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TISSUE ENGINEERING IN DENTISTRY

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Abstract
Dental ailments such as periodontal diseases, dental caries and bone loss are prevalent oral diseases worldwide affecting the quality of life. Tissue engineering is a newly emerging biomedical technology that combines the principles of engineering, material and biological sciences toward the development of therapeutic strategies and biological substitutes that restore, maintain, replace or improve biological functions. The association of biomaterials, stem cells, growth and differentiation factors have yielded the development of new treatment opportunities in most of the biomedical areas, including dentistry. The objective of this paper is to present the principles underlying tissue engineering and the current scenario, the challenges and the perspectives of this area in Dentistry.
Keywords: Tissue engineering, biomaterials, stem cells, scaffolds, molecular biology, regeneration medical therapy.

INTRODUCTION

In the 1980s, Professor Joseph P. Vacanti and Robert Langer from the United States first explored tissue engineering research (Vacanti et al., 1988). In 1993, they defined tissue engineering as "an interdisciplinary field that applies the principles of engineering and the life sciences toward the development of biological substitutes that restore, maintain, or improve tissue function".[1]

Tissue Engineering is a general name of biomedical fields to enable cells to enhance their proliferation, differentiation, and morphological organization for induction of tissue regeneration, resulting in regenerative medical therapy of diseases. For this purpose, it is important that a local environment suitable for the cell-induced regeneration is created by functionally combining various biomaterials, protein, and gene. The recent rapid advent of molecular biology together with the steady progress of genome projects has provided us some essential and revolutionary information of gene which may elucidate several biological phenomena at a molecular level. Based on the genetic information, gene manipulation has become one of the key technologies indispensable to the basic research of medicine and biology, while it also will open a new field for gene therapy of several diseases and tissue engineering. Gene therapy by use of virus vectors and cell therapy with cells genetically engineered have been performed. Although their biological and therapeutic results by virus vectors are practically promising, their research use and clinical therapy are often limited by difficulty in the handling and the adverse effects of virus vector itself, such as immunogenicity and toxicity or the possible mutagenesis of cells transfected.

Therefore, it is of prime importance for future development of the research and clinical fields to create the non-viral vectors of synthetic materials for enhanced transfection efficiency of gene into mammalian cells both in vitro and in vivo.

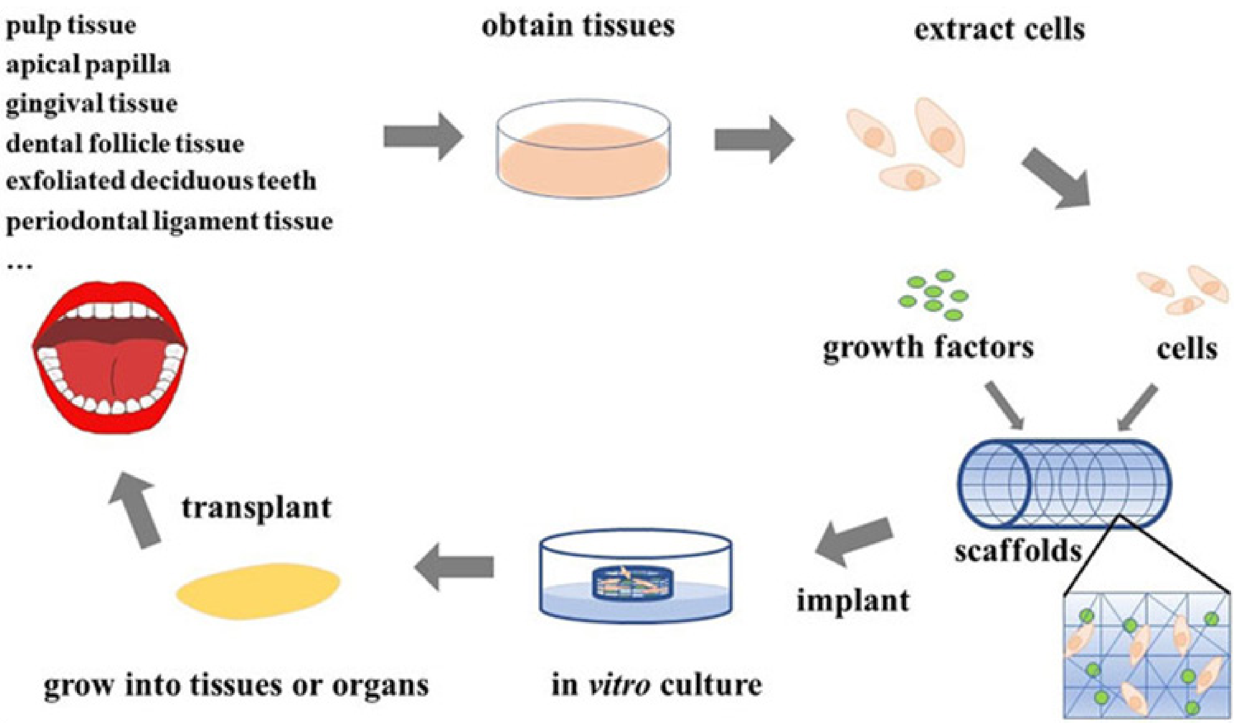
A variety of patients suffer from injured and deficient tissues or damaged organ functions. In this case, there are only two therapeutic choices, reconstructive surgery and organ or/and tissue transplantation. However, they encounter several clinical issues to be resolved, such as poor biocompatibility of biomaterials and artificial organs and the shortage of tissue or/and organ donors or the adverse effects of immunosuppressive agents eventually taken. To break through the problems, it is necessary to develop a new therapeutic strategy. One promising strategy is called regeneration medical therapy where disease is cured based on the natural healing potential of patients themselves.

Tissue engineering is a biomedical technology or methodology which enables cells to enhance the proliferation and differentiation, resulting in natural promotion of tissue regeneration for disease therapy.[2,3,4,5] In tissue engineering, cells and the scaffold or biosignal molecules to accelerate their proliferation and differentiation are combined and used to induce tissue regeneration. Among the signaling molecules, growth factor and the related gene are promising in the cell-based tissue regeneration. It has been demonstrated that growth factors are efficiently used to realize the regeneration therapy of various tissues.[6]

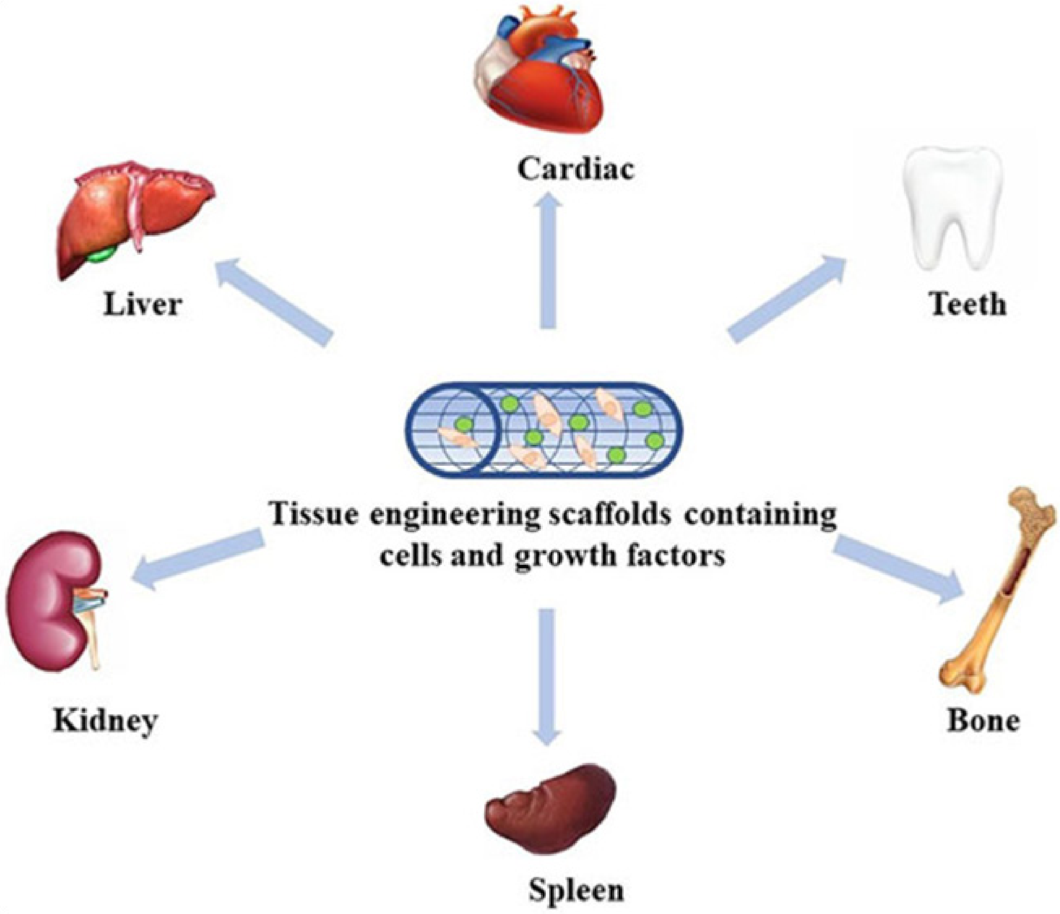
With the recent advent of basic molecular biology and genomics, gene has been considered as one candidate of therapeutic agents. Gene therapy has been experimentally and clinically tried mainly aiming at the therapy of tumor and immunologic disease. However, it will be therapeutically applicable to different types of disease. For example, it is expected that genes which codes biosignal molecules to promote the proliferation and differentiation of cells, play an important role in tissue engineering to induce tissue regeneration. There are two carrier systems for gene therapy, viral and non-viral carriers. The former has been mainly used because of the high transfection efficiency.

However, the inherent toxic and safety issues should be considered. Viral vectors, such as adenovirus, retrovirus, and adenoassociated virus, have been mainly used because of the high efficiency of gene transfection although the clinical trials are quite limited by the adverse effects of virus itself, such as immunogenicity and toxicity or the possible mutagenesis of transfected cells. On the other hand, one large problem of the latter is low efficiency of gene transfection.

Principle of tissue engineering



Application of tissue engineering. At present, tissue engineering has been widely used in many fields, including the heart, liver, kidh.



Stem cells are clonogenic cells capable of self-renewal and capable of generating differentiated progenies. These cells are responsible for normal tissue renewal as well as for healing and regeneration after injuries[7]. Some stem cells are said to be pluripotent, i.e. have the ability to differentiate into many different cell types while the range of others are more restricted. The most pluripotent cells are found in the inner cell mass of blastocyst during the early stages of embryo development [8]. They can differentiate into each of the more than 200 cell types of the adult body [9] when exposed to appropriate stimuli. Along with the potential applications of totipotent cells lies a strong ethical discussion regarding the use of human embryos. This issue has strengthened the retional for the use of adult stem cells, which have been identified in every tissue formed after embryonic development and can be used to the same purpose of embryonic stem cells.

Studies have showed that it is possible to isolate clonogenic and highly proliferative cells from dental pulp using similar research protocol to isolate and characterize bone marrow stem cells [10]

Dental pulp stem cells (DPSC) can differentiate into multiple cell lineages, such as adipocytes, chrondocytes, neurons and odontoblasts.[11-13] Stem cells from human exfoliated deciduous teeth (SHED) were also identified and isolated.[14] SHED has the advantage of being retrievable from naturally exfoliated teeth, which are one of the only disposable post-natal human tissues. As primary teeth are clearly a feasible source of post-natal stem cells, the interest toward the differentiation power of SHED cells has increased. Indeed, today we know that SHED can undergo adipogenic, chondrogenic, osteogenic, endothelial and odontoblastic differentiation.[15,16,17,18] The ability that these cells have to cross lineage boundaries expands the potential use of SHED for therapies involving a large number of tissues.

CONCLUSION

Tissue engineering has broad prospects in stomatology and provides a valuable direction for future research on tooth loss, periodontal defects, dental implants, cleft palate defects, oral and maxillofacial skin or mucosal defects, and bone defects. It is believed that with the in-depth exploration of tissue engineering, ideal seed cell, better scaffold materials, and growth factors will be discovered and applied in effective clinical management of oral diseases in the future.

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