Implementing 3D printing technology in practice

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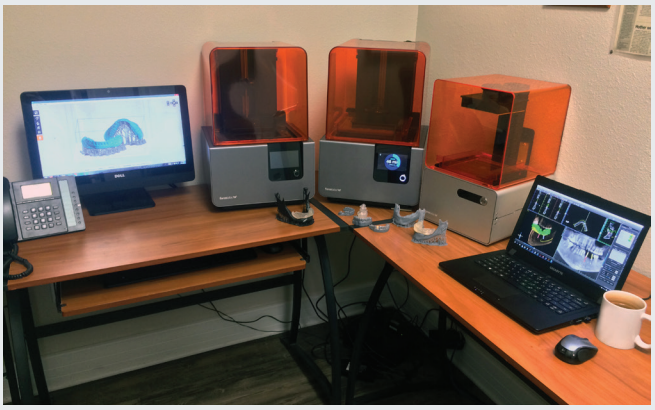
There is a palpable buzz in journals, magazines, and lecture halls about the use of digital technology in clinical practice. Prosthodontists, with our strong laboratory and clinical backgrounds, must lead the charge with implementing technology in everyday clinical workflows.

There is a measured increase in the number of our colleagues who are asking each other, "How do we implement digital scanning and 3D printing technology?" Prosthodontists recognize the limitless possibilities digital techniques can afford in our clinical practices and, in fact, many of us already use it in some fashion by sending files for printing dies and working casts, surgical guides, and medical modeling to laboratories that use large industrial-grade printers.

It seems every day an article is published in a magazine or newspaper touting the use of 3D printing with some new and amazing application and how it improved patient outcomes. While 3D modeling is a relatively new and emerging technology within dentistry, its use has been around for approximately 30 years within mechanical engineering to produce a rapid model of a CAD drawing.[1]

Ultimately, key question is: "How can I use digital technology to make my tasks easier, faster, and equally or potentially more accurate and effective?"

The original 3D printing process was invented in 1986 by Charles Hull. Using stereolithography, commonly referred to as SLA, this technology utilizes a container of liquid photo polymerizing resin and an ultraviolet laser to build parts one layer at a time until a solid object is formed out of the liquid resin container. This process, known as "additive manufacturing," is distinctly different from that of milling or CAD/CAM, also known as "subtractive manufacturing." In milling, a restoration or dental cast is fabricated from a pre-manufactured block of material, such as ceramic or gypsum, whereas in 3D printing, they are fabricated from liquid or powder manufacturing precursors. From the development of the original SLA process, other 3D printing technologies have been



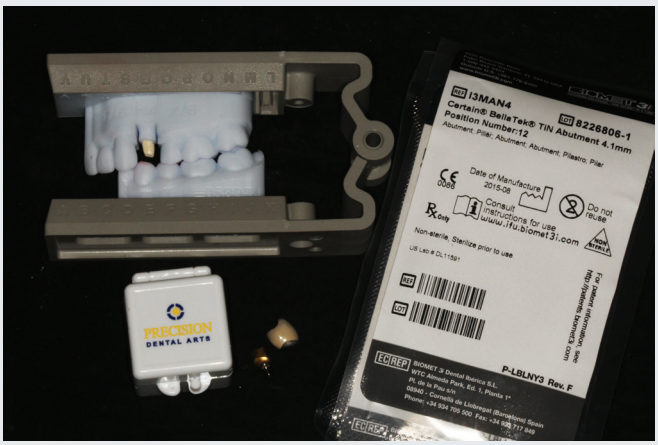


Fig. 1: The digital prosthodontics office with computerized design and 3D printing technology.

Fig. 2: Following intraoral scanning, the final restoration and abutment for a dental implant was fabricated with assistance of an industrially fabricated 3D printed working cast.

Fig. 3: The abutment and crown were inserted with little adjustment needed.

developed such as Polyjet, fluid-deposition modeling, digital light processing, and SLS/direct metal printing.

While most commercially available printers are designed for use for large scale production, recent development into smaller, less expensive SLA printers have opened desktop 3D printing within dental offices. These newer, professional consumer (or "prosumer") grade machines have initial startup costs that are substantially lower than industrial grade 3D printers traditionally available only to large dental laboratories. These 3D printers have optical resolution, reliability, and a form-factor that may rival their significantly more expensive counterparts (Figure 1).

My journey with in-office 3D printing

There are many possibilities for integrating desktop 3D printing into a clinical practice and the demand for utilization varies depending upon the clinician's interest level in digital technology. Many clinicians have the desire to fabricate casts for "crown & bridge" die and working casts, diagnostic tooth assessment and "wax-ups" prior to restorative therapy, and for dental implant surgical guides.

Ultimately, this is the key question: "How can I use digital technology to make my tasks easier, faster, and equally or potentially more accurate and effective?"

In my practice, I wanted to streamline or eliminate tasks that can be cumbersome and fraught with error. First, my goal was to replace the use of traditional technique sensitive impression procedures with a digital impression scanner. Incorporating intraoral scanning techniques and protocols have substantially decreased my daily stress while increasing my precision and reliability surrounding indirect restorative procedures. I was introduced to 3D printing: industrial-grade printing performed by a large-scale laboratory. Soon, my digital impressions were returning from the laboratory with 3D printed articulated casts and restorations designed digitally (Figures 2-3).

After a short period of time, I felt I had validated the digital impression process within my practice and felt like I could look further into eliminating another procedure within my office: diagnostic tooth arrangements and wax-up procedures. Like many of my colleagues, I find it difficult to delegate laboratory procedures and preferred the control performing these procedures myself. I did, however, find it challenging to find time for these procedures within the demands of a busy practice and personal life. I began working with dental labs and their software to help me manipulate digital impression images to assist in diagnostic assessment and digital waxing procedures. While this process was successful, it was frustrating that it took several weeks to receive printed casts and was an expensive endeavor compared to simply making a traditional impression and pouring a gypsum cast.

I had heard about the development of lower cost 3D printers and successful online funding campaigns that helped to launch several companies. I joined the pledge campaigns and purchased 3 different types of low-cost consumer-grade 3D printers. After experimentation, I determined that the original SLA-style printer technology, like the one invented by Hull in 1986, was still the best for demanding dental applications. During this time, I also found free and open source non-dental software that was unrestricted and could open any dental scan, learned how to use the software,

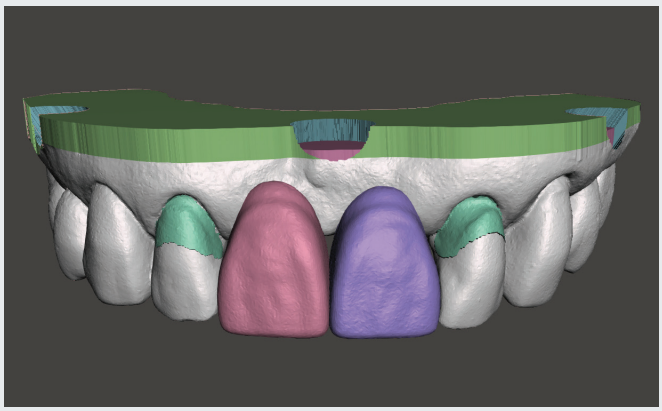


Fig. 4: A patient initially presented requesting a fixed partial denture to replace her missing maxillary (upper) central incisors.

Fig. 5: Utilizing a digital impression and assessment, a diagnostic "wax-up" was performed.

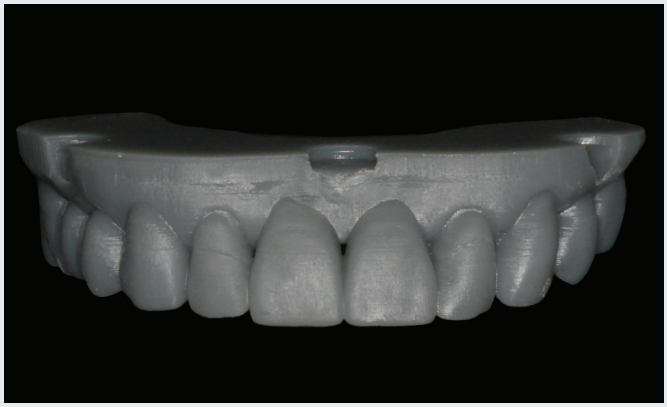


Fig. 6: The digital file was 3D printed utilizing a low-cost desktop 3D printer, forming a cast.

Fig. 7: In order to facilitate making a provisional (temporary) restoration, a vacuum-formed template was fabricated on the 3D printed cast.

and utilized this with my new printer to assist a digital wax-up of two anterior teeth for a routine anterior fixed partial denture procedure (Figures 4-9).

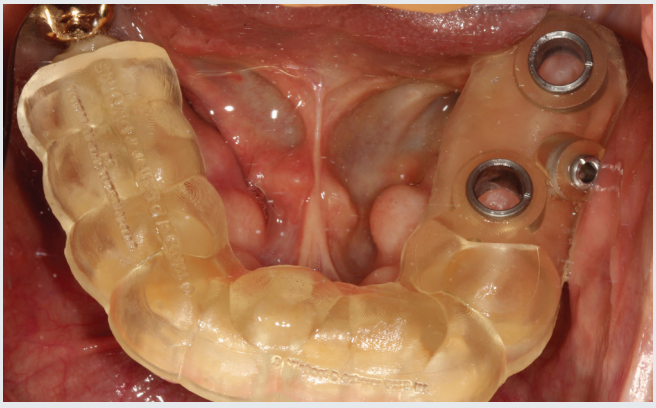
Fast forward and I was able to work with several companies to help bring lower cost dental 3D printer technology to clinical reality including one company with the first desktop printer to have a FDA-approved biological resin that can be utilize intraorally. As a result, countless numbers of clinicians, including myself, have been able to print surgical templates for dental implants within my office to assist in surgical procedures for a fraction of the costs of traditional methods (Figures 10-11).

The story of my journey is not unlike what many other clinicians are facing. How do we validate these procedures? Is the digital technology going to work well for me? How much is it going to cost and can I offer higher quality services to more patients without having to raise fees? Like many others, I had those reservations and found a way that worked for me within my clinical workflow. I encourage you to do the same… as prosthodontists, we must lead the digital evolution of dentistry. ■

References
1. Bártolo, Paulo. Stereolithography materials, processes and applications. New York: Springer, 2011. Print.

Fig. 8: The provisional restoration was fabricated utilizing the template and removed after polymerization.

Fig. 9: The provisional restoration was finished and placed utilizing a luting agent. The final restorative procedures were performed and a definitive fixed partial dental prosthesis will be placed at a later date.



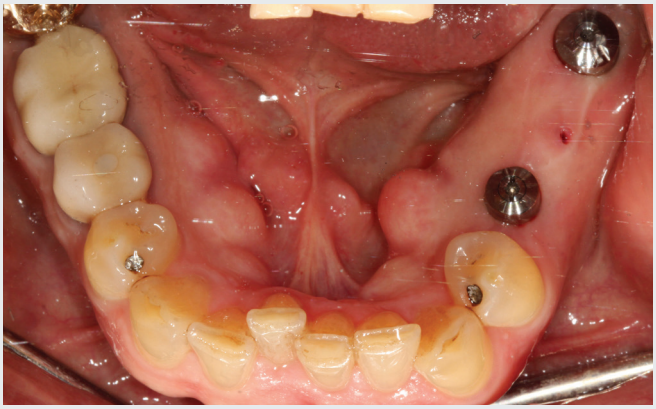


Fig. 10: A dental implant surgical template was designed and fabricated.

Fig. 11: The template was adapted onto the mandibular arch and surgical procedures performed to place dental implants.