

Applications of 3-D Printing in Orthodontics: A Review

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Abstract

The art and science of dentistry have evolved over the past few years more importantly in clinical and laboratory workflows with a progression from an analogous, manipulation of materials manually to a systematic, digitally verifiable process. The field of orthodontics in its new era is stepping ahead to newer technologic perspective. Three-dimensional (3-D) printing application in orthodontics has made the treatment procedures easy, time saving, cost-effective apart from the initial investments. This article is to provide recent trends and updates of application of 3-D printing in orthodontics.

Key words: 3-D printing, Appliances, Digitization

INTRODUCTION

A three-dimensional (3-D) printing is also known as additive manufacturing or desktop fabrication. It is a process of making 3-D solid objects from a digital file. The digital 3-D model is saved in STL format and then sent to the 3-D printer where the layer by layer design of an entire 3-D object is formed.^{1,2} This creation of the 3-D printed object is achieved using additive processes. Each of these layers can be observed as a thin sliced horizontal cross-section of the eventual object.²

HISTORY

1984 seems to be the beginning when Charles (Chuck) Hull of 3-D Systems developed the first working 3-D printer.⁶ Later, in 1986, Charles Hull founded 3-D Systems and developed the first commercial 3-D Printing machine and it was called as Stereo

lithography Apparatus.³ He obtained patency for this Stereo lithographic technique. In 1993, Massachusetts Institute of Technology (MIT) patented “3-D Printing techniques.” It is similar to the inkjet technology used in 2D Printers.

In 2010 - Organovo, Inc., a regenerative medicine company prioritized on bio printing technology, announced the release of data on the first fully bio printed blood vessels.³

WHAT IS A 3-D PRINTER

The 3-D printer is unlike of the common printers in which the object is printed by 3-D (Figure 1). A 3-D model is built up layer by layer. Therefore, the whole process termed as rapid prototyping or 3-D printing.³

The biggest drawback for the individual home user is still the high cost of 3-D printer, and also it takes hours or even days to print a 3-D model (depending on the complexity and resolution of the model). Besides above, the professional 3-D software and 3-D model design are also in a high-cost range.³

Alternatively, there are already simplified 3-D printers for hobbyist which are much cheaper and the material it uses is also economical. Such 3-D printers for home use are not

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as accurate as commercial 3-D printer.³

ADVANTAGES OF 3-D PRINTING

1. Enhanced treatment procedures;
2. Patient treatment becomes fast, smooth and with greater precision;
3. Dependably superior appliances.

MATERIALS USED TO PRINT 3-D OBJECTS

Various materials that can be used for 3-D printing are ABS plastic, PLA, polyamide (nylon), glass filled polyamide, stereo lithography materials (epoxy resins), silver, steel, titanium, photopolymers, wax, polycarbonate.³ The Objet 500 and 260 Dental Selection 3-D Printers work with the full range of PolyJet dental materials.⁴ Materials for dental application is available in convenient sealed cartridges.

The known three PolyJet dental materials, specially engineered for dentistry are:-

1. Clear Bio-compatible (MED610),
 - Can produce orthodontic appliances
 - Delivery and positioning trays and
 - Surgical guides for temporary in
 - Mouth placement.
2. Vero Dent Plus (MED690),
A dark beige material that creates amazingly fine features and finish, and offers excellent strength, accuracy and durability placement.
3. Vero Glaze (MED620),
An opaque material with A2 shading designed to provide the suitable color match for veneer try-ins and diagnostic wax-ups. Vero Glaze is medically approved for temporary in-mouth placement, up to 24 h.

Website with 3-D models database:

- 3-D Marvels
- 3-D Via
- GrabCAD
- Google 3-D Warehouse
- Ponoko Product Plans
- Shapeways 3-D Parts Database
- Thingiverse
- Turbosquid: Free objects.

3-D modeling software which can be downloaded for free:

1. Google SketchUp
2. 3-Dtin - The simplest 3-D software
3. Blender

4. Open SCAD: Focus on CAD aspect
5. Tinkercad.

REVOLUTION

As 3-D printing can replicate the human form more accurately than traditional manufacturing techniques. Orthopedics and dental implants are the most common medical uses of the technology.⁵ Estimates of IBIS World (2013) are that there are already more than half million 3-D printed dental implants in patients worldwide. The University of Toronto's Bio Printer project is exploring the use of 3-D printed tissue for the treatment of burned patients. 3-D printing also allows the production of complex shapes (such as hollow figures) and lightweight parts that can be used to create implants a growing demand in countries with aging populations. Bone replacements and support structures for growing body parts made by 3-D printers are at different stages of research.

Another possible application in the medical industry is to use 3-D printers to create models of human parts from computed tomography scans or magnetic resonance imaging images to assist surgeons during complex surgeries (Figures 2 and 3). Designers and engineers are also exploring the development of new and specialized surgical tools made by 3-D printers.

APPLICATIONS OF 3-D PRINTING IN DENTISTRY

1. Dental restorations, especially dental prostheses, including crowns, veneers, inlays and on lays, fixed bridges,
2. Dental implant restorations,
3. Dentures (removable or fixed),
4. Orthodontic appliances.
5. Print craniofacial structures for reference before complex surgeries.⁵

ORTHODONTIC PERSPECTIVE

Orthodontist creates beautiful smile and crafting smile is a time-consuming process. But with digitization, it has become easy. 3-D printing is revolutionizing the orthodontic process, providing digital advantages over the traditional workflow process.⁶ After the 3-D scan is done, it is transferred to the computer to get 3-D images of patient's teeth. Either these files can be sent out to labs for fabrication or in office set up where the 3-D CAD file is dragged into the 3-D printer. Compact 3-D Printers

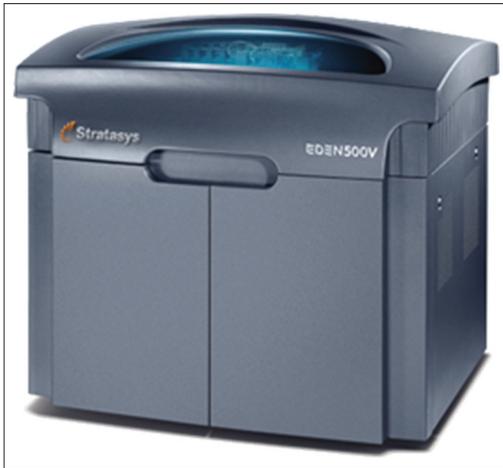


Figure 1: 3-D Printer. Source: <http://ObjetEden500V3-DPrinter>



Figure 3: Colored 3D print of craniofacial structure

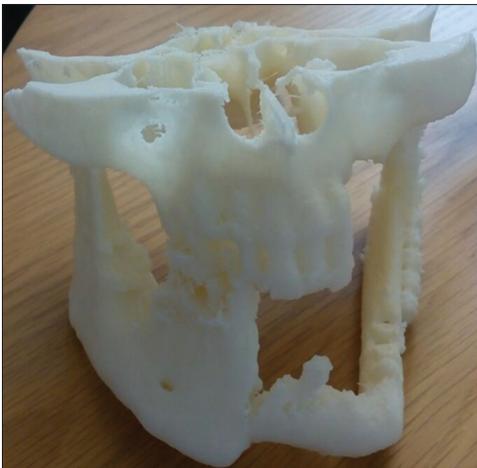


Figure 2: 3-D print of craniofacial structure in cancer patient after computed tomography scan



Figure 4: Orthodontic study models. Source: <http://3dprint.com/29835/e-appliance-envisiontec/>

for clinical setup and small labs are introduced by various companies (e.g.: Objet30 Orthodesk from Stratasys). Here, 20 models per printer can be created.⁶ Various removable appliances (like Hawleys retainer, splints), functional appliances, arch expansion appliances, clear aligners, retainers, arch wires, brackets, auxiliaries, trays for indirect bonding, set up models which will make lingual orthodontics and mock surgeries fast and easy, also study models (Figure 4). The process is quick, clean and accurate. These factors can dramatically accelerate professional time of an orthodontist, eliminate physical impression, and put an end to bulky physical model storage.

Many years back digital orthodontics was only a dream. For those eager for the day when everything from scheduling to final appliances can be achieved digitally and automatically, the future is here. With a 3-D printer doing the hard work, dental labs eliminate the manual modeling and let the business grow.⁷⁻¹⁰

CONCLUSION

Automated model-making with the 3-D printer dramatically reduces fabrication times and exponentially increases output per technician. Thus by transitioning to a fully digital process, there is no need to store bulky physical models and keep all your cases digitally, for as long as you need.

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