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Original Research Article

3D Printing: A Boom in Dentistry

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Abstract

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.Used in aerospace, defence, art and design, 3D printing is becoming a subject of great interest in dentistry. 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 orthopedic 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.

Keywords: 3D printing, prototyping, craniomaxillofacial.

INTRODUCTION

3D printing is also known as additive manufacturing (AM), rapid prototyping, layered manufacturing or solid free form fabrication. It is the process in which multiple layers of material are added one by one under computer control to create three-dimensional object. The key idea of this innovative method is that the three dimensional model is sliced into many thin layers and the manufacturing equipment uses this geometric data to build each layer sequentially until final desired product is completed [1-3].

Additive manufacturing is gaining rapid potential in nearly all dental fields. It differs from formativeand subtractive manufacturing as in the additive manufacturing process the object is "printed" by adding the building material layer by layer [4]. The most widely applied additive manufacturing methods include fused deposition modeling (FDM), selective laser sintering (SLS), stereolithography (SLA), polyjet printing, and bioprinting [5, 6].

The entire process of additive manufacturing technology can basically be divided into four steps: (1) creating a digital 3D model designed with a software or using intraoral scans or computed tomography data. (2) processing and slicing of the 3D model into many two-dimensional layers. (3) printing the 3D end product layer by layer. (4) post-processing of the printed object [7, 8].

Advantages

Conventional standalone subtractive manufacturing techniques such as milling create high wastage by their very nature. This can be minimized by utilizing these techniques in adjunction with additive manufacturing. Among all the available digital processing methodologies used for this purpose, 3D printing is clearly has an edge. Its higher efficiency, passivity, flexibility and superior material utilization earn it its distinction [9]. They provide the possibility of high quality restorations with quick and easy fabrication. The quality of these restorations has been demonstrated by several studies, although cost is still a major issue [10].

Disadvantages

The benefits from high material utilization might in some cases diminish when compared to the drawbacks due to its extended post processing duration. Other shortcomings include its high cost, the

occurrence of layered deposition, inconsistent reproduction and requirement of support materials. Ceramics, one of the most popular materials used in dentistry lacks the ability to be 3D printed due to the high porosity caused during fabrication [9].

The disadvantage of stereo lithography and digital light processing is that they are available only with light curable liquid polymers and the support materials must be removed. Also, resin is messy and can cause skin irritation, and it could also cause inflammation by contact and inhalation. Also, they present a limited shelf and vat life and cannot be heat-sterilized, while being a high-cost technology. The disadvantage of selective laser melting is that it is an extremely costly technology and a slow process [10].

Applications of 3D printing in dentistry and oral and maxillofacial surgery

One of the earliest applications of 3D printing in surgery, medical modelling, may be thought of as the production of an anatomical study model [11]. Ready access to CBCT, which provides similar data and is more prevalent in a hospital setting makes it is possible to provide volumetric 'image' data to a 3D printer before surgery and to make detailed replicas of the patient's jaws. This allows anatomy, particularly complex, unusual, or unfamiliar anatomy, to be carefully reviewed and a surgical approach planned or practiced before surgery [12]. This has led to the development of new procedures and approaches to surgery and along with the production of drilling or cutting guides using 3D printed technology or conventional laboratory technology, can lead to expedited, less invasive, and more predictable surgery [13].

Oral Surgery

Anatomical models made using rapid prototyping methods are a novel approach to surgical planning and simulation. Such methods allow the replication of anatomical items, including three-dimensional physical models of the skull or other structures that allow the surgeon to obtain an overview of complex structures before surgery. The migration from a visual environment to one that allows both visual and touch interactions introduces a new code called
"touch to comprehend" [14].

Chemical data indicate that rapid prototyping helps to minimize the risks that might occur during surgery. 3D printing techniques can be used in areas such as oral surgery by making surgical guides and conducting various blocks to augment bone defects, and for learning modules
to create mandibles and jaws that can be easily showed to the students [15].

Implantology

Positioning the implant in improper locations has the effect of decreasing predictability of the implant-supported prosthesis. The use of 3D printing technology has gained popularity in dental implantology due to the introduction of guidelines of the surgical procedure to insert a dental implant [16]. Rapid prototyping techniques allow industrial or customized manufacturing of 3D objects by using data taken from a computer [17].

3D printers can print bone tissue tailored to the requirements of the patient, and can act as biomimetic scaffolds for bone cell enhancement and tissular growth and differentiation [18]. In bone regeneration procedures, novel 3D printed alginate-peptide hybrid scaffolds can also be used. Studies indicate that the alginate-based scaffolds provide a stable environment for the growth of stem cells [19]. It can create composite powders that can be printed into scaffolds. Calcium phosphate (CaP) powders can be mixed with a 3D printing (3DP) powder based on calcium sulphate (CaSO4), and the scaffolds can also be used as bone augmentation material [20].

Maxillofacial Prosthesis

The absence of the external ear either partially or completely can occur due to congenital disorders or can be acquired. In the attempt to restore these missing parts with prosthetic materials, the prosthesis should be customized for a better understanding of its part in the complex. When defects are unilateral, it is best to scan the opposite side and restore the affected side by duplication. Besides the ears, it is also possible to print cartilage and blood cells [21].

Prosthodontics

Custom trays can be manufactured from computerized scans of impressions/models and printed, or can be created with readily available materials. There are two methods that are used for the development of study models for working in a virtual setting. The initial method includes scanning of the impression and transferring it into a program. The second method consists in taking the impression with a stock or semi-custom tray and pouring the model in stone. The stone prototype can be scanned or used directly in the manufacturing protocol. If needed, the study prototype can be replicated with duplicating hydrocolloid or printed, provided that a good quality scan is present [10, 22].

Orthodontics

Several years ago Normando et al. introduced the idea of using 3D face scans and 3D printing to print not only the anatomically correct and precise dental arches of patients but also orthodontic brackets [23]. As a result, patient-specific adjustments in terms of angulation, bending, and material selection during the manufacture of brackets are possible. With the help of

this computeraided technique it is now possible to virtually present the changes caused by the braces in advance [24].

CONCLUSION

Different 3D printing techniques have become imperative in maxillofacial and implant surgery, to assist the complex treatment planning by constructing virtual an atomical models. It is widely acknowledged that surgery may be less invasive and more predictable with the use of surgical guides printed in resins (commonly) or autoclavable nylon. With the evolution of 3D printing it has become possible to replicate desired geometry without an expensive mold and tooling which were not feasible with conventional techniques. 3D printers are becoming accessible and affordable but the cost of running, materials, maintenance, and skill of operators must be taken into consideration.

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