Public Abstract

Complex Orbital Reconstruction

Principal Investigator: GRAYSON, WARREN L
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Rationale and Objective: When significant portions of more than one facial subunit are discontinuous from traumatic war events, replacement in these patients is limited. For decades, plastic and reconstructive maxillofacial surgeons have tried to adequately reconstruct war victims severely disfigured by burns, traumatic avulsions, and ballistic trauma. Even the most inventive reconstructive surgeons using conventional techniques -- grafts, tissue expansion, local tissue rearrangement, distant pedicle flaps -- have disappointing results with poor motor function and unsatisfactory aesthetics. A major challenge in treating these patients is that the bone tissue has complex geometrical shapes and is highly vascularized. Therefore, a composite (vascularized bone) tissue replacement strategy is required, and there is significant need for better solutions to achieve adequate anatomical, functional, and aesthetic restoration of the complex periorbital injuries.

Mid-face and periorbital injuries in particular represent a unique surgical challenge. Recent epidemiological data from 2001-2011 found that there were 1760 craniofacial injuries in the Iraq and Afghanistan conflicts. While mandibular defects are a common focus of inquiry and an important topic, midface fractures have unique challenges. There is a high incidence of orbital fractures and severe globe injuries. There is also a high complication rate (30%) with current treatment modalities that include malalignment, implant exposure, and infection. Thus, there is significant need for innovative therapies that can provide an accurate anatomic correction of the bony skeleton to reduce these complications. Because of the complex geometry of bone in the periorbital region including the thin orbital floor, it is necessary to employ a strategy capable of recapitulating precise geometries and robust mechanics. To regenerate the tissue, it is essential to employ porous constructs capable of facilitating and inducing ingrowth of blood vessels to stimulate the formation of robust vascular networks within the newly regenerating bone tissues. Due to the close interplay between bone and the vascular components during the trauma and reconstruction, these tissues and their corresponding therapeutic replacements must be considered together from the early stages of design and testing. The proposed research will translate technologies developed under an Investigator-Initiated Proposal to provide Complex Orbital Reconstruction through a hybrid synthetic/biological scaffold that direct tissue growth.

Ultimate Applicability of the Research: Craniofacial injuries are prevalent among deployed Soldiers due to the difficulty in achieving adequate protection for the face. Explosives in particular create complex facial injuries damaging multiple tissues. Non-battlefield craniofacial injuries are also a challenge and affect both military and civilian populations. These non-battlefield injuries include trauma blunt trauma from motor vehicle accidents and falls. Preliminary data, mostly obtained during the previous Investigator-Initiated Craniofacial Reconstruction Grant, demonstrates the development of the technology for the treatment of hard tissue defects. The translation of the developed technologies requires a number of steps to move towards clinical testing including formulation "lock," development of Standard Operating Procedures, and manufacturing according to regulations. Here in this proposal we will translate a technology for bone reconstruction that utilizes 3D printing techniques to generate a biosynthetic degradable implant that matches the exact anatomical needs of a specific patient injury. Furthermore, new tissue development is promoted with the intraoperative use of cells from fat tissue that aids in regenerating a vascular supply as well as new bone. This new technology provides unprecedented capability to reconstruct complex periorbital bone defects.

Benefit to Military Service Members: The expected developments in the technology and surgical management of these complex injuries as a result of the proposed research have the potential to improve the standard and ease of care for military personnel experiencing both battlefield and non-battlefield trauma injuries. Flexible composite tissue reconstruction solutions will be translated to provide solutions for the unique hard tissue injuries in the periorbital region to achieve better functional and aesthetic outcomes with fewer surgical procedures and therefore reduce patient morbidity.
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