Conferences on Orthodontics Advances in Science and Technology (COAST) Foundation's Second Biennial Symposium: Craniofacial Skeletal Bioengineering, Asilomar Conference Center, Pacific Grove, CA, USA, August 27–30, 2004

In the August volume of this journal, the manuscripts discussed the basic foundations and principles of tissue engineering. In this volume, the papers present the translation of these findings and concepts to bioengineer skeletal and dental tissues and organs, and their applications to restoration of craniofacial defects and deficiencies in humans. The specific focus of these manuscripts is on research and development, manufacture and clinical applications of bone or cartilage alone or in combination, as well as that of teeth and the periodontium.

The regeneration and repair of bone and cartilage has been studied extensively and engineered tissues have had substantial but not complete clinical success. The application of general principles of engineering bone and cartilage to the regeneration of specific craniofacial skeletal tissues is discussed. Skeletal tissue engineering is entering a new phase involving the development of complex tissues with heterogeneous phenotype such as osteochondral tissues that have potential applications to joint reconstruction. Osteochondral tissues have been developed *in vitro* by co-culturing osteogenic cells and chondrogenic cells on a three-dimensional load-bearing bioresorbable polymer scaffolds. This initial promise of engineered osteochondral tissues is likely to lead to the engineering of even more complex structures such as the temporomandibular joint in the future. This exciting area for future developments will require substantial interdisciplinary interactions to decipher what are the optimal scaffolds and cells for the different tissue types in the joint, the temporal and spatial localization of appropriate mechanical and biologic stimulants, mechanical testing of the product *in vitro*, and the evaluation of its success *in vivo*.

Repair of tooth-supporting structures destroyed by the chronic inflammatory disease periodontitis has had relative success over the past few years through use of guided tissue regeneration and bone grafting techniques supplemented with growth factors. However, comprehensive periodontal tissue engineering whereby the complex periodontal tissues comprising the tooth cementum, periodontal ligament and bone regenerate *in vitro* or *in vivo* is still in its infancy. The major future goal of periodontal reconstructive therapy will entail regenerating these tissues predictably. The papers presented include a review of emerging therapies in the areas of materials science, growth factor biology and cell/gene therapy in periodontal regeneration, and highlight the use of several different polymer delivery systems that aid in the targeting of proteins, genes and cells to periodontal and peri-implant defects.

Over the past three decades substantial progress has been made in understanding the developmental, cellular and molecular biology of tooth development. This together with the greater understanding of mesenchymal/epithelial interactions in tooth morphogenesis and the availability of stem cells from developing or exfoliated teeth has led many investigators to envision engineering teeth for transplantation into patients who have developmentally missing teeth or have lost them due to disease. One of the main long-term goals of such studies is to generate biological replacement teeth using autologous tissues obtained from the tooth of the recipient. To accomplish this goal, a number of obstacles must first be overcome, including: identification of adult tissues that can be used to generate bioengineered tooth structures; to devise methods to generate and characterize enriched populations of human dental stem cells; to perfect the tooth tissue engineering techniques to reproducibly generate bioengineered tooth tissues, including dentin, enamel, cementum, periodontal ligament, and alveolar bone, of predetermined size and shape, and identify appropriate scaffolds. Accomplishing these goals will provide the necessary foundation to begin clinically relevant human biological replacement tooth therapy trials that will ultimately lead to dramatic transformation of the practice of dentistry.

The ultimate goal of all the research in tissue engineering is its successful application in human subjects. Thus far many of the successes in animal models have not necessarily been replicated in humans. Furthermore, several issues of technology transfer still remain to be addressed. These include questions such as: 1) Defining clinical protocols to optimize transplantation of engineered tissues to ensure their long-term success. 2) Identifying the best approaches to teach new methodologies to practicing clinicians and those currently enrolled in dental schools. (3) Determining the clinical and laboratory skill sets that clinicians will need to be conversant (e.g. will they need to have the knowledge and expertise for retrieving stem cells?) and/or speak and understand the language for appropriate referrals for these procedures. (4) How will these clinicians identify patients that are good candidates for these treatments? (5) How will current and future tissue engineering corporations best interact with clinicians? (6) Are tissue-engineering processes amenable to being automated in order to support increased output efficiencies and reduced costs? It is our hope that, as the field of bioengineering matures, these questions and others will be answered at such future conferences.

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