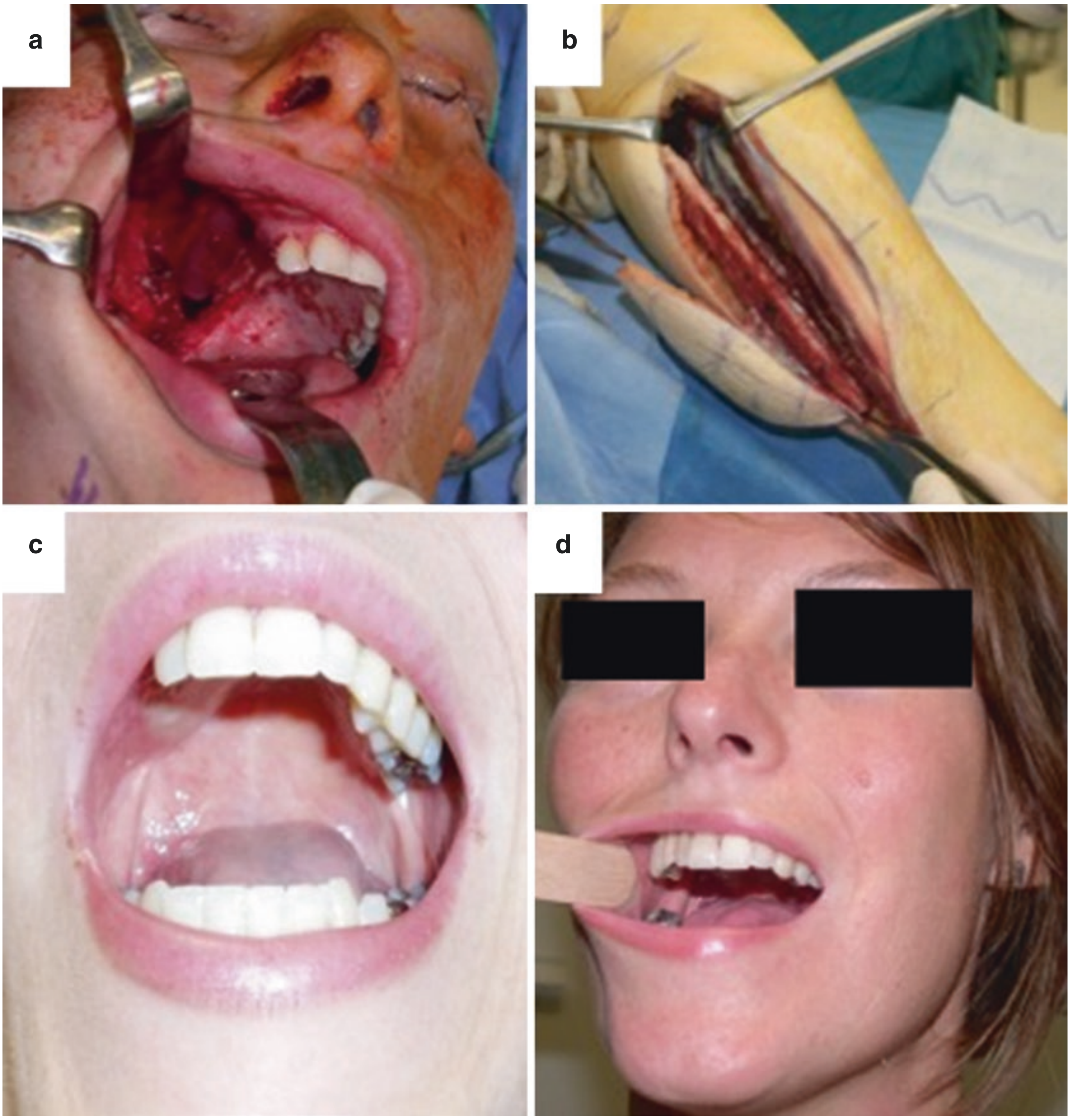

Fig. 2.10 Fibula free flap for maxillary defect: (**a**) Right maxillary defect affecting a tooth-bearing area of the hard palate. (**b**) Fibular free flap elevated with a skin paddle to act as an internal lining. (**c**) Six-month postoperative picture showing good skin mucosalization. (**d**) Five-year postoperative picture with full dental rehabilitation using implants

importance of cosmesis is paramount to achieve a satisfactory reconstruction.

Oromandibular

Tumors of the lower alveolar ridge and retromolar trigone commonly involve the bony mandible. There are two types of mandibular resections that can be performed for tumors in these regions. Marginal mandibulectomy or rim mandibulectomy removes the overlying soft tissue and the adjacent cortex of the mandible but leaves behind at least 1 cm of mandibular height, thereby maintaining the continuity of the mandible. This can be performed in cases where the tumor involves only the periosteum or superficial cortex of the bone. If a marginal mandibulectomy is performed, the reconstruction requires only soft tissue. Infrequently, the soft tissue can be closed

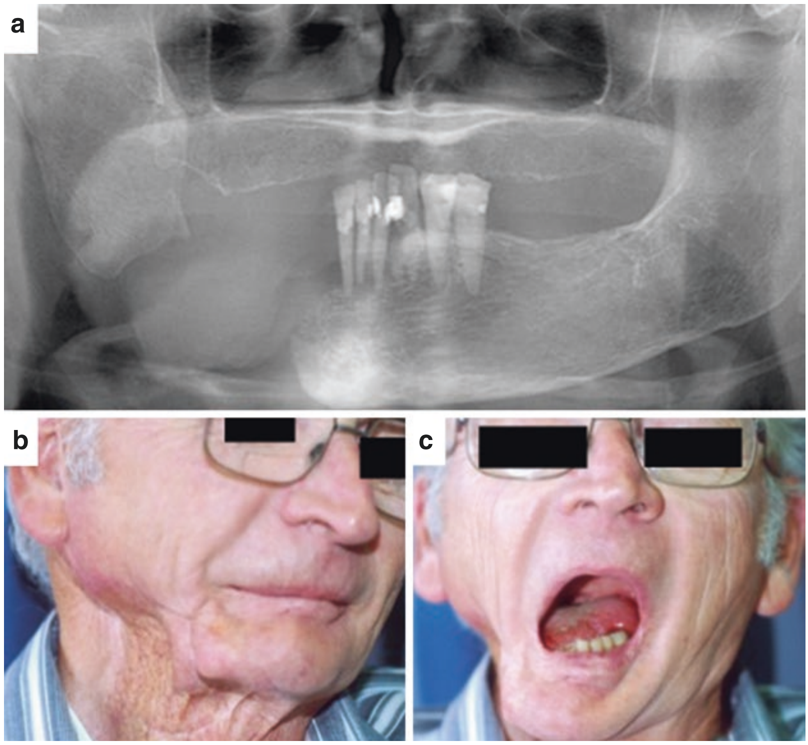

Fig. 2.11 Lateral mandibular resection without reconstruction: (**a**) Dental panoramic radiography revealing the absence of the left parasymphyseal, angle, and ascending ramus of the mandible left mid-body. (**b**) Photo of the same patient depicting facial asymmetry and (**c**) the latero-deviation of the jaw (also known as "swinging mandible") after no reconstruction

primarily, but in most cases soft tissue flaps are required. Once again, the radial forearm free flap is highly versatile and enables reliable coverage of the exposed bone while restoring mucosal lining. Pedicled flaps may also be used for selected defects. If the bony cortex of the mandible is breached, then a segmental mandibulectomy is required. This results in discontinuity of the mandible which must be restored in most cases.

For segmental oromandibular defects, several reconstructive options are available depending on the location of the mandible defect and patient-specific factors. Segmental defects posterolateral to the mental foramen are considered lateral defects. The most common form of reconstruction is to reconstitute the mandibular bony arch with a vascularized free flap of bone and skin. However, in selected cases the bone segment may be bridged with a metal plate with soft tissue coverage. Historically, lateral defects of the mandible were managed by restoring soft tissue loss but without restoring bony continuity. This resulted in a "swinging mandible" because there were two free floating discontinuous segments of mandible. The functional and aesthetic implications of this approach were significant. This approach is an uncommon occurrence in contemporary head and neck surgery except in rare circumstances (Fig. 2.11).

Reconstitution of the mandibular arch using a titanium alloy plate coupled with soft tissue coverage is a common approach for the lateral oromandibular defect (Miles, Goldstein, Gilbert, & Gullane, 2010). The addition of a load-bearing reconstruction plate helps to stabilize the two free bone segments and can help to avoid malocclusion, crossbite, pain, and deformity (Wei et al., 2003). Soft tissue coverage can be achieved by regional pedicled flaps such as the pectoralis major myocutaneous flap or, more commonly, free flaps such as the radial forearm or anterolateral thigh.

The ideal reconstruction of soft tissue/bony defects is through composite tissue transfers. The advent of free tissue transfers has allowed numerous options for restoring soft tissue and

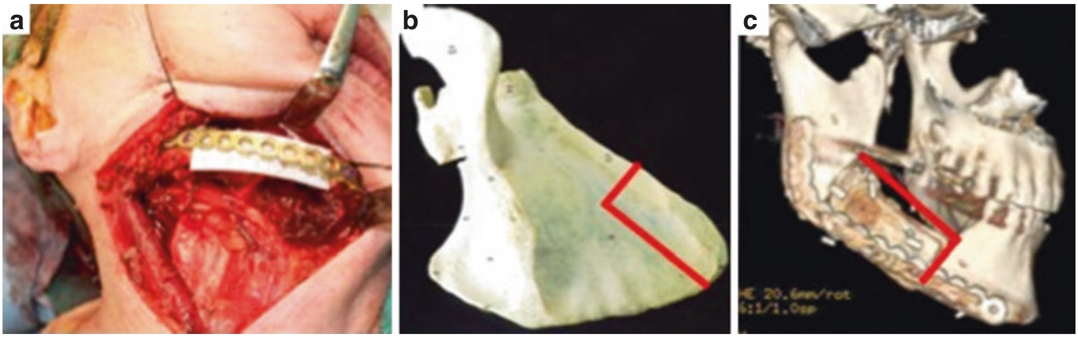

Fig. 2.12 Scapular tip free flap for lateral mandible reconstruction: (**a**) Intraoperative right lateral defect of the mandible with the reconstruction plate inserted. (**b**) Schematic illustrative image of the bone cuts. (**c**) Postoperative CT with 3D reconstruction showing the final result

mandibular arch with a single flap. Restoring bony union not only provides the most stable form of reconstruction but importantly enables dental rehabilitation through osteointegrated implantation. Bone flap options include the fibula (Brown et al., 2017), the scapula (Yoo et al., 2013) which is shown in Fig. 2.12, the radius (Brown et al., 2017), and the iliac crest (Miles et al., 2010; Shnayder et al., 2015) with their respective soft tissue components. Each flap has unique advantages and disadvantages and specific indications; however, the details of those concerns are beyond the scope of the present chapter.

Segmental defects of the mandible that involve the parasymphyseal region are considered anterior defects. In contrast to lateral mandible defects, anterior mandible defects require mandibular arch restoration using vascularized bone. Plate reconstruction is inherently unstable in this location, and it has been associated with an unacceptably high-rate plate extrusion and plate fracture (Wei et al., 2003). As previously described, several options for bone-containing free flaps include the fibula (Fig. 2.13), scapula, radius, iliac crest.

Through-and-Through Defects

In some oral cavity cancers, tumors can enlarge and extend to involve the external skin. Typically, once a tumor involves the external skin, it has reached a substantial size often involving bone and soft tissue which then necessitates a large volume reconstruction. Resection of the tumor and the overlying skin results in what is termed a "through-and-through defect." These are among the most formidable of reconstructive challenges and may require a single complex multi-paddle free flap or a combination of free and pedicled flaps. Due to the volume and size of deficits, at least one free tissue transfer is usually necessary to address the defect. If the defect involves bone and soft tissue, the reconstruction can be achieved with either a single composite free flap containing bone with a large volume of soft tissue or with the use of two flaps, one of which includes bone. Large composite flaps can be based off the subscapular system to include either bone from the lateral border of the scapula or the scapula tip (Fig. 2.14). The bone can be harvested to include multiple paddles of soft tissue. Alternatively, a single free flap can be used to reconstruct the oral cavity defect and a cervicofacial rotation flap, or a pedicled flap with a skin graft can be employed to reconstruct the remaining external skin defect. If a single free flap is insufficient, two free flaps can be used to reconstruct the oral cavity defect and the external skin defect separately.

Summary

The oral cavity is essential for speech, chewing, swallowing, and aesthetics. Achieving the best results in reconstruction after tumor

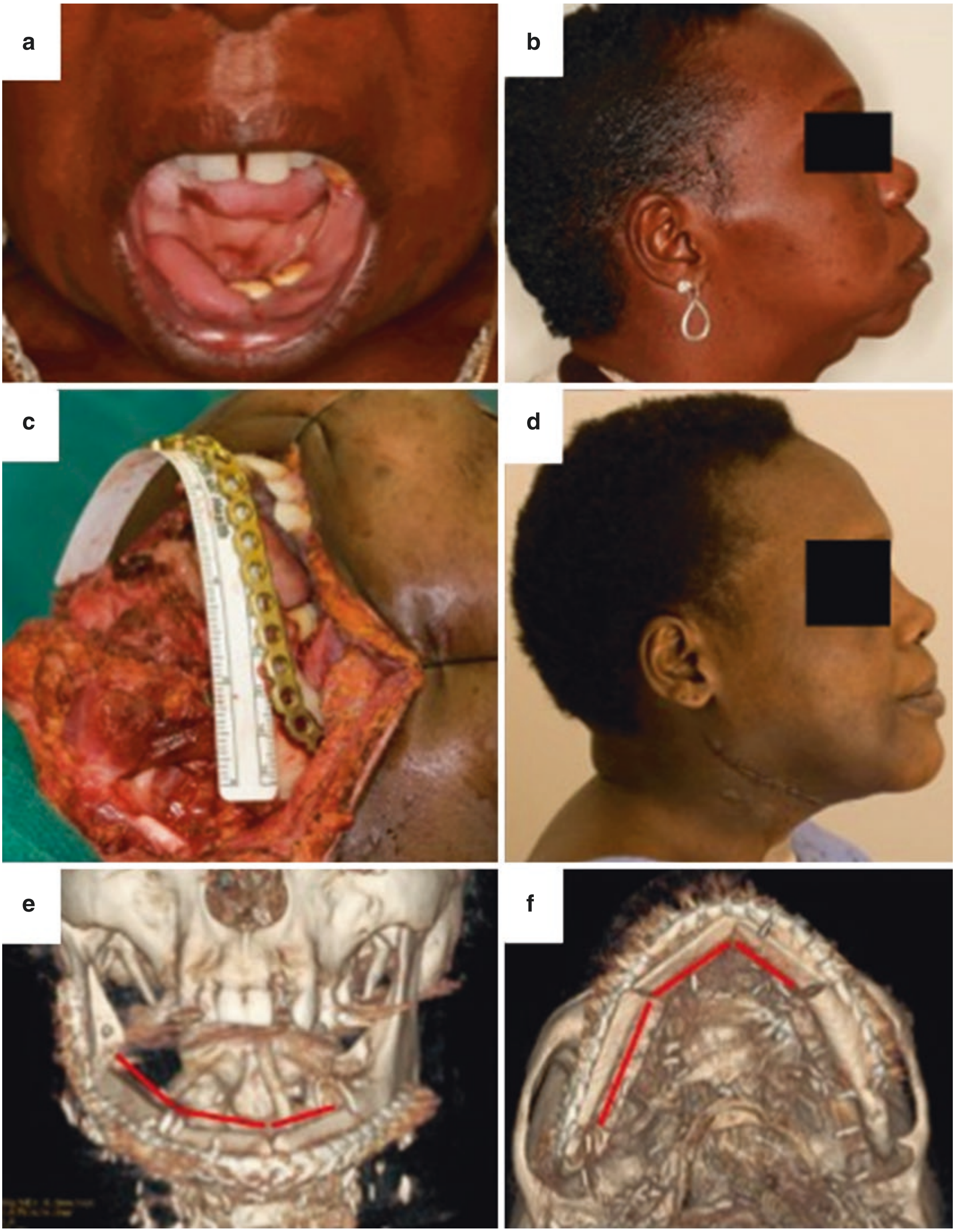

Fig. 2.13 Fibula free flap for anterior and lateral mandible reconstruction: (**a**, **b**) Preoperative picture showing bone resorption in a patient with osteoradionecrosis of the anterior mandible. (**c**) Intraoperative photo with an angle-to-angle mandibular defect. (**d**) Postoperative image with restitution of the facial contour. (**e**, **f**) 3D CT scan of the reconstruction with a fibular flap replacing the entire defect

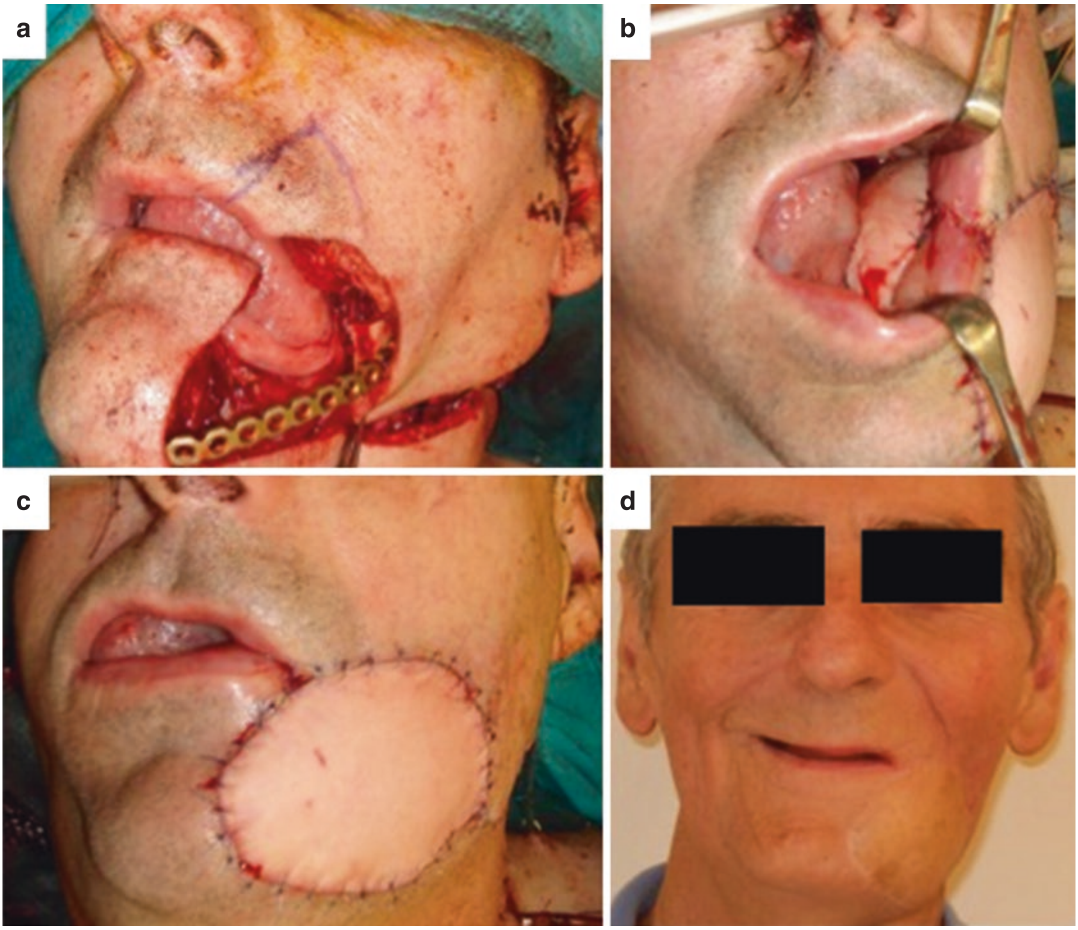

Fig. 2.14 Scapular tip free flap for a through-and-through defect: (**a**) Through-and-through defect after a mandibular tumor invading the skin and the buccal mucosa. (**b**, **c**) Immediate post-reconstructive picture using a scapular tip free flap with a large skin paddle which covered both the cutaneous and intraoral defect. (**d**) Remote postoperative image with good lip continence and cosmesis

ablation requires a clear understanding of its role in relation to tongue mobility, mastication, oral-nasal competence, and physical appearance. Surgical options include a vast spectrum of operations ranging from primary closure to complex free tissue transfer. Understanding the functional and aesthetic implications of the anatomic defect in conjunction with the unique patient-specific factors is the foundational basis for selecting the appropriate reconstruction.

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