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ADVANCES IN SURGERY

Tissue Engineering

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Keywords

• Tissue engineering • Regenerative medicine • Scaffolds • Cells • Stem cells • Growth factors

Key points

- Tissue engineering (TE) is a rapidly growing, interdisciplinary field that is devoted to the manufacture of intact tissue and organ constructs by imitating natural biological development.
- TE typically involves the seeding of cells on growth-supporting scaffolds to generate viable, implantable tissues, which can then replace, restore, and/or maintain function in sites of injury and damage in vivo.
- The ultimate goal from a TE standpoint is to bioengineer and transplant complex organs from the patient's own cells and material.
- The monumental progress in TE demonstrates that regenerative approaches to problems in general surgery justify attention and investment from the government and private companies.

INTRODUCTION

Tissue engineering (TE) is a rapidly growing, interdisciplinary field within the health sciences that is devoted to the manufacture of intact tissue and organ constructs by imitating natural biological development (Box 1). The field aims to regenerate whole biological components outside the body for eventual replacement therapy (ie, implantation) via the manipulation of cells, natural or synthetic cell-supporting scaffold materials, and bioactive molecules [1,2]. TE holds promise in addressing the urgent need of all surgical subspecialties requiring viable, transplantable body parts for the reconstruction of a myriad

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Box 1: Basic nomenclature

- Regenerative medicine: In 2006, UNESCO stated that regenerative medicine is a superdiscipline whose contours are still being defined (http://unesdoc.unesco.org/images/0014/001454/145409e.pdf). As of now, no official, universally accepted definition of regenerative medicine has ever been formulated by any of the societies that sponsor this field. A reasonable definition would be that regenerative medicine refers to a field in the health sciences which, through the manipulation of cells, natural or artificial scaffolding materials, growth factors, gene manipulation, or combinations of all these elements, aims to restore or reestablish normal function in a nonfunctioning bodily district. Some sources have associated the term regenerative medicine with the idea of repairing the human body by replacing diseased cells, tissues, or organs with their new counterparts. Nevertheless, the idea of ''replacing'' body parts is inappropriate and abusive, as it refers to an idea that is intimate and peculiar to transplantation. The process of regenerating body parts can occur in vivo or ex vivo.
- Tissue engineering: Refers to the manufacturing of body parts ex vivo, a goal that is achieved mainly by seeding cells on and/or into a supporting scaffold. All bioengineered organs that have been implanted in humans thus far have been manufactured using tissue engineering technologies. Tissue engineering theoretically is a subfield of regenerative medicine.
- In this article, the terms regenerative medicine and tissue engineering are used synonymously.

of anatomic structures. For instance, TE has shown potential to address major problems in transplantation, such as donor organ shortage and the need for lifelong immunosuppression, by (1) serving as a potentially inexhaustible source of tissues and organs and (2) circumventing the need for immunosuppression by growing tissue via the expansion of autologous cells (Fig. 1) [3–5].

Indeed, recent reports on the manufacture and implantation of bioengineered vessels [6–13], bladders [14], airways [15–17], urethras [18], and heart valves [19] showcase the manners in which TE methodologies could dramatically enhance the toolkit of surgical reconstruction. Equally provocative have been advances in the bioengineering of solid organs such as the heart and its valves [20–22], the liver [23–26], the lung [27,28], the kidney [29], the pancreas [30], and the small bowel [31].

Although the appearance of the term TE in the academic literature is a relatively recent development (Fig. 2), it is not difficult to recognize that the surgical fields of transplantation and reconstruction have significant overlap with TE with regard to their histories and goals. Furthermore, recent advances in TE make clear that large-scale clinical translation is a pertinent goal for the current generation. Thus, with patients in mind, the time is right for TE and surgery to properly coalesce and spark a new paradigm. This review examines the most important applications of TE particularly as applied to transplantation and reconstruction while highlighting the key principles guiding current investigations.