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Mandibular reconstruction

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A B S T R A C T

Mandibular reconstruction presents unique functional and aesthetic challenges to the reconstructive surgeon. This review will cover current techniques for mandibular reconstruction, including the various plating strategies for rigid fixation, the choice of osseous donor site, and the concurrent reconstruction of associated soft tissue defects. Recent developments and future horizons in mandibular reconstruction including the use of virtual surgical planning and tissue engineering will also be addressed.

Introduction

Since the introduction of free tissue transfer, surgical techniques for mandibular reconstruction have continued to evolve at a rapid pace, leading to improved functional and aesthetic outcomes for patients. Several large series have reported excellent results with a variety of free flap osseous donor sites, establishing microvascular free tissue transfer with bone as the gold standard for reconstruction of the mandible [1–4]. This review will cover current techniques for the reconstruction of mandibular defects, including the various plating strategies for rigid fixation, the choice of osseous donor site, and the concurrent reconstruction of associated soft tissue defects. Recent developments and future horizons in mandibular reconstruction including the use of virtual surgical planning and tissue engineering will also be addressed.

Indications and goals for reconstruction

A variety of conditions, some of which are listed in Table 1, can affect the mandible and may necessitate removal and/or replacement of a segment of bone (segmental mandibulectomy). Loss of mandibular continuity can cause a variety of problems including airway compromise, difficulty with mastication due to loss of teeth or malocclusion, difficulty with speech and swallowing, and cosmetic deformity due to loss of lower facial contour. There may be associated soft tissue defects of adjacent structures involving, for example, the tongue, buccal mucosa, and/or skin of the face and neck, that can have equally important functional and aesthetic consequences. Therefore, the goal of mandibular reconstruction is to avoid the functional and aesthetic problems listed above by addressing both the mandibular bone and associated soft tissue defects. In the setting of oncologic ablative surgery and reconstruction, it is also critically important that the patient be healed in time to receive adjuvant radiation therapy, if indicated, within 6 weeks following surgery, in order to maximize patient survival from the cancer [5].

Defect classification

While numerous classification systems have been proposed to describe mandible defects, there is no consensus on an ideal system. Boyd et al. [6] and Urken et al. [7] have proposed the two most widely cited classification schemes. Both of these schemes break up defects by subsite of the mandible affected and have additional descriptors for the associated soft tissue components of the defect. Boyd uses the terms hemimandible, central, and lateral (HCl), while Urken uses the standard anatomic breakdown of the mandible (i.e. condyle, ramus, body, symphysis). Both of these schemes recognize the important differences between lateral and anterior mandible defects in terms of reconstructive challenges. A more recent classification proposed by Brown et al. [8] uses four classes: class I (lateral), class II (hemimandibulectomy), class III (anterior), and class IV (extensive) with the addition of c for condylectomy as needed (e.g. Class Ic denotes a lateral defect including the condyle). They promote this new system as capturing the increasing complexity of the reconstructive effort as class of defect increases (e.g. when compared to class I lateral defects, class III and class IV defects may require longer segments of bone with more osteotomies). These classification schemes are certainly important in the effort to compare reconstructive modalities with respect to functional and aesthetic outcomes for mandibular reconstruction. In clinical

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Table 1
Conditions that may necessitate mandibular reconstruction with free tissue transfer.

Head and neck mucosal squamous cell cancer (e.g. oral cavity or oropharynx cancer)
Other head and neck cancers (e.g. salivary gland, sarcoma)
Benign and malignant odontogenic tumors (e.g. ameloblastoma)
Osteoradionecrosis
Bisphosphonate related osteonecrosis of the jaw (BRONJ)
Trauma (most commonly ballistic)
Osteomyelitis

practice, however, most surgeons incorporate a variety of factors when planning a reconstruction that are not neatly captured by any classification system.

Current techniques and special considerations

Reconstruction without osseous free flap

In order to maximize functional and aesthetic outcomes, free tissue transfer with bone is most often the reconstructive modality of choice when dealing with a segmental mandibulectomy defect and will therefore be the primary focus of this review. However, it should be noted that certain defects in selected patients may also be reconstructed using a different approach.

For example, for selected posterolateral mandible defects with large associated soft tissue surface area and volume loss, acceptable results have been achieved using free flap or regional flap reconstruction containing soft tissue only [9,10]. In these cases, the functional and aesthetic impact of the soft tissue reconstruction may outweigh the impact of the leaving the posterior mandible without bony reconstruction or rigid fixation. Soft tissue myocutaneous or fasciocutaneous free flaps such as the rectus abdominus and anterolateral thigh offer large, flexible skin paddles with sufficient bulk to address these soft tissue defects. In the absence of rigid fixation, the remaining mandible will tend to deviate to the unaffected side due to unopposed muscle pull, however this deviation may not be of functional or aesthetic consequence to the patient in terms of appearance, mastication, and swallowing [10].

Lateral mandibular defects in edentulous patients who are poor candidates for osseous free flap reconstruction can be addressed with plate fixation and soft tissue reconstruction without bone. The rate of plate failure (hardware loosening or plate fracture), plate exposure, and other complications with this approach has been reported to be high (50–80%) [11–13]. However, Chepeha et al. showed that the rate of such complications could be reduced by over-reconstruction of the soft tissue defect to support the plate medially which lowers the risk of plate extrusion [14]. Dentulous patients are poor candidates for this approach because the forces of mastication, in the absence of bone continuity and support, will inevitably lead to hardware failure. Dental rehabilitation is also not possible in the absence of a bony reconstruction.

For selected patients, rigid fixation with non-vascularized bone grafting may be an option for reconstruction. Shorter, lateral defects in non-cancer patients who are not previously radiated or planned for adjuvant radiation are the best candidates for such an approach. Numerous autogenous and allogenic non-vascularized bone donor sites have been described with variable results compared to vascularized bone flaps [15]. More recently, favorable results have been reported with the adjunct use of tissue engineering, as will be discussed further below [16–18]. With increasing success and efficiency with vascularized bony flaps, these techniques have received less attention from some surgeons, but remain a good option for selected patients and a promising avenue for ongoing research and development.

Plating

For the vast majority of patients, titanium plate fixation will be part of the reconstructive plan. Currently, rigid fixation is most often achieved with a single locking titanium reconstruction plate [19]. Over time, smaller, lower profile plates (e.g. 2.0 mm instead of 2.5 or 2.7 mm) have been substituted with equivalent hardware fixation outcomes and better aesthetic results [20]. Titanium miniplates can also be used depending on surgeon experience and preference with equivalent results [21]. When the mandible can be preplated prior to segmental mandibulectomy, a locking reconstruction plate that spans the defect can be used to restore the patient to premorbid occlusion and mandibular contour. The free flap bone can then be shaped with osteotomies to conform to this plate and secured using locking or nonlocking screws.

Preformed plates have recently been produced by hardware manufacturers with designs based on the averaged computed tomography scans of mandibles from large numbers of patients. Sizers are used intraoperatively to select the appropriate size plate, and then minimal anterior and posterior bending is required to achieve fixation of the mandible. These plates are designed for lateral defects with minimal symphysis involvement. The advantage of the preformed plates over hand-bending plates intraoperatively lies in the reduced operative time, and the theoretical benefit of reduced plate fatigue from bending [22].

Improvements in preoperative 3-D modeling have allowed for the development of custom or patient specific plates that are milled from titanium. These plates do not require any sizing or bending intraoperatively and therefore also save time and effort for the surgeon while reducing operative time for the patient. The premorbid mandibular contour can be most accurately recreated with the use of such plates. Similar to preformed plates, an additional theoretical advantage of patient specific plates lies in the elimination of plate bending which can lead to plate fatigue and premature hardware failure. Further possible advantages of preoperative virtual surgical planning will be

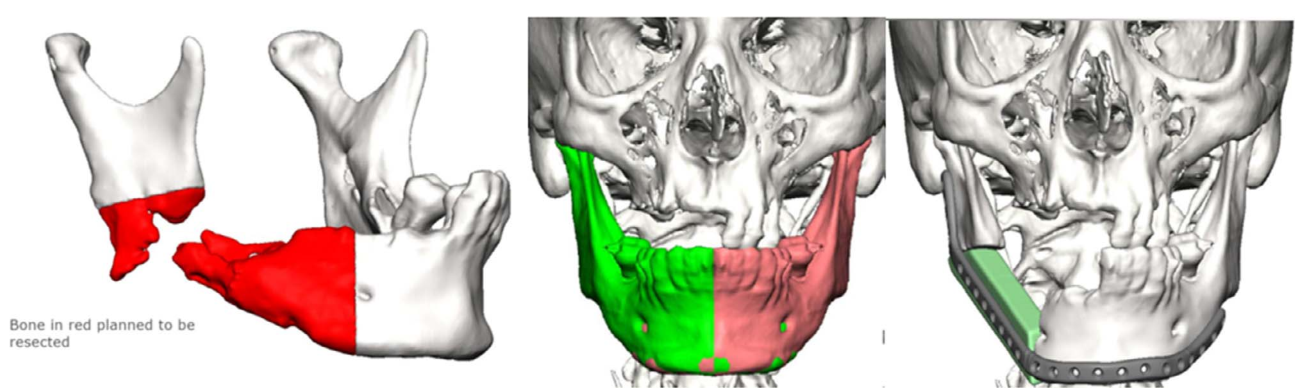

Fig. 1. Virtual Surgical Planning with patient specific custom plate. Mandibular fracture with displacement of the condyle from chronic osteomyelitis. Mirror image of the contralateral mandible with condyle placed back into fossa used to create a custom plate and plan for fibula free flap reconstruction.