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RESEARCH ARTICLE

BIOIMPLANTS: THE FORTHCOMING ADVANCEMENT

*,[1]Dr. Amit Kumar, [2]Dr. Shivani Parmar, [3]Dr. Archana Nagpal, [4]Dr. Eish Sethi and [5]Dr. Ankur Gautam

[1]Senior Lecturer, Department of Prosthodontics, Desh Bhagat Dental College & Hospital, Punjab
[2]PG Student, Department of Prosthodontics, Himachal Dental College, HP
[3]Head & Professor, Department of Prosthodontics, Himachal Dental College, HP
[4]Reader, Department of oral & Maxillofacial Surgery, GIDSR, Punjab
[5]PG Student, Department of Radiodiagnosis, Dr.RajendraPrasad Medical College, HP

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ABSTRACT

Bio materials are those materials that are accepted by living tissues and can be used for tissue replacements. Dental implants are the most improved treatment for teeth that have been either extracted or have been ejected as a result of periodontal disease. We have engineered a "bio-implant" that provides a living PDL connection for titanium implants. The bioimplant consists of a hydroxyapatite coated titanium screw, ensheathed in cell sheets made from immortalized human periodontal cells. Different biomaterials and various AM technologies can be used to create customized bioimplants to suit the individual needs. With the aid of 3D printing this could lead to new foam and design of bioimplants in the near further

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INTRODUCTION

Bio materials are those materials that are accepted by living tissues and can be used for tissue replacements. On a macroscopic level these devices are used to fix or replace a bone and to support its healing process. With the worldwide increase in the average age of population there is a subsequent increase in the number of surgical procedures which has in-turn urged researchers to improve and optimize bio materials.

Dental implants are the most improved treatment for teeth that have been either extracted or have been ejected as a result of periodontal disease. Although implant treatment has a high success rate, there are some fundamental vulnerability associated with osseointegration, the healing mechanism between the bone and the titanium implant fixture (Alissa, 2012; Branemark *et al*., 2001). The osseointegration process at the implant surface, however, does not incorporate the periodontal ligament (PDL) space. Natural teeth are connected to surrounding fibrous tissues for efficient biologicalfunction performance (Alissa, 2012). Since dental implants are secured only by osseointegration, they are more susceptible to infections. This arises because without the existence of periodontal sensory mechanisms, including proprioception, pain perception is absent when periodontal diseases, including peri-implantitis arise and undermining shape bone resorption occurs. Hodosh and colleagues were the first to use custom-made root-analogue implants placed into the extraction socket, reducing bone and soft-tissue trauma (Branemark, 2010). Experimental studies with root-identical titanium implants yielded extremely favourable results with clear evidence of osseointegration and clinical stability (Oshima, 2014). The ensuing clinical trial resulted in 100% primary stability at insertion and 1-month follow up. Due to the high failure rate of 48% over the short time period of 9 months, this particular implant system was not recommended for clinical use (Hodosh *et al*., 1969).

Corresponding author: **Amit Kumar,**
Senior Lecturer, Department of Prosthodontics, Desh Bhagat Dental College & Hospital, Punjab

Technology for Fabrication of Bioimplants

Additive Manufacturing (AM) also known as rapid prototyping (RP) technologies or 3D printing consists of different automated fabrication. The AM process consists of design modelling and production. 3D models can be designed by 3D CAD software or obtained through CT scan or MRI. After which, the file is converted to a STL (stereolithography) file or the new AFM format and sliced into series of 2D cross-sectional layers, creating a computer file showing the path for the printer to take for tracing (Kohal *et al*., 1997). The process is usually done bottom up. Depending on the AM technology, parts may or may not have to be post processed to obtain the finished product. Other advantages include customization, lower cost, lesser tooling machines and little technical expertise required to operate machines (Kohal *et al*., 2002). Even though AM possesses many advantages; it still has some disadvantages such as pre- and post processing requirements, limited amount of printable materials and high equipment cost.

Types of AM Technologies

There are currently many different AM technologies used for making bio-implants such as Inkjet Printing (Polyjet), 3D printing (3DP), Stereolithography (SLA), Selective Laser Melting (SLM), and Bioprinting which is another category byitself. They are classified by various ways such as the type of energy source used or the production process etc. For this paper, we will classify them based on the ability to print biological materials: (i) directly or (ii) indirectly.

- Directly – prints support structure and biological materials (cell,
- DNA, proteins) together, also known as Bioprinting.
- Indirectly – prints support structure only (Webb, 2000; Honiball, 2010)

Direct bioprinting have been gaining huge interest in the field of science as there is a need for accurate control of cell position and tissue architecture in 3D constructs with micro-scale precision. Currently, there are three main ways that cells can be printed on the implants directly, (i) Inkjet, (ii) Extrusion and (iii) Laser Assisted Based (LAB). Indirect printing technologies do not print biomaterials. Such methods are used mainly for the construction of scaffolds which are then used for the seeding of cells, drug delivery systems, potential biochips or biosensors. However, it is important to note that each technology has its own limitations and applications. Some technologies such as SLA and polyjet inkjet-based systems use ultraviolet (UV) or white light to cure liquid materials while others use laser to melt or soften materials for joining (SLS, and SLM) and some like 3DP uses binding materials such as glue to stick the materials together (Melchels *et al*., 2012).

Bioimplants and Their Types

Bioimplants possess individual specific requirement and are usually produced in low volume. As their name suggests, bioimplants are for medical-clinical applications such as porous implants, prosthetics, drug delivery and biosensors they can be described as implants since they are usually most or less implanted into the body for long periods of time.

There are three types of bio implants and can be classified as

- Biological implants
- Biologised implants
- Biofunctional implants

The difference between the three classifications is mainly due to the amount of cellular components that make up the implants.

Biological implants

Biological implants are manufactured from biological materials such as cells, protein etc using bioprinting. Usually two key components are needed for making biological implants; firstly a bioprinter containing materials such as living cells (i.e. stem cells or tissue spheroids and biodegradable scaffolds/matrices (hydrogels) which predetermine the 3D form for creating the organ. Organ printing is defined as a computer aided process in which cells or cell-laden biomaterials are placed in the form of aggregates, which then serve as building blocks and are further assembled into a 3D functional organ. The ability to mimic the organs by accurately placing multiple cell types at its specific location may offer the possibility of manufacturing patient specific organs commercially. This usually involves integration of three areas (i) Functionality of the cells to ensure the cells are performing their specific role (ii) Production of the organ or tissue by combining cells and 3D scaffold using biofabrication techniques (iii) Characterization of the biofabricated construct to focus on the issues of immunology, toxicity and ability to remain its form after post implantation (Chua *et al*., 2010). Although currently there are no functional organ printed but as technology and research advances we might be able to see it sooner rather than later.

Biologised implants

Biologised implants are made of a combination of cellular components and permanent biomaterials. The difference between biological implants (mentioned previously) and biologised implants are the degradability of the 3D structure. Biologised implants structures are permanent and non-biodegradable. The permanent biomaterial structures are biocompatible and provide the mechanical stability for cellular colonisation.Most biomaterials involved in the implants are Bioinert (materials that do not react with the body- implant covered in a thin layer of mucous membrane). For example, stainless steel, tantalum, gold, titanium, nitinol, inum and aluminium oxide ceramic. This section will focus on orthopedics and dental implants mainly made from metals and using indirect printing methods made of titanium and its alloys. Most dental implants and many other orthopedic implants are now made up of titanium and its alloys. The use of AM technologies for dental applications has a huge potential due to the complex geometric involved, low volume and the need of personal customization (Rezende *et al*., 2012). The framework for used of SLS and SLM for direct application of dental prosthesis for stainless steel, Ti6Al4V CoCr-alloy was done. Other studies for SLM for dental applications were further studied (Khatiwala *et al*., 2012). A lot more in rapid prototyping for dental application can be further explored through additive manufacturing.

Biofunctionalised implants

Biofunctionctionalised refer to the field of surface treatment with the purpose to optimally use the surface for life science applications. This means that after implantation, bioactive surfaces of biofunctionctionalised implants interact with the biological environment in the body. The development and application of customised properties of the base materials required. The materials for biofunctionalised implants are usually bio-active. Bio-active materials refers to materials that integrates into the organism without capsule formation and develop a permanent bond and materials includes glassceramics, hydroxyapatite and glass ionomer cement. The use of 3DP of scaffolds from hydroxyapatite or tricalcium phosphate (TCP) was shown to be able to improve cell proliferation and spreading when compare to current commercial products such as bone replacement material BioOss® (Liu *et al*., 2006). Elke and team were able to print simultaneous geometry with hydroxypropylmethylcellulose (HPMC) and tricalcium phosphate (TCP), localized organic bioactive loading (recombinant bone morphogenic protein 2 (rhBMP-2), heparin (a model polysaccharide), and vancomycin (an antibiotic glycopeptide), and localized diffusion control (Bibb *et al*., 2016).

Conclusion

In summary, additive manufacturing will enable the production orfabrication of improved 3D-printed medical implants. 3D printingallows implants to be custom-matched to a specific individual and this review showed that it is used for making better titanium bone implants, prosthetic limbs and orthodontic devices. As more inter-disciplinary researchers are recruited into the field together with the advancement in biomaterials, it is likely that AM machines and techniques will be further improved over the years.

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