Role of Free Tissue Transfer in Facial Trauma

Roderick Y. Kim, DDS, MD[1] Momofiyin Sokoya, MD[2] Fayette C. Williams, DDS, MD, FACS[1]
Tom Shokri, MD[3] Yadranko Ducic, MD, FRCS(C), FACS[2]

[1] Division of Maxillofacial Oncology & Reconstructive Surgery, Department of Oral and Maxillofacial Surgery, John Peter Smith Health Network, Fort Worth, Texas
[2] Otolaryngology and Facial Plastic Surgery Associates, Fort Worth, Texas
[3] Department of Otolaryngology, Pennsylvania State University, Hershey, Pennsylvania

Address for correspondence Roderick Y. Kim, DDS, MD, Division of Maxillofacial Oncology and Reconstructive Surgery, Department of Oral and Maxillofacial Surgery, John Peter Smith Health Network, 1625 St. Louis Avenue, Fort Worth, TX 76104 (e-mail: kim0do@uw.edu).

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Abstract

For large composite traumatic defects of the head and neck, free tissue transfer presents a reconstructive allowing for the reconstitution of both form and function. Furthermore, the ability to provide bulk, soft, and hard tissue, as well as immediate dental rehabilitation, makes free tissue transfer an efficient and attractive option for head and neck reconstruction. Herein, we discuss the utility of free tissue transfer in facial trauma, its problems, complications, and controversies.

Keywords
- maxillofacial trauma
- free tissue transfer
- free flap
- head and neck reconstruction

There are multiple etiologies for facial trauma, and the most complex injuries include composite defects of the maxillofacial complex. These defects are often due to ballistic injuries, with unpredictable and evolving wounds affected by thermal injury, blast injury, infection, and significant amount of dead space.[1] Especially devastating is the self-inflicted gunshot wound (GSW) that leads to composite tissue loss of the maxillomandibular complex. This type of trauma may include the potential morbidity of vision loss and compromised facial harmony, both in form and function. Some defects may lead to the inability to swallow or maintain a patent airway and require temporary or permanent gastrostomy and tracheostomy (►**Fig. 1**).

Free tissue transfer, which is widely used for both ablative and traumatic defects, offers the facial surgeon possibilities of reconstructing both the form and function of these devastating injuries. While it is a common option for the reconstruction of the maxillofacial complex, free tissue transfer is not without complications and complexities. In this article, we discuss the utility of free tissue transfer in facial trauma, its problems, complications, future directions, and the associated controversies.

Problems

When discussing free tissue transfer as an option for reconstruction, the facial surgeon must account for the significant disruption of vital functions within the facial complex following traumatic injury. This is often avulsive in nature, resulting in disruption of the skin, muscle, and bone, which results in the loss of bulk, exposure of vital structures, and loss of muscle attachments with significant functional compromise. Categorizing defects by location allows, from an organizational standpoint, anticipation of potential challenges and reconstructive goals. Common categories of the defect are the scalp, midface, and mandible. Each of these areas has unique functional and esthetic considerations for reconstruction, as described next.

In the scalp trauma, there is limited tissue pliability of the remaining tissue. Thus, unlike areas such as the posterior and lower neck, scalp yields little flexibility to simply advance and close soft tissue defects. While large rotational flaps are available, they have the potential of distal flap necrosis, as well as frequent need for skin graft.[2] Furthermore, these flaps often require multistaged treatment, poor cosmetic outcome, and potential transfer of hair to nonhair-bearing areas. Cranial bone defects often resulting from trauma add another complex

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Fig. 1 Self-inflicted gunshot wound with significant composite tissue loss. (These images are provided courtesy of Dr. Daniel Hammer.)

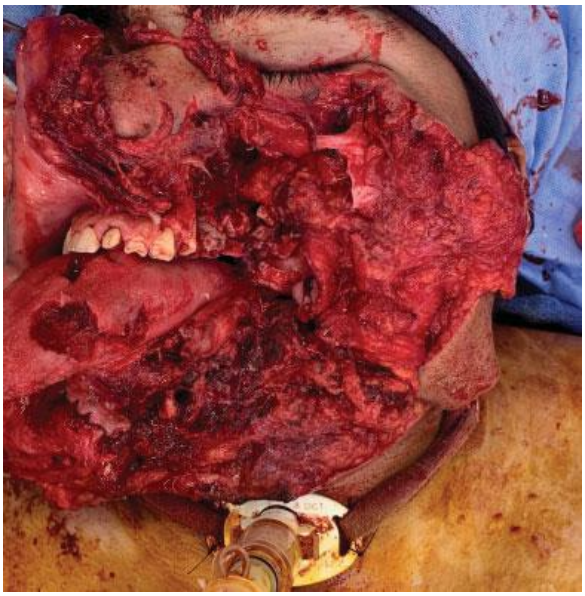

Fig. 2 Massive tissue loss at the maxilla and mandible. (These images are provided courtesy of Dr. Daniel Hammer.)

dimension and require predictable coverage to protect intracranial contents and coverage of the craniofacial hardware such as titanium or polyetheretherketone (PEEK) implants.

In midface and orbital complex trauma, there are limited locoregional flap options available for reconstruction in the setting of trauma, particularly with significant tissue loss. While restoration of the bony foundation is of critical importance to establish midface projection and soft tissue support, there are very few predictable reconstructive options for large avulsive injuries. For example, with large ballistic injuries resulting in massive tissue loss, the facial surgeon must be able to reconstruct the bone, associated tissue or muscle attachments, and the skin defect (►**Fig. 2**).

The midface has been described as the focus of how one perceives another human.[3] Therefore, the importance of the proper support of soft tissue from the underlying osseous framework, as well as its esthetic harmony, cannot be overstated. Furthermore, when the injuries result in communication between the oral cavity with the midface and skull base, the reconstruction must obliterate any potential fistulous tract.

Traumatic mandibular defects are the most functionally devastating due to this area's critical role in speech, swallowing, and airway support. Loss of these abilities can result in permanent dependence on a tracheostomy and gastrostomy tube. Damage to dentition also leads to decreased mastication, altered speech and articulation, and lip collapse, leading to poor esthetics and facial support. Overall, these detriments of form and function significantly impact the patients' quality of life.[4] In the era of virtual surgical planning and free tissue transfer, reconstruction of these structures should aim to return both form and function (►**Fig. 3**).

Fig. 3 Microstomia and exposed mandibular hardware after initial closure after gunshot wound.

Current Options

In the reconstruction of the scalp, free tissue reconstruction of choice is based on the thickness and size of the skin paddle required. In the temporal region where temporalis maybe avulsed, an anterolateral thigh flap, subscapular system flap employing both the skin and muscle, or a chimeric flap may be necessary to prevent temporal hollowing and provide bulk and skin coverage. However, in common mechanisms such as motor vehicle induced scalp trauma,[5] the tissue overlying the vertex of the skull is frequently compromised. In this scenario, a thin and pliable flap such as the latissimus dorsi flap leads to the replacement of both the bulk and coverage of possible skull defect (►**Fig. 4**).

Fig. 4 Thin and pliable latissimus dorsi flap.

The skin for these large muscle flaps is provided by split-thickness skin graft, which matures and epithelizes over a short period of time with satisfactory results (►**Fig. 5**).

In the reconstruction of the midface, especially for the cases of self-inflicted GSW, the free tissue reconstruction must achieve the following goals: separation of the intracranial components to the mouth, obliteration of the dead space, hard tissue reconstruction for future prosthesis and soft tissue support, and reconstruction of the soft tissue. The main challenge is that there is no one free tissue transfer that reconstructs the large amount of skin defect and bulk and also offers adequate bone for endosseous dental implantation. With the soft tissue defect of the midface, anterolateral thigh or radial forearm may be utilized based on the bulk required. When osseous reconstruction is necessary, especially when skin coverage may not be required, fibula free flap poses a viable option. The benefit of utilizing fibula, especially if one harvests soleus and flexor hallucis longus, allows obliteration of the dead space and coverage of the palate. This is achieved by suturing these muscles to the palatal defect, which initially leads to significant granulation tissue but eventually is epithelialized with oral mucosa. In some cases, to achieve coverage of the soft tissue defect in addition to adequate bony support and possible endosseous implantation, two separate free tissue transfers are required, such as radial forearm free flap for the soft tissue coverage and fibula myo-osseous flap for the bony support.

Fig. 5 (**A**) Immediate postoperative photo of meshed skin graft on muscle-only latissimus dorsi free flap. (**B**) After maturation of the skin graft.

Similarly, in the mandible, if several subunits of both the soft tissue and underlying structural framework are missing, one or two flaps may be necessary. While it may be adequate to use one flap to reconstruct both the bony and skin defect, many of these composite defects require both inner (oral cavity) and outer (skin) lining. Thus, many times, a single flap may lead to poor oral competence and obliteration of the vestibule to support prosthesis, and may lead to inadequate location of the fibula for future dental prosthesis. A viable option for the reconstructive facial surgeon in reconstituting composite defects involves utilizing a forearm to resurface the oral cavity and tongue, and fibula to reestablish the neo-mandible and, if necessary, any cutaneous component. Furthermore, in the current era of virtual surgical planning and in-house three-dimensional printing, jaw reconstruction with free tissue transfer, endosseous dental implants, and placement of dental prosthesis within a single operative procedure is possible (►**Fig. 6**).

Complications

Despite the ability to reconstruct extensive facial defects with the utilization of free tissue transfer, restoration of premorbid form and function remains a daunting challenge for the reconstructive surgeon. When compared with tissue defects following oncological ablation, traumatic injuries present with inherently unique reconstructive dilemmas. Devitalized and potentially contaminated tissue results in a continually evolving process of soft tissue loss, as tissue necrosis ensues. This is particularly relevant in close range blast injuries such as GSWs. Fibrosis and tissue contracture subsequently result in continued wound distortion due to damage to the underlying skeletal framework and forces from antagonistic muscle groups.[6] In this setting, it is exceedingly challenging to reconstitute structural support, restore function, and reestablish aesthetic form. Secondary procedures are often required to further refine facial aesthetic subunits. The surgeon's management strategy and preoperative counseling of the patient should emphasize staged reconstruction with initial prioritization of the structural framework followed by attempts at restoration of aesthetics.

Notably, concern for contamination does not preclude free tissue transfer. Contaminated wounds should be appropriately debrided to optimize outcomes. However, the presence of contamination within traumatic wounds has not been shown to correlate with increased perioperative or long-term complications after early free tissue reconstruction of facial injuries. Therefore, definitive repair with free flap reconstruction should not be delayed.[7]

Infection in the setting of soft tissue trauma, particularly in cases of ballistic injury, may represent a significant risk. Early debridement, institution of antibiotics in contaminated wounds, debridement of all nonviable tissue, and removal of foreign material are integral in mitigating this risk.[8–11] Additionally, any bone grafts utilized in reconstruction should be rigidly fixated and surrounded by vascularized tissue.[8,12] Nonvascularized osseous grafts should only be used in sterile wounds with adequate soft tissue coverage. The degree of fracture comminution also likely influences fibrous union, calcification, and, ultimately, overall healing between osseous

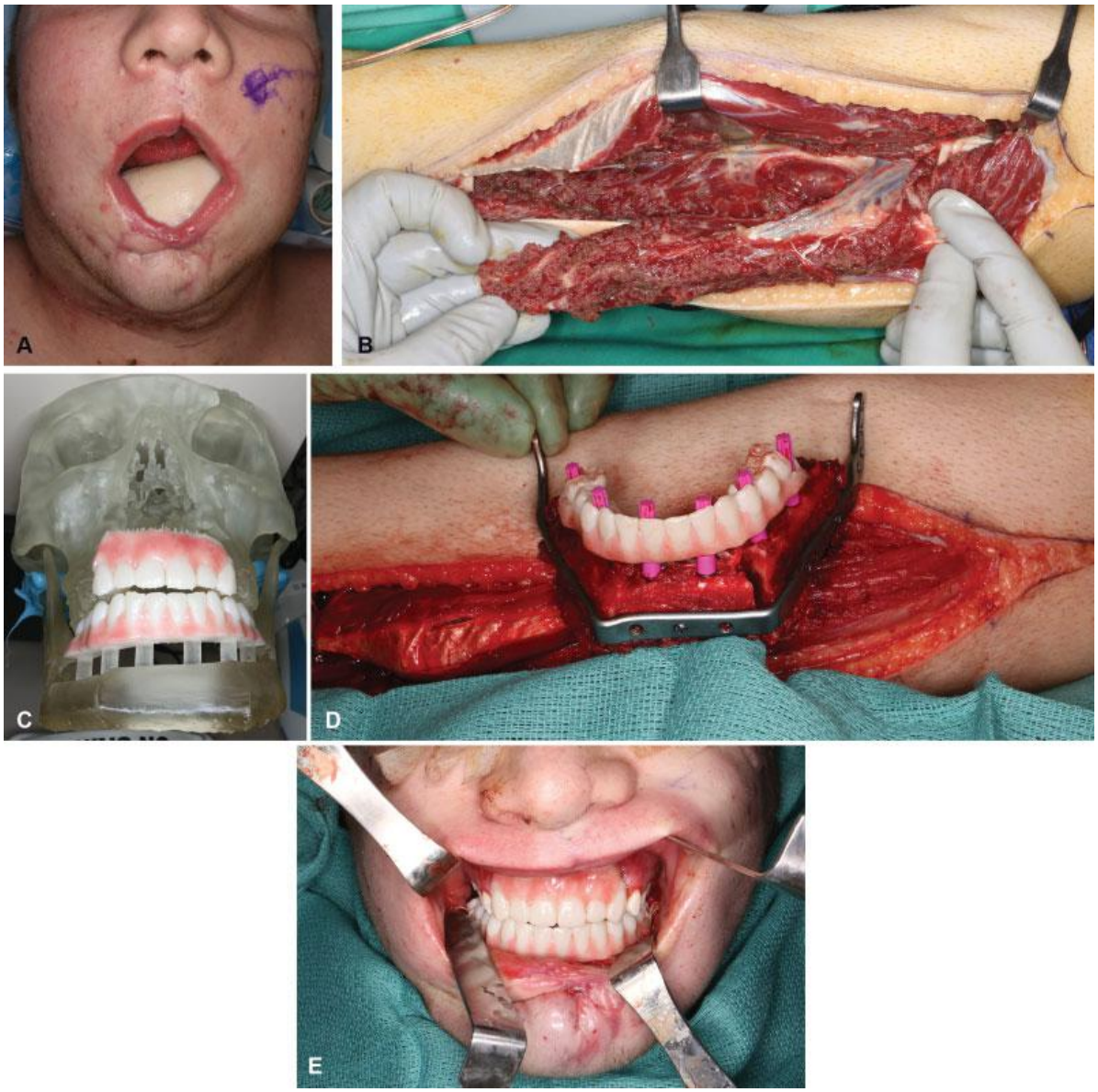

Fig. 6 Two free flaps to reestablish loss of oral cavity mucosa and the mandible, with total immediate reconstruction of the fibula with endosseous dental implants and prosthesis. (**A**) Radial forearm free flap grafting performed during the initial stage to reestablish the oral mucosal component. (**B**) Fibula osteocutaneous free flap grafting to reconstruct the mandible. (**C**) Three-dimensional printed maxillary obturator and mandibular prosthesis for immediate dental rehabilitation. (**D**) Dental implants with immediate prosthesis. (**E**) Postoperative photograph.

fragments. The mandible is particularly susceptible to nonunion given its mobility and functional weight-bearing. Plate exposure and wound dehiscence are also potential complications following free tissue reconstruction and have been attributed to patient medical comorbidities.[13] Special consideration should be given to ballistic injuries, particularly self-inflicted injuries, as these have shown an increased predilection toward postoperative complications.[14]

Traumatic injury to both the periorbital soft tissue and underlying skeletal scaffold may result in clinically apparent dystopia with resultant telecanthus, facial asymmetry, blunted canthal angles, enophthalmos, or hypoglobus. The resulting facial disharmony is not only disconcerting for the patient but also often accompanied by functional deficits including diplopia and visual compromise. Reestablishment of normal intercanthal distance should therefore be prioritized in the primary reconstructive effort as revision surgery to correct traumatic telecanthus is extremely difficult. Facial asymmetry secondary to soft tissue atrophy may be unpreventable to a certain degree. Anticipated late-volume changes may be expectantly managed with appropriate use of flap soft tissue composition. Excess volume may be later corrected with staged debulking procedures 6 to 12 months following primary reconstruction.[15,16]

Reconstitution of nasal form and function represents a particularly challenging component of facial reconstruction following trauma. Decreased nasal projection and deformity may be addressed in a delayed fashion with dorsal augmentation utilizing autologous dorsal bone or rib grafts, and alloplastic material such as porous polyethylene and silicone implants. A detailed review of dorsal augmentation techniques is beyond the scope of this article. Interested readers are directed to the references section for detailed review.[17–19] If color match with the recipient tissue is poor, medical tattooing may be used to camouflage the transition between donor and native tissue.[20] Dermabrasion also represents a viable option, although this should be employed in a more conservative and staged fashion 6 months to 1 year following free tissue reconstruction.[21]

Composite flap reconstruction of the floor of the mouth and oral cavity should be watertight to prevent fistula formation. If infection does ensue following reconstructive procedures, prompt recognition with drainage is critical in ensuring viability of the vascular pedicle and prevention of malunion. Additional soft tissue coverage of the pedicle may be necessary in this setting with the use of locoregional flaps such as pectoralis myofascial flap when possible.[22] In most cases, unless the oral tongue musculature is severely injured, oral intake and speech are preserved following an initial healing period. Oral function may, however, be compromised in cases of malocclusion, microstomia, and oral stomal incompetence. Restoration of premorbid occlusion, specifically in tooth-bearing mandibular segments, is critical and reliant on reestablishment of the maxillomandibular positioning. Use of intermaxillary fixation devices, dental splints, and prioritization of centric occlusion during reconstructive efforts have been shown to facilitate early oral rehabilitation.[23,24]

Lastly, when discussing reconstruction with free tissue transfer, we must discuss the flap compromise itself. The rates of flap failure secondary to vascular compromise appear to be similar to those reported in postablative oncological procedures.[1] Midface reconstruction, requiring lengthy vascular pedicles tunneled to donor vessels within the neck, are particularly susceptible to geometric kinking of vascular anastomoses with resultant venous thrombosis.[1,25] Efforts may be made to prevent this by dissecting a generous soft tissue tunnel through the buccal fat pad and over the mandible to mitigate the risk of vascular compression while orienting the pedicle to prevent vessel occlusion. A coronoidectomy may also facilitate extension of the pedicle in maxillary reconstruction.[26] Vein grafts may be employed if tension is anticipated along the length of the vascular pedicle.[27] In cases with extensive soft tissue edema of the lower neck, removal of the submandibular gland may facilitate access to branches of the external carotid system.

Future/Controversies

There have been more than 30 total facial allotransplantations performed in the United States.[28] This technique relies heavily on the principles of free tissue transfer, as it represents composite free tissue transfer of the face. Although this option allows reconstruction of the whole face, implementing the previously discussed principles, long-term effects and functional recovery have not been studied. Furthermore, rejection is a well-documented complication.[29,30] As expected with all chronic immunosuppression and organ transplantations, facial allotransplantation patients have a higher risk of malignancies and associated morbidities. However, for patients without superior options, facial allotransplantation may soon become a more established reconstructive option.

Tissue engineering offers the potential of autogenous cells that can be grown ex vivo and, ultimately, transferred to the sites of traumatic injury. However, given the significant extent of tissue involvement, this is likely too large to grow in a laboratory setting, particularly without a vascular supply. A proposed future direction to bypass this daunting limitation exists: ex vivo growth of the key structure, autoimplantation of the substructure to areas such as latissimus dorsi, then conventional free tissue transfer of both the substructure and host free tissue bed supplying the vascularity. Although in active research, this is not yet performed in humans.[31,32]

Conclusion

Free tissue transfer is an established option within the reconstructive surgeon's armamentarium and offers creative ways to reconstitute head and neck traumatic defects. It offers surgeons the ability to repair composite defects and restore function. Although frequently utilized, it should not always be considered the primary option in all traumatic defects. The limitations should be familiar to reconstructive surgeons, allowing optimal case selection and appropriate perioperative care.

Conflicts of Interest
None declared.

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