3 Reconstruction Considerations for the Posttraumatic, Benign Tumor, and Oncologic Patient

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3.1 Introduction

Patients undergoing reconstructive surgery are subjected to a complicated and often arduous process and must therefore be carefully selected to ensure the most desired outcomes. In planning for the functional and aesthetic reconstruction of the midface and mandible, there are common pre-surgical considerations which must be addressed, regardless of the patient's primary disease process. The most important of these include type and extent of defect, overall patient health, comorbidities, and patient preference.

Overall patient health is a broad term that includes many of modifiable and non-modifiable factors. Of these, age has been highly studied and has not been shown to affect flap outcome or perioperative mortality rate. It should therefore not be a limiting factor in deciding which type of reconstruction to pursue [1]. Biological age, rather than chronological age, should be the greatest concern. No significant differences in disease-specific or overall survival were shown when comparing free flap patients less than or greater than 70. However, medical comorbidities have been found to be significant predictors of medical complications. In the same study, disease stage was the only significant predictor of recipient site complications [2]. Looking at flap survival specifically, preoperative comorbidity and not age was associated with poorer outcomes. It is important to note, however, that older patients are statistically more likely to have a higher presence of medical comorbidities [3], though the overwhelming body of literature demonstrates that it is the preexisting comorbidities, and not age, that portend poorer outcomes.

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3.2 Reconstructive Options

Once a thorough preoperative risk assessment has taken place, it is important to explore all surgical and nonsurgical options available to give a patient the best possible functional and aesthetic results while minimizing morbidity. Furthermore, a thorough evaluation of all available options will allow the surgeon to appropriately counsel the patient in making an informed treatment decision. While free tissue transfer occupies the peak of the reconstructive ladder and is considered by many to be the gold standard of maxillofacial reconstruction, patients may also benefit from a combination of local or regional flaps, nonvascularized grafts, alloplastic materials, or the use of regenerative medicine techniques to restore form and function. Additionally, there is a role for the use of prosthodontics and obturators, especially

J. C. Melville et al. (eds.), *Regenerative Strategies for Maxillary and Mandibular Reconstruction*,
https://doi.org/10.1007/978-3-319-93668-0_3

for those patients who are poor surgical candidates or at significant risk for decreased healing. Often, these may also be the ideal options simply due to patient preference.

Obturators can be used alone or in conjunction with other reconstructive surgeries to improve functional outcomes. Factors that must be considered in choosing to use an obturator include donor site morbidity, operative time, the possibility of recurrence, and willingness of a patient to undergo surgical reconstruction. Oral function has been shown to be equal in patients who received implant-supported obturators compared to implant-supported fixed prostheses in free vascularized flaps, although there was lower patient-reported quality of life for patients with obturators [4]. Furthermore, an obturator can provide a valuable bridging option until a more definitive reconstruction can be performed.

Another option to consider in patients who are not good candidates for a prolonged or staged reconstructive surgery is the use of alloplastic materials, such as an immediate reconstruction with titanium bridging plates. While the use of alloplastic materials is a common aesthetic technique, their role in functional reconstruction is less clear. The little evidence available shows that the benefits afforded by a faster reconstruction and avoidance of donor site morbidity can be offset by relatively high failure (30.8%) and complication (40.1%) rates when used for mandibular reconstruction [5]. Failure rates with this approach increase in correlation with larger defect size, when the defect includes the mandibular symphysis, and in smokers [6]. Alloplastic reconstruction may have a role in patients with small defects or as a temporary measure, but the replacement of resected bone is usually necessary for successful reconstruction in the long term.

The functional success of a bony reconstruction primarily depends on bony union and viability of endosseous implants. Nonvascularized bone grafts (NVBG) are more often used after resection of benign lesions and vascularized bone grafts (VBG) after malignancies due to the size of the defect. Despite larger defect size, older age, presence of malignancy, and prior irradiation, patients with VBG showed higher incidence of bony union and implant success rate compared to NVBG [7]. Although there is theoretically decreased operative time and blood loss with NVBG, they have shown a higher complication and failure rate, with infection being the most common complication [8]. NVBG require soft tissue coverage often in the form of adjacent tissue transfer, which may or may not be a viable option depending on the extent of the initial resection and viability of the surrounding tissue. Local or regional flaps may be used in patients who are poor candidates for microvascular anastomosis and may be performed in conjunction with NVBG, as the use of NVBG often requires additional soft tissue coverage.

Despite the myriad of proposed options for VBG, the modern-day workhorse for maxillo-mandibular bony reconstruction is the fibular free flap (FFF), with high reported success rates and relatively low donor site morbidity [9]. While there is a high success rate for the FFF, certain considerations must be taken regarding patient selection including patient mobility and the evidence of peripheral vascular disease. Decreased patient mobility may negatively affect rehabilitation after a FFF. In cases where donor site morbidity from a FFF is a concern, the scapular free flap may be a more viable option [10]. Even with expected functional loss and postoperative symptoms experienced by FFF recipients, overall quality of life is not significantly lower than reference populations [11].

The use of regenerative medicine techniques may be implemented in conjunction with any of the aforementioned reconstructive strategies and will be discussed in greater detail in the remaining chapters. All the available reconstructive options and their associated risks and benefits should be discussed with the patient to allow the patient to make an informed decision. Patient preference should be taken into consideration, and sufficient preoperative counseling should be provided given that more complex surgeries will entail a much longer time for recovery and rehabilitation. Patient compliance can play an important role in surgical outcomes especially in staged reconstructions.

After considering all variables related to patient health, comorbidities, and patient preference, we can broadly classify patients requiring maxillofacial reconstruction into three main groups: posttraumatic, oncologic, and benign tumor. Each of these clinical scenarios merits special considerations that address the characteristics unique to their basic pathophysiology.

3.3 Posttraumatic

Maxillofacial trauma secondary to avulsion or severe ballistic injuries can create complex composite defects. A common factor in the management of these traumatic injuries is timing of intervention and specifically how it relates to the body's inflammatory response to said traumatic event. In the case of graft placement, one such concern is the viability of the tissue at the recipient site and how this may affect overall graft survival.

The value for a staged approach to reconstruction of severe facial trauma has been previously delineated [12]. Initial assessment of complex facial wounds involves patient stabilization, the evaluation of multi-system trauma, and consultation of neurosurgical and ophthalmological teams as indicated. Preoperative imaging, specifically CT angiogram, is often indicated as the incidence of major vascular injury in facial gunshot wounds (GSWs) is 10–50% depending on the entry point.

Early surgical reconstruction of the underlying bony framework is important in preventing soft tissue contracture [13]. This can be accomplished with the use of bone grafting and locking reconstruction plates depending on availability of soft tissue coverage. Thorough investigation of remaining viable bone and soft tissue is important in determining the extent of reconstruction necessary [12]. Waiting an adequate amount of time for the nonviable tissue to declare itself, while logical, should be weighed against the risks of progression of the inflammatory cascade and eventual scar formation when determining timing of definitive repair [14]. The amount of time needed for demarcation of tissue viability differs depending on the mechanism but often will become clear within 24–72 h.

Unlike blunt facial trauma, avulsive or projectile injuries are more apt to progressive tissue loss secondary to necrosis or infection seen after the time of initial injury and may therefore require more time to determine the extent of tissue loss. Projectile injuries are generally classified as low or high energy, relating to the amount of damage inflicted on surrounding tissue. Resistance of energy transfer from the projectile is greater in dense tissues such as bone and causes compressive waves which damage surrounding tissues [15]. When evaluating blast injuries, damage is directly proportional to the distance from the blast, and damage may be much more severe than what is seen superficially.

In addition to tissue necrosis, there is a significantly increased risk of infection in penetrating facial trauma, with a reported 39% wound healing complication if a gunshot passes through the oral cavity [16] and as high as 100% after close range shotgun blast [17]. Infection can occur either from bacteria carried into a wound by a projectile or contamination of the wound after initial injury. Animal models have shown that the volume of necrotic tissue needing debridement is decreased by earlier debridement and use of antibiotics [18]. There is limited data, however, demonstrating the benefit of prophylactic antibiotics in facial trauma. It has been shown to be beneficial in preoperative mandibular fractures, but the advantage is less certain for midfacial fractures or in the postoperative setting [19]. Therefore, while early surgical debridement may be important, the role of prophylactic antibiotics is less clear.

Over time, there has been a shift from delayed repairs to more immediate definitive reconstruction in an attempt to decrease scar contracture of the face [20]. Bringing well-vascularized bone and soft tissue into a seemingly unhospitable wound in the form of free tissue transfer has allowed for reconstruction of the bony skeleton and overlying soft tissue shortly after extensive facial injury without compromising aesthetic or functional outcomes [21]. The use of free tissue transfer in posttraumatic reconstruction is beneficial due to the improved vascularity, decreased contracture and scarring, ability to reduce infection, and replacement of composite tissues that this method affords. Its use is sometimes even necessary in settings such as violation of the anterior skull base and active cerebrospinal fluid leak, where a vascular tissue seal is required. There are no clear guidelines on the exact timing of the reconstructive process, and further prospective investigations are still needed, but current trends favor more immediate reconstruction as it may help to avoid soft tissue contracture and lead to improved long-term functional results.

3.4 Malignant Tumors

Head and neck cancer patients can present a unique set of challenges for the reconstructive surgeon. Perioperative care, usually by an interdisciplinary team, is important for optimal recovery from surgery. A systematic review by the Enhanced Recovery After Surgery Society examined 17 different areas of perioperative care for head and neck cancer patients, recommending a focus on nutritional status; antibiotic, antiemetic, and thromboembolic prophylaxis; prevention of hypothermia; early mobilization and decannulation; opioid-sparing analgesia; and pulmonary physical therapy [22]. Ensuring a successful reconstruction outcome starts long before the actual surgery, with a focus on one very important and controllable risk factor: nutrition.

Up to 80% of head and neck cancer patients are malnourished, often as a direct result of their disease process. Unfortunately, this is often not addressed at the time of a reconstructive surgery. Decreased BMI has been shown to be a negative prognostic factor independent of tumor stage, with a 5-year survival of 27.1% (underweight) vs 59.9% (normal weight) patients undergoing chemoradiotherapy [23]. Nutrition, especially on the day of surgery, is also important as traditional preoperative fasting has been associated with delayed recovery and poorer outcomes compared to a 2-hour fasting window after clear liquids [24]. Malnourished patients are also not surprisingly at a greater risk for infection and poor wound healing.

Infection after reconstructive surgery is associated with longer hospital stays, increased healthcare cost, and poorer functional and aesthetic outcomes. Postoperative wound infection in clean-contaminated head and neck surgeries has been reported as high as 80% [25]. Infection rate is higher in patients of the male sex and with previous alcohol and tobacco use and tumors of the base of the tongue or mandibular gingiva and those who underwent segmental mandibular resection or had nasogastric tubes at the time of surgery [26]. Given the importance of perioperative nutrition and possible infection risk related to nasogastric tubes, an emphasis on prophylactic gastrostomy placement may also improve patient outcomes. Randomized controlled trials of perioperative antibiotic prophylaxis continued for at least 24 h after surgery in clean-contaminated procedures consistently show decreased wound infection [27]. Longer courses of antibiotics, however, do not show any additional benefit compared to 24 h, even in patients undergoing free flap reconstruction [28]. Given the existing data, all patients undergoing reconstruction for a defect secondary to resection of a malignancy would likely benefit from a short course of perioperative antibiotics.

In addition to the risks of postoperative wound infection, all cancer patients are at an increased risk for venous thromboembolism (VTE), including both deep vein thrombosis (DVT) and pulmonary embolus (PE). The risk of VTE is also increased in patients undergoing reconstructive surgery given long operative times and postoperative immobility secondary to donor site morbidity. The use of pharmacologic prophylaxis in head and neck cancer patients undergoing free flap reconstruction has been shown to effectively protect against VTE [29]. Despite this benefit, the use of antithrombotics has not been shown to definitively decrease the rate of flap thrombosis or failure, but their use does increase the risk of postoperative hematoma [30].

One main reason that head and neck cancer patients differ from other reconstructive candidates is the high likelihood that they will receive or have already received adjuvant radiation and/or chemotherapy. The introduction of radiation, in particular, into the healing reconstructive field further complicates wound healing. Any maxillofacial reconstruction in a cancer patient must be able to withstand the tissue-damaging effects of these adjuvant therapies.

Patients who have already undergone radiation therapy present a unique set of challenges. Flap failure is believed to be more common after radiation, and a recent meta-analysis showed a statistically increased risk of flap failure (RR 1.48, $P < 0.004$), complications (RR 1.84, $P < 0.001$), reoperation (RR 2.06, $P < 0.001$), and fistula (RR 2.05, $P < 0.001$) in previously irradiated patients undergoing microvascular reconstruction [31]. Animal studies, however, have shown no effect of prior radiation therapy on the patency of anastomosed vessels despite observations of significant damage to the surrounding tissue [32]. In addition, irradiated tissue can become more difficult to work with due to scarring. Also, operative complications tend to increase as the time between radiotherapy and surgery increases [32]. Despite this, the overall dose of radiation has not shown to be an independent predictor of outcomes. Patients who had T3 or T4 cancers and those who continue to smoke, however, have been shown to be poor candidates for salvage surgery with microvascular reconstruction as they have an increased rate of recurrence [33]. In addition, many patients undergoing head and neck oncologic surgery are former and current tobacco users. The continued use of tobacco is clearly detrimental to the success of reconstructive patients, and abstinence from smoking has been shown to improve wound healing [34], with cessation at least 3 weeks prior to surgery showing the greatest benefit [35]. All potential reconstructive patients should be counseled and given resources for smoking cessation prior to surgery.

The need for reconstruction in head and neck cancer patients is not only important after tumor extirpation but also as a result of osteoradionecrosis (ORN) from radiation therapy. Although irradiated tissue is inherently damaged and therefore at risk for poor healing, patients who undergo free flap surgery for ORN do not have greater risks of 90-day perioperative complications or differences in free flap viability compared with patients who undergo microvascular reconstruction for other causes [36]. This is believed to be secondary to the introduction of vascularized free tissue from a non-irradiated donor site into the reconstructive surgical field.

The use of regenerative medicine in cancer patients presents a unique challenge. One of the most commonly used regenerative substances in maxillofacial reconstruction is recombinant human bone morphogenetic protein 2 (rhBMP-2). However, bone morphogenetic proteins (BMPs) are involved in both tumorigenesis and regulation of cancer progression. Regarding tumor growth, they have been used as biomarkers for the prognosis of certain cancers. BMP-2 level, specifically, is an independent negative predictor of prognosis in patients with non-small cell lung cancer. This is important given that many head and neck cancer patients have an extensive history of smoking and are therefore at increased risk of developing lung cancer as well. In direct opposition to this are the findings that BMPs may also play a role in tumor suppression [37]. Hence, the exact role BMPs might play in head and neck cancer has not yet been fully elucidated.

Despite the potential risks of increased tumor growth or recurrence, the use of BMPs has been attempted as an adjunct to reconstruction of head and neck cancer patients. A case series looking at the use of rhBMP-2 at the time of free flap reconstruction for osteoradionecrosis of the mandible demonstrated no increase in the rate of cancer recurrence but also failed to show any improvement in healing or complications compared to the control group [38]. Regenerative medicine may yet to have an important role to play in reconstruction of cancer patients, but more research is needed looking at the interaction of BMPs and head and neck cancers.

3.5 Benign Tumors

In certain aspects, benign tumors may arguably be seen as a less complicated group of patients requiring reconstruction. There is often limited damage to surrounding tissues, unlike trauma or postradiation, and patients are less likely to have the myriad of other perioperative concerns often present in patients with malignancies as discussed above. Two common types of benign maxillofacial tumors include ameloblastoma and keratocystic odontogenic tumor (KOT). Clinical presentation of the most common ameloblastoma subtype, solid or multicystic, can include malocclusion, asymptomatic swelling, or mucosal ulceration. Controversy still exists regarding the management of this aggressive benign tumor between conservative and radical treatments. Conservative treatment through enucleation and curettage has a reported 48.7% recurrence rate [39], while primary resection generally yields recurrence rate <15%. However, "recurrence" is believed by some to be in fact residual disease, with gross pathologic tumor extension measured at a mean of 4.5 mm beyond radiographic margins [40]. Given this, adequate margin should be taken at initial resection if further reconstruction is planned, as this tumor has the ability to extend into and through bone. The same can be said for the KOT, which has been classified as a neoplasm because of its aggressive behavior and tendency for recurrence. Therefore, the classification of benign tumor should not be interpreted as a provision that allows for less meticulous or thorough evaluation and management.

Attention to the type of resection performed and risk of recurrence for benign maxillofacial neoplasms is essential to ensuring a lasting reconstruction. The use of regenerative medicine in the form of rhBMP-2 has shown excellent regeneration of large mandibular defects after resection of ameloblastoma, obviating the need for autogenous bone graft [41]. Additionally, a case series of mandibular reconstructions after removal of benign lesions or trauma demonstrated only one of six patients with a postoperative complication of infection [42].

3.6 Conclusion

Despite the course that leads a patient to requiring reconstructive maxillofacial surgery, care must be taken to investigate all patient comorbidities and barriers to surgery. Biological rather than chronological age should be used to help guide the decision-making process. All available surgical options should be discussed fully with the patient as they are indubitably an important stakeholder in the reconstructive process. Patients undergoing reconstruction after severe facial trauma should have all devitalized tissue debrided and receive reconstruction surgery as soon as possible to minimize scarring that may limit reconstructive options and outcomes. Head and neck cancer patients present a unique set of circumstances which may hinder successful reconstruction. More focus is needed on perioperative and preoperative health status including nutrition and smoking cessation. Prior radiation therapy complicates the reconstructive process and portends to potentially poorer overall outcomes. Benign tumors of the maxilla and mandible often have a high recurrence rate, and proper attention must be given to the method of tumor extirpation prior to reconstruction. Reconstructive surgery of the midface and mandible, regardless of the primary disease process, is a complex endeavor. Careful preoperative assessment, prudent surgical intervention, and thorough perioperative management are necessary for optimizing treatment outcomes in these patients.

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