Chapter VIII
Advances and Trends in Tissue Engineering of Teeth

Shital Patel
Swinburne University of Technology, Australia

Yos Morsi
Swinburne University of Technology, Australia

ABSTRACT
Tooth loss due to several reasons affects most people adversely at some time in their lives. A biological tooth substitute, which could not only replace lost teeth but also restore their function, could be achieved by tissue engineering. Scaffolds required for this purpose, can be produced by the use of various techniques. Cells, which are to be seeded onto these scaffolds, can range from differentiated ones to stem cells both of dental and non-dental origin. This chapter deals with overcoming the drawbacks of the currently available tooth replacement techniques by tissue engineering, the success achieved in it at this stage and suggestion on the focus for future research.

INTRODUCTION
The occurrence of children born with missing primary and/or adult teeth (hypodontia) is momentous (Nunn et al.) and tooth loss resulting due to various pathological conditions like periodontal disease, dental caries, trauma, or a variety of genetic disorders affects most adults around the world. As per Mooney et al., periodontal disease is one of the most significant oral health problems in the U.S. (35% of the U.S. population is estimated to have periodontitis, and 80% of these also suffer from gingivitis).

Although there are several materials, which are used to replace lost tooth structures, none can completely replace the lost functions. Thus, as compared to endodontic treatment, tooth transplantation, and dental implants, the de novo
regeneration of dental tissues might be a better approach in restorative dentistry (Zhang et al.). John Hunter carried out homologous transplantation of teeth in humans, which was a common technique in the United Kingdom during the eighteenth century. According to him, if teeth were transplanted from a “sound and healthy” person, they might last for years. However, there is a possibility of transmitting infections in some cases; which was also discussed by him (Schultheiss et al.). Present day technique of dental implant is more prone to mechanical and biological failure as compared to the natural dentition. In addition to this, they require a minimum level of bone, which makes its use limited in cases of severe bone loss (Ferreira et al.). Also these techniques can elicit an immune stimulated host rejection response.

As the innate, biological tooth is better equipped to deal with biological threat and mechanical loading, the long-term goal of dental research is to develop methods of tooth replacement biologically. The ideal way of tooth replacement is to create a new, natural tooth from autologous human tissues. Progress in the field of tissue engineering and stem cell biology make it now feasible to investigate ways to make this become a reality. Ferreira et al have talked of several different methods that have been proposed to achieve biological tooth replacement. These include stimulation of the formation of a third dentition, the construction of a tooth by bioengineering the different component parts separately, seeding of tooth shaped biodegradable scaffolds with stem cells and producing embryonic-like tooth primordia from cultured cell populations. Each of these approaches has advantages and disadvantages.

**Tissue Engineering Approach**

Tissue engineering (TE) is a multidisciplinary area that integrates the principles of engineering and biological sciences to develop a biological substitute, which can be used to repair, regenerate or replace parts of the body.

A general approach of TE involves the use of temporary porous three-dimensional scaffolds to: (a) define the complex anatomical shape of the tissue, (b) guide the proliferation and differentiation of seeded cells and (c) provide mechanical support for the cells (Morsi et al.). Thus scaffold plays a key role in tissue engineering by providing the initial extracellular matrix required to support the growth and proliferation of cells.

Various techniques are available for manufacturing the three-dimensional scaffolds that are dependent on the optimal scaffold required for the application on hand. The ideal scaffold should possess following characteristics: (i) the rate of scaffold degradation should be in accordance to the rate of tissue growth, (ii) the surface of the scaffold should be conductive to cell attachment, growth and differentiation, (iii) possess required pore size and interconnectivity for tissue integration, vascularisation and transfer of nutrients and waste removal, (iv) have adequate mechanical strength and flexibility to suit intended application, (v) possess high surface area to volume ratio and (vi) the scaffold should be easy to process and be manufactured in a cost effective manner.

The design of an ideal scaffold has to be accompanied by the selection of a suitable material. Several synthetic biodegradable polymers, such as polyglycolic acid (PGA), polylactic acid (PLA) and their copolymers, natural materials like collagen, fibrin and alginate are the most commonly used materials as scaffolds for tissue engineering applications. Irrespective of the type of material used and its application, it should be biocompatible, easy to modify, should have structural stability, and should be versatile, biodegradable and malleable.

The techniques being used for manufacturing 3D scaffold for TE has undergone considerable changes in the last decade and these techniques are continuously being evolved to accommodate...