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Current Digital Technology in Dentistry: Three-dimensional Printing



The place of digital technologies in medical practice is rapidly increasing and dentistry is taking its share. With the help of digital technologies, production of clinical application tools with three-dimensional (3D) printing and the diagnosis of diseases using 3D imaging techniques become possible. As a result, in the last decade, the “3D printing” technology started to spread rapidly in dentistry.^[1]

The idea of 3D printing of tangible objects is not so new. The first modal of 3D printing was developed in 1980s. However, it took nearly two decades for the first practical applications, and it was used to treat the first patient in 1999.^[1,2] Nowadays, this technology is increasingly being used in our daily life and many different areas.

3D printing technology depends on computer-aided design (CAD) software and computer-aided manufacturing (CAM) systems. With CAD/CAM systems, a large number of desired tools for dentistry can be easily created with a high degree of accuracy. 3D printing is an additive manufacturing process, and a 3D printer produces a tangible object (a certain designed object such as a brace for faster teeth alignment, orthodontic appliance or implants, prosthesis, and dental crowns) that is being created in layers.^[1,3,4]

The first step in the workflow is generating a 3D patient model and begins with the result of a CAD or 3D scanning of the live patient itself. Besides, computer-aided modeling data can be obtained from 3D imaging systems such as computed tomography (CT), conical-beam CT, and intraoral or laboratory optical surface scanners. Then, a specific object (e.g., prosthesis) is designed with the CAD software, and the sliced model is prepared for printing. The sliced data are sent to the printer, and the material is placed as a layer in the printer. As a result, the 3D printed object is washed, processed, and ready for use.^[1,5,6]

Selective laser melting, stereolithography, fuse-deposition modeling, and digital light processing are the most used 3D printing technologies in dental medicine.^[1,5] These techniques

differ regarding power sources, layering techniques, and material usage.

3D printing is used in dental medicine for the following treatments:

1. Oral surgery
2. Implantology
3. Maxillofacial prosthesis
4. Prosthodontics

What are the benefits of 3D printing that help general dentists, orthodontists, and prosthetists in their daily work? Here are some important examples of this technology as follows:^[4]

3D printed braces with LED lights are proposed to align and straighten the teeth faster. In these braces, each tooth has a battery which produces light and this light energy supports the teeth to move faster. This technology is still in development.

3D printed aligners were first produced by Amos Dudley, a college student of the Jersey Institute of Technology. He had to produce his own 3D printed aligners because he could not afford the regular braces. As a result, he was able to produce 3D printed aligners (12 aligner orthodontic sets), at a considerably reduced cost of 60\$.

3D printing has become an important player in dental implant surgery and restoration. It is now possible to replace a missing tooth with a 3D model. This process is not only easy and fast but also more accurate and economical than the traditional method.

The most common 3D printing practice in dentistry is the production of crowns, which can be quickly performed by the dentist himself.

What are the most significant advantages that the 3D printing technology provides^[3]?

- Compared to traditional production forms, 3D printing or other additive manufacturing is really fast
- Along with the increase in the number of companies that produce 3D printers and software, their user interface

has become more friendly, and access to 3D printing technology has become easier

- The prototypes produced with 3D printing technology have a much higher homogeneity and, therefore, have better quality compared to prototypes produced using conventional methods
- The prototype of virtually designed products is easy to test, and any discovered errors can be corrected and repaired even on the same day
- The costs of conventional development/manufacturing of a prototype are very high due to intense human labor. However, with 3D printing, only one person could be enough to control a printer
- Conventional manufacturing is best suited to produce many copies of a single master. On the other hand, customized solutions can easily be produced with 3D printing
- With 3D printing technology, almost any kind of geometric object can be produced while molds or cutting processes are applied for conventional manufacturing
- In 3D printing technology, a wide variety of raw materials including glass, metal, paper, ceramics, biomaterial, and silver can be used and even combinations of these are available
- In 3D printing technology, the raw material is completely consumed, and almost no waste is leftover. However, in conventional production, there is usually too much waste that affects natural life and causes environmental pollution
- With 3D printing technology, the risk of getting low-quality output in mold production is very low. This avoids the bad consequences that may arise in production investment.

Does 3D technology have any disadvantages? Of course, there are still problems to be solved for this technology.^[7] The main disadvantages of 3D technology are as follows: energy consumption, cost, and environmental issues. Both energy consumption and cost of 3D printers are still very high. Besides, the risk of producing toxic emissions of 3D printers, especially those that use thermoplastic raw materials, is at considerable levels. Finally, biocompatibility of the end product may be a problem. All these bring the question of “Is 3D printing safe?” to the minds.^[8,9]

Although there are some problems that still need to be solved, it is not wrong to foresee that 3D printing technology will be used by every dentist in the next decade. Therefore, we can foresee that both 3D and smart devices await us because 3D printing technology will be more involved in our lives.

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