Soft Tissue Engineering

Roderick Youngdo Kim, DDS, MD, Sam Seoho Bae, DDS, MD,
Stephen Elliott Feinberg, DDS, MS, PhD*

KEYWORDS

• Soft tissue engineering • Craniomaxillofacial surgery • Oral and maxillofacial surgery
• Head and neck reconstruction • Composite flap • Prelaminated • Lip reconstruction
• Oral mucosa

KEY POINTS

- Barriers that compromise the outcome of soft tissue reconstruction include restoration of vascularity, motor function, sensory innervation, esthetics, and lack of tissue availability.
- Prelamination, prefabrication, and reconstructive innovations such as free tissue transfer have improved the surgical options for patients who sustain avulsion injuries to the craniomaxillofacial structure.
- Complex soft tissue units can be created in vitro and then be implanted onto a muscle bed to create a prelaminated flap in vivo.
- Prelamination/prefabrication of tissue engineered constructs may be the next stage of reconstructive innovation.
- Current proposed methods have the promise of complex tissue reconstruction with volitional, esthetic, and sensate rehabilitation.

INTRODUCTION AND BRIEF HISTORY OF SOFT TISSUE ENGINEERING IN CRANIOMAXILLOFACIAL SURGERY

There is a recognized need to reconstruct and restore complex craniomaxillofacial (CMF) soft tissues that have been damaged and/or disfigured as a consequence of motor vehicle accident, trauma, burn injury, or tumor resection. In trauma, injuries often create extremely complex geometric and avulsion defects, and the anatomic and functional intricacies of CMF composite soft tissue structures such as the lips, eyelids, and nasal complex make the reconstruction particularly challenging for maxillofacial surgeons (Fig. 1).

The value of function and esthetics has been a strong factor in driving innovations in CMF surgical techniques and technology. Currently, CMF surgeons frequently use commercially available skin substitutes such as collagen sponges and freeze-dried cadaveric human dermis to replace soft tissue. Unfortunately, these materials do not contain muscle, nerve, or epithelial components and, thus, fail to restore the necessary tissues to allow restoration of the functional properties seen with complex composite soft tissue injuries. Even with advances in both the efficacy and accuracy of surgical techniques and technology such as computed tomography-guided navigation

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Department of Oral & Maxillofacial Surgery, University of Michigan Health System, Towsley Center Rm G1114, 1515 East Medical Center Drive, Ann Arbor, MI 48109-5222, USA
* Corresponding author.
E-mail addresses: sefein@med.umich.edu; sefein@umich.edu

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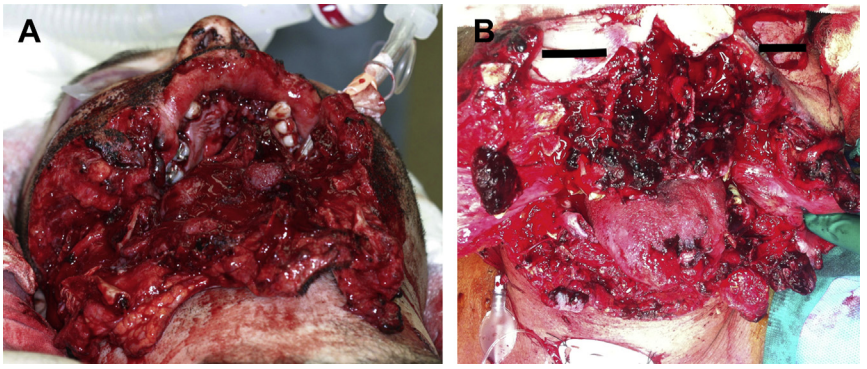

Fig. 1. Complex avulsed defect after self-inflicted gunshot wounds. (*A*) Lower lip only. (*B*) Complete "set" of lips. (*Courtesy of* [*B*] Dr Sean P. Edwards, University of Michigan, Ann Arbor, Michigan.)

systems, 3-dimensional computer-aided surgery, and vascular free tissue transfer, the reconstructive goals of form and function have not been met even in the hands of gifted reconstructive surgeons.[1]

Numerous approaches have been attempted to reconstruct CMF soft tissues, including autogenous, allogeneic, alloplastic, and xenogeneic options.[2] Currently, the majority of soft tissue reconstructive procedures use autologous tissue in the form of tissue grafts and vascularized flaps (pedicle or free), to bring healthy tissue to a compromised defect for optimal healing. However, this has inherent disadvantages of limited tissue availability, color mismatch, and shape incongruity.[3,4]

Several barriers that compromise the outcome of soft tissue reconstruction are the restoration of vascularity, motor function, sensory innervation, esthetics, and the lack of tissue availability. This article focuses on the role that tissue engineering/regenerative medicine (TE/RM) can play in addressing these barriers, and the impediments to optimal tissue reconstruction of complex soft tissue structures. We use the lips as an example to illustrate our points.

CURRENT RECONSTRUCTIVE OPTIONS IN SURGERY

CMF soft tissues form a dynamic complex structure that poses unique challenges in anatomic reconstruction and functional restoration. The lips are an example of a functional soft tissue facial unit that is complex and includes a mucocutaneous junction, innervated muscle, sensory innervation to both skin and mucosa, and blood vessels. Significant loss of lips is both a functional and esthetic concern (Fig. 2), because the neuromuscular control of normal lip structures is required for eating, drinking, talking, and social gesturing.

Avulsion of the lips is a survivable injury. However, without functional lip reconstruction, life for injured individuals is burdened by drooling, food spillage while eating, unintelligible speech, and social rejection. Present lip reconstructions are limited to harvesting existing anatomic units. This includes advancement flaps such as the Karapandzic, rotational flaps such as the Abbe flap, and free vascularized flaps such as the radial forearm fasciocutaneous flap. Functional reconstruction of the lips is so important that when more than 50% of the lips are avulsed or when more than 50% of the transplant team members deem the conventional means of reconstruction impossible or unsatisfactory, face transplantation under lifetime immunosuppression becomes an option.[5]

Fig. 2. Reconstructed lips with poor function, complicated by drooling, inability to incise, and unintelligible speech.