ORIGINAL RESEARCH PAPER

Periodtonlogy

3D PRINTING AND ITS APPLICATIONS IN DENTISTRY

KEY WORDS:

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ABSTRACT

3D printing has been hailed as a disruptive technology which will change manufacturing. Used in aerospace, defence, art and design, 3D printing is becoming a subject of great interest in surgery. The technology has a particular resonance with dentistry, and with advances in 3D imaging and modelling technologies such as cone beam computed tomography and intraoral scanning, and with the relatively long history of the use of CAD CAM technologies in dentistry, it will become of increasing importance. Uses of 3D printing include the production of drill guides for dental implants, the production of physical models for prosthodontics, orthodontics and surgery, the manufacture of dental, craniomaxillofacial and orthopaedic implants, and the fabrication of copings and frameworks for implant and dental restorations. This paper reviews the types of 3D printing technologies available and their various applications in dentistry. We also briefly discuss their possible adoption for periodontal regeneration.

INTRODUCTION

The term 3D printing is generally used to describe a manufacturing approach that builds objects one layer at a time, adding multiple layers to form an object. This process is more correctly described as additive manufacturing, and is also referred to as **rapid prototyping** [1]. 3D printing technologies are not all new; many modalities in use today were first developed and used in the late 1980s and 1990s [2].

Bone augmentation can be carried out using different techniques. Although conventional bone grafting materials serve the role of a supporting matrix, they have several disadvantages: allografts, xenografts, and alloplasts are brittle, poorly processable into porous forms, and are unable to generate structures tailored to the specific needs of patients. Likewise, they are unable to maintain the desired generated tissue volume under mechanical forces, hindering their ability to provide a proper template for effective cell interaction. To this end, tissue engineering has become more commonly used for oral bone grafting procedures [3].

Tissue engineering is a multi-disciplinary field which aims to incorporate aspects of cell and molecular biology and material science in order to regenerate lost or damaged tissues and organs. A variety of tissue engineering approaches have been proposed for alveolar bone and periodontal regeneration, involving a combination of different cell types, bio-scaffolds and biologically active molecules. This article will discuss novel bone tissue engineering[BTE] approaches using 3D bioprinting and biofunctionalization of scaffolds with growth factors and drugs [4].

3D Scaffolds in Periodontal Tissue Regeneration

BTE has opened new doors for regeneration through the introduction of scaffolds which possess three-dimensional (3D) architecture that closely mimics native extracellular matrix (ECM). Such arrangements eventually enhance cell adhesion, proliferation, differentiation, and overall tissue regeneration [5]. In general, scaffolds must exhibit an adequate degree of hydrophilicity [6, 7], roughness, and specific surface topography; a topographic landscape on micro- and sub micrometer scales must be developed to replicate the natural process of bone regeneration [8]. Development of a multiscale scaffold has been emphasized in periodontal tissue regeneration [9].

To achieve success in bone regeneration, the template should demonstrate mechanical strength close to native tissues to support target cells, the surrounding tissues, and newly formed ones, mainly in load-bearing areas, until full tissue formation is achieved [10, 11]. In order to maintain this process, degradation rate of a scaffold should be in concordance with the remodeling processes of the target tissue [12]. For dentoalveolar reconstruction, degradation within 5-6months is considered appropriate [13].

Although the previously presented features constitute the basics in scaffold designing for bone regeneration, it must be noted that the design and balance between biomaterials and scaffolds are a complex and interdisciplinary matter. Furthermore, this aspect can become more complicated when alveolar bone regeneration is attempted along with cementum and periodontal ligament tissues. In this scenario, spatial organization is necessary by utilizing a multiphasic scaffold, which encloses variable architectural and chemical composition to closely capture the structural organization of native tissue and/or its cellular and biochemical composition. Therefore, "compartmentalization" is essential for controlling the spatiotemporal events resulting in effective regeneration of the periodontal complex . Which could prevent tooth ankylosis. This can be achieved by ensuring compartmentalized formation of bone and functionally oriented periodontal ligament fibers (PDL) that are integrated over time [14].

FUTURE ASPECTS

BTE is based not only on cellular and molecular events and interactions, but al soon the development of biomaterial sand scaffolds with prescribed biomechanical properties, representing a fundamental part of the BTE paradigm. Dental literature on 3Dscaffolds and related biomaterials as alternative to bone grafts is still scarce, with extremely limited clinical trials. Validation of the efficacy of scaffolds tested in animal models is obligatory, because the already published results are not representative due to small defects, graft size, and also a completely different healing process in small animals. Randomized controlled clinical trials are mandatory, with adequate number of patients and long-term follow-up of implant therapy following scaffold employment in preimplant augmentation procedures. Thorough evaluation of biological and mechanical properties, as well as degradation profiles of 3D scaffolds in periodontal applications, is needed. The effect of 3D scaffolds on "blood clot stabilization" should be assessed, as it is an important prognostic factor in alveolar bone regeneration [15].

CONCLUSION

Scaffolding matrices are an attractive alternative to bone replacement grafts in surgical procedures related to endosseous implant placement, that is, vertical and/or horizontal bone augmentation, socket preservation,and in augmentation. Scaffolding matrices can also be used as a membrane and grafting material in periodontal tissue regeneration. Much work lies ahead to translate the promising results of preclinical studies into clinical reality.

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