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Applications of 3D printing technologies in the dental implant sector

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ABSTRACT

In this study, applications of 3D printing technologies in the dental implant sector are explained. In implant applications, there are single or poly coating, bridge, and implant tooth making studies. The traditional manual method has been a lot of disadvantages such as, taking much more time, ending with unprecise dental applications, wasting much material, and giving patients more disturbances. To that end, the 3D printing technology has been gaining more importances, and therefore has started to be important and necessary in dentistry.

Keywords: 3D Printer, Implant Design, 3D Scanning

I. INTRODUCTION

3D printing technology began in the 1980s. However, after 2010, the name has become more pronounced and has become more widely used today. The reason behind this is that entrepreneurial firms invest more and more in this technology, the interest of academia, the advantages and advantages of technology in many areas, and the reduction of production costs. The first 3D was produced in 1984 by Chuck Hull of 3D Systems. The dental industry requires custom-part, single-unit production with excellent accuracy. Therefore, dentistry is getting more and more attention in the 3D printing industry. Additive manufacturing equipment manufacturers and material suppliers for these printers are already taking notice. Currently, 3D printing is used to provide a number of products in the dental industry. Most common are wax patterns for fixed prosthodontics and models fabricated from intraoral or impression scans. However, its popularity is gaining for orthodontics and removable prosthodontics [1]. In the early 19th century, studies on implants that were to be accepted as intra-bone implants began with the widespread use of metal in the field of dentistry, as in the case of every field in the early 19th century. Until the 1930's, implants prepared from precious metals such as silver, gold, platinum and iridium, because they constitute; The concept of bone integration of the implanted implant is based on microscopic studies of bone healing on rabbits in 1952. The first publication of the case, which was treated with implants integrated with the bone, was made in 1969.

Bone integrity first was used in 1977 and this expression was accepted by the researchers. Research and development studies on implants continue today at full speed [2].3D printer technology has become rapidly developed and easily accessible in recent years.

Printers can be used in engineering, architecture and industrial design. 3D printing is the process of creating three-dimensional solid objects in the real world in 3D models created digitally in computer-aided design programs. In 3D printer technologies, the digital model is divided into layers, and each layer

is printed on top of each other [3]. There are different three-dimensional printer technologies, and in this work, a printer of type FDM (Fused Deposition Melting) has been preferred. The reason why this printer type is preferred is because it is open source and its cost depends on other technologies it is relatively more convenient [4].

II. 3D PRINT

The 3D printer is a machine that manufactures physical models by adding layers of material to the 3D data without sending any mold, model or similar tool designed by computer aided design (CAD) programs. Three-dimensional printing is the process of printing any three-dimensional object designed in the virtual environment in solid form. Devices that perform this process are called 3Ds. The prints can be made with the use of raw materials in many species. Raw materials which are the most common usage on the basis of regular users are hard plastics called PLA and ABS. There are 3Dthat can print on different types and techniques. The working principle of 3Dwith the most common use is based on virtually dividing any three-dimensional object created in the computer into layers and printing each layer in a superimposed manner by pouring the melted raw material. The fields where 3D printer is used and applied are shown in Fig.1 Accordingly, it is understood that the medical and dental area 3D printers are used in a significant amount in these areas. Printing prosthetic parts, organs, medical models, synthetic skin, etc [5].

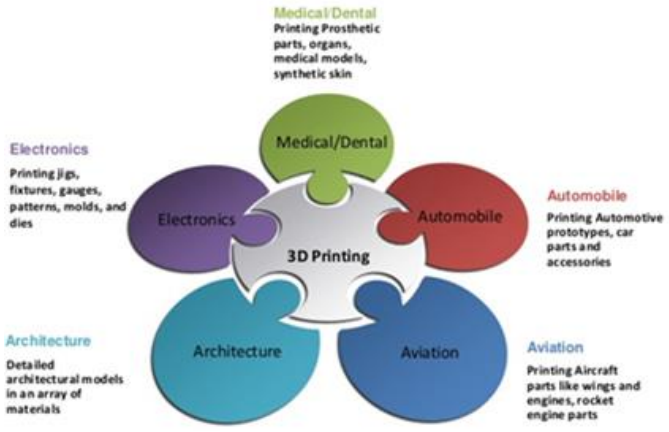

Figure 1. 3D Printing using fields [7]

There are basically 5 different 3D printing technologies being used in the dental industry today: Digital Light Projection (DLP), Jet, Stereo-Lithography Apparatus (SLA), Selective Laser Sintering and Direct Laser Metal Sintering (DLMS). The variety of each technology is in the materials used, how those materials are solidified, and how they can be used.

III. IMPLANT

The word implant is made up of the Latin words 'in' and 'planto = meaning of planting, planting, placing, embedding'. It means, in order to obtain a function, the name given to an organic or inorganic object placed at an appropriate place and passed through other languages from French. Implantation is called this placement process. Envy means placing an implantable material into the body [6]. Figure 2 shows the formation of an implant.

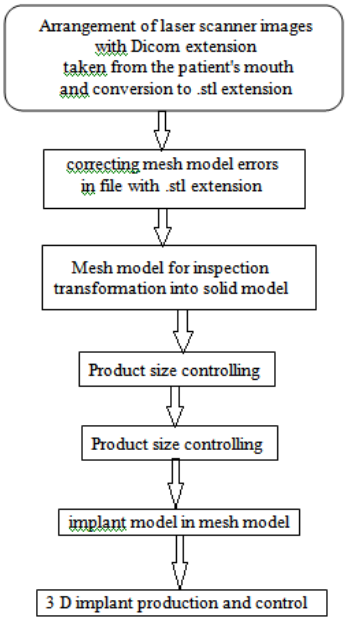

Figure 2. Implant flow diagram in 3D printer [9]

The crown coating (metal or acrylyc) made from a 3D printer is attached to the mouth of the patient as shown in Fig. 12. DMLS method is preferred as a 3 D printer process in Crown coatings [7].

3.1. Implant Materials

Implant materials have superior mechanical properties due to crystal structures and strong metallic bonds they possess. For this reason, metal and metal alloys are used as implant materials. 316 L stainless steel, Co-Cr alloys and Ti alloys are the most commonly used metallic materials (Figure 3).

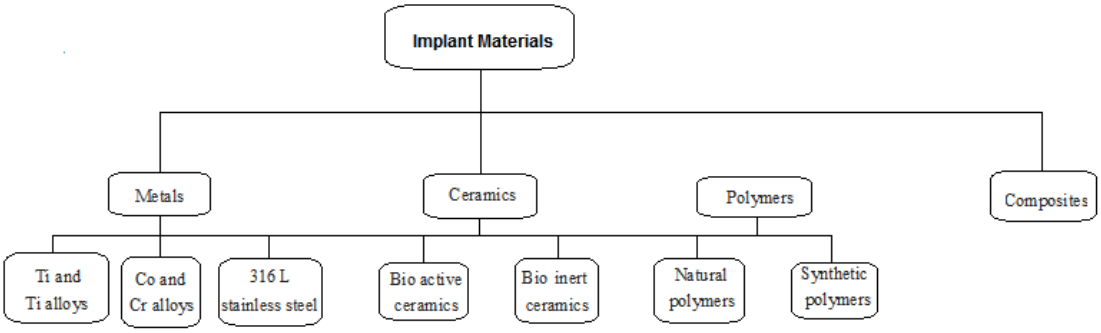

Figure 3. Implant materials used in 3D [8]

The dental benefits of 3D printer application are; High accuracy positioning of implants, Obtaining the prosthesis or cron coating parts,which can not be obtained with CNC (Computer Numerical Controlling) or conventional methods with a more precise 3D printer, High process speeds, Zero waste and low cost, Since the workflow process is digitalized, the least error, Possibility to work with biocompatible materials of dental materials (Resins). Intra oral digital scanner is used to scan the tooth structure or appearance of the patient's mouth [8].

The model of the desired tooth structure according to the scanned image is modeled by drawing in the CAD (Computed Aided Design) program. The modeled tooth is sent to the 3D printer. The crown coating (metal or acrylyc) made from a 3D printer is attached to the mouth of the patient as shown in Fig. 4. DMLS method is preferred as a 3 D printer process in Crown coatings [9].

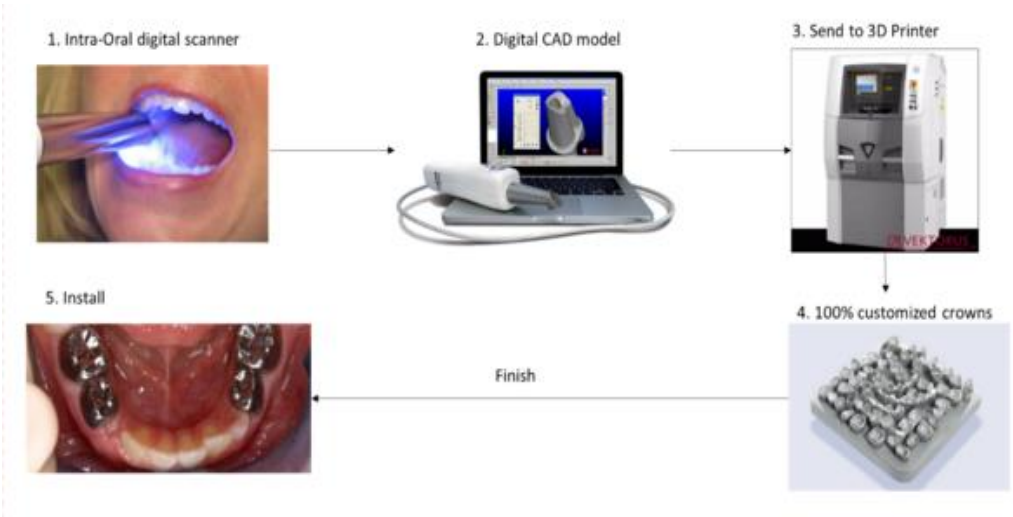

Figure 4. Loop of Implant product [9]

3.1. Dental Implant Types

Implant varieties have three distinct types in appearance and in general. They are designed in the jawbone, on the jawbone and along the jawbone.

a) In jawbone b) On jawbone c) During jawbone

Figure 9. Implant various [8]

3.2. Implant production in 3D printer

The model file with the extension ".stl" is then called as ".stl" to the 3d printer program (Simplfy3D) and positioned in the appropriate position in the model print area. Generally, PLA (Polylactic Acid) material is used for printing. Printing is performed on the Leapfrog Creatr HS 3B printer, an FDM type printer. The reason for choosing this printer; is comparatively low cost compared to other types of printers, and at the same time testing whether open source printers can be manufactured with sufficient precision for use in medical applications [10].

3D printer technology is important implant construction. Today it is used effectively. As seen in the above, bridge production is done. The term bridge dent means the group used in dentistry. These teeth are the production options that are produced before the prosthesis. In the classical system, pre and robust teeth are used as bridge supporting legs. But now bridge legs are made as implant instead of solid teeth. Bridge group teeth are also produced in 3d printer [11]. Fig 5 shows fixed partial denture (bridge). In other words, a 3-member bridge with an implanted leg is seen in Figure 5.

Figure 5. Three members of crown and implant [10]

The concept of implantation, which means implanting a non-female tooth at birth into the mouth of the patient, has recently become important in terms of oral health. In discussing the effect of metal screws used at implantation on the jawbone, it is more prevalent than bridging and crowning methods. If they endure an economic outcome, sometimes they use the choice of implanting all oral teeth totally. Figure 6 shows the implant crown coating [12].

The implant screw is also shown. The disadvantage of Crown coating is shudder; besides the dental decay to be covered, the intact parts must also be shaved. Because the crown does not sit completely in the tooth. This leveling made in consideration of the adhesion, damages the toothy areas especially the enamel layer. If carcino- genic and economical disadvantages are not taken into account, the implant method is preferred over crowns [13].

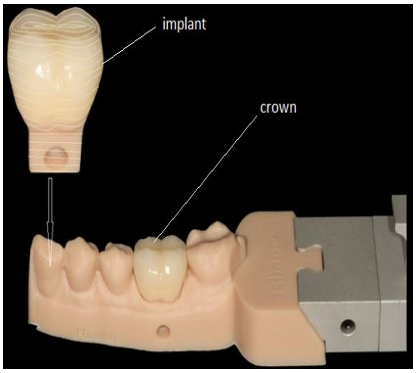

Figure 6. Single members of crown and implant with screw [9]

Figure 7 shows the relationship between the implant and the jawbone. The implant, called dental implantation or grafting to the jawbone, is secured to the female bone by means of a screw. There is a special task here for jawbone cells. Because of the impact of the operation and to break the fractures are required [14].

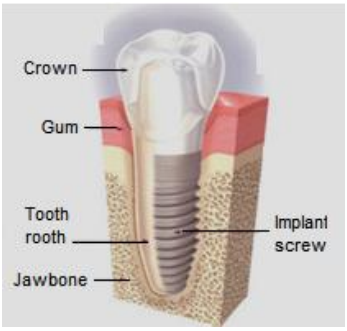

Figure 7. The jawbone and implant with screw [9]

Dental implants available for clinical uses are conventionallyproduced from rods of titanium (Ti) or its alloy Ti-6Al-4V (90% titanium, 6% aluminium, and 4% vanadium). Manufacturing processes involve machining,at a later stage, postprocessing with application of surface treatments, with the aim of enhancing healing processes, and osseointegration around dental implants [15].

Photographic images of the actual implementation of an implant are shown in Fig. Placement of a single titanium dental implant in this application (a) Preparation of the implant cavity. (b) Placement of the implant in the post extraction socket. (c) implant in position [16].

(a)

(b)

(c)

Figure 8. Placement of a single titanium dental implant (a) Preparation of the implant site. (b) Placement of the implant in the postextraction socket. (c) implant in position [16]

IV. CONCLUSION

The first step in implant production is the material selection. The availability of the selected material for CAD / CAM systems and 3D printer systems in accordance with the patient's mouth structure is examined. The scanning operation is performed after the material selection. The scanned data transferred to the computer is designed with CAD / CAM, and afterwards, sent to the 3D printer. The implant method has reduced the time compared to conventional measurement methods. Instead of the standard bracket, the implant bracket is manufactured in such a way that it is able to be compatible with the patient. As a result, the implant appearance is observed to give the patient benefits in both aesthetics and functionality. The harmony between

the patient and the implant will directly affect the health satisfaction.

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