Tissue Engineered Prevascularized Bone and Soft Tissue Flaps

F. Kurtis Kasper, PhD[a], James Melville, DDS[b], Jonathan Shum, DDS, MD[b], Mark Wong, DDS[b,*], Simon Young, DDS, MD, PhD[b]

KEYWORDS

• Maxillofacial reconstruction • Microvascular surgery • Tissue engineering • Bioreactors • Growth factors • Personalized medicine

KEY POINTS

- Large composite defects of the maxillofacial region continue to pose major challenges to the reconstructive surgeon.
- Despite advances in reconstructive surgery using microvascular free flap techniques, donor site morbidity and the inability to recreate the original form of the bony defect has driven research into novel modalities of reconstruction.
- The in vivo bioreactor represents a promising method that combines microvascular surgical techniques with tissue engineering principles to create patient-specific vascularized bone flaps for the reconstruction of challenging maxillofacial defects.

INTRODUCTION

Large composite defects of the maxillofacial region pose major challenges to the reconstructive surgeon. This is especially true in the setting of a compromised wound environment (ie, osteoradionecrosis, contaminated/infected wounds, multiply operated sites). Advances in surgical techniques through the use of microvascular osteocutaneous flaps have increased the predictability of reconstructing large defects missing both hard and soft tissue. However, autologous tissue presents limited availability for transfer and is often not of ideal dimensions. Additionally, the harvesting of bone from the patient, either as a graft or as a free flap, necessitates donor site morbidity, with free tissue flaps requiring increased operating room time and technical expertise.

With the birth of tissue engineering in the mid-1980s[1] the groundwork was laid for identifying the different developmental processes and structures responsible for tissue and organ formation and applying this knowledge to regenerate tissue with anatomic accuracy and functional fidelity. Despite the transformation of tissue engineering from a nascent science into a scientific and commercial industry, few actual tissue engineering products have entered into clinical practice. One of the principal limitations identified by tissue engineers is the difficulty to create sufficient vascularity to support the constructs produced in the laboratory. This article describes the use of in vivo bioreactors to address this challenge and our experiences and those of others who have adopted this approach as a potential method of

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[a] Department of Orthodontics, The University of Texas School of Dentistry, 7500 Cambridge Street, Suite 5130, Houston, TX 77054, USA; [b] Department of Oral and Maxillofacial Surgery, The University of Texas School of Dentistry, 7500 Cambridge Street, Suite 6510, Houston, TX 77054, USA
* Corresponding author.
E-mail address: Mark.E.Wong@uth.tmc.edu

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producing composite grafts for maxillofacial reconstruction.

CURRENT METHODS OF MAXILLOFACIAL RECONSTRUCTION

Maxillofacial reconstruction has evolved from nonvascularized grafting to the introduction of microvascular free flaps in the late 1980s and early 1990s. The impact of free flap reconstructions has been so profound that it has been considered to be one of the most influential advances in head and neck surgery to date.

Generally, the goals for head and neck reconstruction are addressed with the use of flaps from one of three areas. The fibula, anterior lateral thigh (ALT), and radial forearm free flaps are the most commonly used donor sites because of their ease in harvest, modest donor site morbidity, and ability to include a large volume and variety of tissue types from a single vascular pedicle. For defects requiring composite soft tissue and bony reconstruction, options include the fibula, scapula, and deep circumflex iliac artery sites.

The fibula is commonly used for bony reconstructions of the head and neck because of its long bone stock, generous vascular pedicle caliber and length, ability to incorporate soft tissue, and acceptable morbidity at the donor site. Variations in anatomy of the fibula can limit the height and width of the flap requiring additional bone grafting procedures, and variations in the vasculature of the lower leg can affect the pedicle length necessitating the use of interpositional vein grafting. The lack of adequate bone height, especially when reconstructing nondentate mandibles, leads to discrepancies in the bone level and this can make dental rehabilitation a challenge. Fig. 1 demonstrates a reconstructed

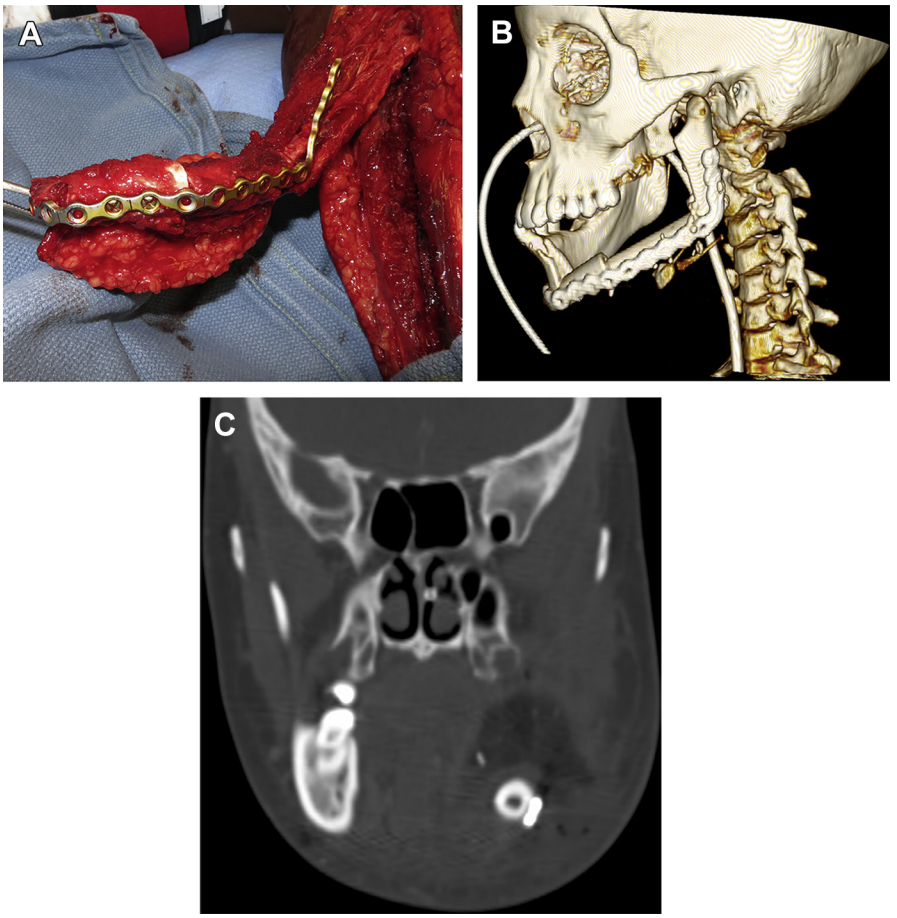

Fig. 1. (*A*) Fibular construct for a left segmental mandibulectomy defect before harvest from the donor site. (*B*) Lateral postsurgery three-dimensional reconstruction with fibular construct inset into recipient site of left segmental mandibulectomy defect. Note the deficient bone height compared with the contralateral mandible. (*C*) Coronal view at the level of the body of the mandible. The right native mandible is compared with the left reconstructed mandible.

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