Emerging Biomaterials in Trauma

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KEYWORDS

• Amniotic mesenchymal stem cells • Osteosynthesis • Bicortical fixation • Biocompatible • Resorbable • Scaffolds

KEY POINTS

- The goal of research in the field of biomaterials is to find replacement constructs that can replicate, both in form and function, any lost or missing native tissue.
- The ideal characteristics of such constructs must mimic native tissues regarding weight, density, strength, and modulus of elasticity, among many others.
- Autografts are currently the gold standard for the replacement of missing tissues, but the possibility of producing replacement tissues without having a patient incur discomfort from a donor site is a close reality.
- Biomaterials currently in use include titanium, silicones, porous polyethylene, polylactic acid, vicryl meshes, and hybrids of these and many other materials.

Video content accompanies this article at http://www.oralmaxsurgery.theclinics.com.

INTRODUCTION

Injuries of the facial skeleton pose unique and complex challenges to the maxillofacial trauma surgeon. Over the past few decades, significant advances in biotechnology have provided materials and tools to more efficiently, predictably, and reliably reconstruct and rehabilitate patients who have suffered such injuries. Goals to restore form and function have been aided immensely by the advent of new and innovative biomaterials and clinicians should strive to be familiar with and incorporate these new technologies.

This article reviews the various biomaterials available for repair and reconstruction of most maxillofacial injuries. The more common/traditional materials used to repair each type of fracture as well as some of the newer options available are reviewed. Indications and benefits for the various options of materials commonly used for each type of fracture are discussed.

IDEAL MATERIAL CHARACTERISTICS

Biomaterials are generally categorized as either naturally occurring or synthetic. Naturally occurring materials include autogenous grafts, allografts, and xenografts. Alloplasts are generally synthetic materials (Table 1).

Potter and Ellis[1] established the ideal properties of biomaterials. First and foremost, they should be able to replicate native tissues – that is, they should take on the required shape and contour of the tissues they are meant to repair/reconstruct, and they should retain those features. They may either be prefabricated to fit a necessary dimension or possess the ability to be cut/shaped to these required contours. Furthermore, they should also ideally have similar weight and density, modulus of elasticity, and strength of the tissue they are replacing.[1–4] For example, titanium plates used for mandibular reconstruction are designed to bear the load of occlusal forces while having

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Oral Maxillofacial Surg Clin N Am 29 (2017) 51–62
http://dx.doi.org/10.1016/j.coms.2016.08.010

Table 1
Biomaterials commonly used in maxillofacial surgery

Metals	Calcium Ceramics	Polymers	Acellular Biologics	Bioengineered
Stainless Steel	Hydroxyapatite	Silicone	Collagen	rhBMP
Cobalt-chromium	Hydroxyapatite cement	PMMA	Dermal allograft	Amnion
Titanium	Bioactive glasses	Nonresorbable polyesters		Chorion
Gold	Tricalcium phosphate	Resorbable polyesters		rPDGF (Gem21)
		Polyamides		
		Polyethylene		
		Cyanoacrylates		
		PTFE		

Abbreviations: PTFE, polytetrafluoroethylene; rPDGF, recombinant PDGF.

the ideal strength and hardness to avoid fatigue or failure. Second, they should be biocompatible, meaning they are chemically inert, are nonallergenic, are noncarcinogenic, and do not promote bacterial growth or infection. Last, they should have adequate ease of handling. Again, the operator must be able to adjust the contour and size of the material to the appropriate dimensions as well as have the ability to fixate or otherwise stabilize it in the native tissues. The ideal material should also be sterilizable without deformation.

Additionally, it should be designed to remain in place indefinitely unless it is resorbable yet also easily removable if necessary due to rejection, infection, and/or failure.[5] If the material is designed to be resorbable it should be completely resorbed by the body in an appropriate time frame with minimal adverse biological reaction (**Box 1**).

Additional properties that are preferable include low cost and availability and radiopacity for radiographic evaluation. There is no perfect material for every indication or every situation, but the authors select the materials based on their properties and their applicability in each individual scenario. The advent of newer biotechnology has refined and perfected many of the properties sought in an ideal biomaterial.

Box 1
Ideal properties of biomaterials

- Replicate native tissue contour
- Similar density/modulus of elasticity
- Strength/stabilizable
- Biocompatible/inert
- Noncarcinogenic
- Ease of handling
- Cost effective
- Available
- Radiopaque versus radiolucent
- Sterilizable

REDUCTION AND OSTEOSYNTHESIS OF FACIAL FACTURES

Although description of specific operative techniques for the repair of each injury is beyond the scope of this article, the material properties for reduction, fixation, and reconstruction after several different types of facial injuries, including but not limited to, orbital, frontal sinus, naso-orbitoethmoidal, zygomaticomaxillary complex, Le Fort, and mandible fractures, are discussed. The various materials available for bone and soft tissue grafting in the immediate and delayed stages are also discussed.

Orbital Fractures

Material selection in the repair of orbital trauma is unique for many reasons, predominantly due to the shape of the bony orbit. Additionally, size, contour, number of walls involved, and the capacity for immediate versus delayed repair have played a role in implant selection. For the ideal orbital material, the implant should be able to be cut, contoured, and sized with precision, because the orbital volume is limited. Furthermore, the material should be malleable and without memory but have enough rigidity to retain a desired shape and support orbital contents. Likewise, the ideal orbital material must allow for enough support to enable restoration of volume and proper globe projection while also being thin enough to avoid exophthalmos when placed beneath the globe and orbital soft tissues. The material must also have a smooth surface to avoid impingement or