Functional Assessment of Engineered Tissues and Elements of Tissue Design

Breakout Session Summary

Moderator
FARSHID GUILAK, Duke University Medical Center
RAVI KAPUR, Cellomics, Inc.

Panelists
MICHAEL V. SEFTON, University of Toronto
HERMAN H. VANDENBURGH, Brown University School of Medicine
ALAN P. KORETSKY, National Institutes of Health
ANDRES KRIETE, Tissue Informatics, Inc.
REGIS J. O’KEEFE, University of Rochester

Rapporteur
FARSHID GUILAK, Duke University Medical Center

BROAD STATEMENT

Tissue engineering is a rapidly growing field that seeks to repair or replace tissues and organs by delivering combinations of cells, biomaterials, and/or biologically active molecules. Tissue engineering merges several aspects of engineering, biology, and medicine, and many rapid achievements in this field have arisen from significant advances in the integration of these fields. Despite early successes, however, few functional tissue-engineered products are currently available for clinical use. The development and application of rational design criteria and technologies for the assessment of tissue function would be expected to improve the success of engineered products.

VISION

Tissue engineering has the potential to dramatically alter the treatment of numerous diseases by enabling the repair of injured or diseased tissue with living replacements. The overriding vision of this field is to improve the speed, extent, and duration of tissue repair over currently available methods. Most tissue-engineered products must serve multiple, complex functions, including inter-related metabolic and structural (i.e., biomechanical) demands. Many challenges still remain in the ability to restore the native function of various organs and tissues. In the next 5–10 years.

years, advances in two important and related areas are presented as mechanisms to improve the outcome of engineered tissue replacements: (1) the assessment of function in engineered tissues, and (2) the application of rational design principles. Incorporation of these approaches must span multiple hierarchical scales, from the macroscopic level, directed at satisfying the clinical requirements of the product, to the microscopic level, directed at satisfying the cell and molecular requirements for long-term functional success.

OBJECTIVES

The ultimate goal of tissue engineering is to restore the function of injured or diseased tissues. However, many challenges remain, particularly with respect to functional assessment and the design of tissue replacements. Many of the complex structural and metabolic functions of tissues and organs are not fully understood, even for native tissues. In this respect, what constitutes “success” needs to be defined a priori and will be expected to differ among tissues. For example, tissues or systems that are designed to prolong life may tolerate a lower margin for error than those that are designed to improve the quality of life. The difficulty in performing a surgical procedure, and the duration that a specific treatment lasts will influence the cost-effectiveness of a procedure and therefore may also factor into its perceived success. For example, therapies of replacement or regeneration of blood vessels or cardiac muscle might be expected to last the lifetime of the individual, while replacement of cartilage may be considered successful if it delays total joint replacement for five to ten years.

OBSTACLES AND CHALLENGES

The following obstacles and challenges were identified: (1) A primary need in this field is the development of fundamental principles and standards that cross multiple disciplines. In this respect, researchers with different expertise and backgrounds will be more likely to seek common goals in the development of engineered tissues. (2) As it is unlikely for an engineered replacement to meet all of the functional demands of native tissue or organ, it is critical to prioritize the needs and to determine the relationship between specific functional properties and the overall clinical success of product. The definitions of “function” should be broadened to include biomechanical, electrophysiological, and metabolic properties, where appropriate. (3) Trial-and-error approaches have led to rapid advances in the field of tissue engineering, but are inherently limited in many cases. A balance of “rational” design approaches with trial-and-error methods is recommended. Such approaches will require further basic science studies in tissue engineering systems in addition to translational research. (4) Interdisciplinary collaborations are the foundation of tissue engineering and will be necessary for significant advances in the field. Such approaches must be fostered from the student level to that of research partnerships through increased interaction and communication among disciplines.

The breakout panel identified the following specific areas as critically in need of investigation: (1) minimally invasive imaging in tissue engineering; (2) high-
throughput cellular activity profiling and molecular characterization; (3) modeling of biological systems in reparative medicine; (4) the influence of biophysical factors on engineered tissues; (5) and controlled, prospective, and randomized outcomes studies in reparative medicine.

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