

3D printing

international magazine of dental printing technology

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Dr George Freedman

Editor-in-chief



3D printing in dentistry: Revolution in progress

3D dental printing today is reminiscent of cosmetic dentistry in the early 1980s: the needs are many, the technologies are numerous, the applications almost unlimited and the potential open-ended. Just as cosmetic materials and techniques brought aesthetic restorative dentistry into the hands of every practitioner, 3D printing promises to bring the functional and artistic control of the restorative process into the chairside setting.

Stereolithography, first developed in the 1980s, was soon followed by additive manufacturing, the deposition of material in increments. Dental applications are more recent. 3D printing has been utilised for rapid prototyping and modelling for more than a decade. The size and cost of the earlier printers meant that they were limited to larger laboratories.

The digital transformation of dentistry, including CBCT, intra-oral and extra-oral scanning, milling of ceramic and composite materials, and robotic implant placement, is firmly established. Linking with these advances, the most recent desktop printers have a much smaller footprint, are easily affordable for the single practitioner, communicate with existing software platforms and offer high levels of precision with a wide range of materials.

Current 3D printers are fully capable of managing the great demand for temporary, transitional, and permanent restorations and appliances and of achieving the clinical excellence required by the dental profession. Consequently, there has been a growing acceptance of this transformative technology. Increasingly, 3D printing is viewed as an industry game-changer and a forecast of the future direction of the dental practice.

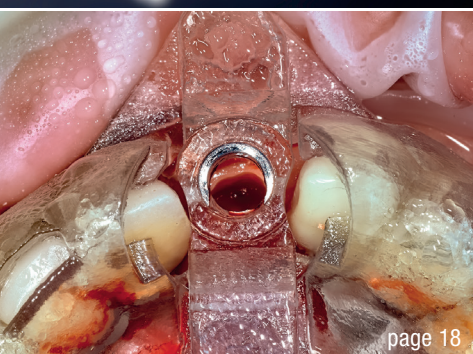
3D-printing techniques include stereolithography, fused deposition modelling, selective laser sintering, powder binder printing, photopolymer jetting, electron beam melting and direct light processing. These currently unfamiliar names will soon become standard dental terminology.

The documented, wide-ranging 3D printing applications can be grouped by treatment category:

- *Fixed prosthodontics*: Permanent and provisional indirect restorations (crowns, onlays, inlays, bridges) and permanent monobloc direct restorations can all be custom-fabricated chairside within minutes of scanning the preparation.
- *Removable prosthodontics*: Both complete and partial dentures, including digital occlusal design, are deliverable within hours.
- *Implant dentistry*: 3D printing of surgical guides has facilitated ideal implant positioning. Biomimetic custom 3D-printed bone implants replace missing segments, minimising stress transfer to the remaining bone.
- *Orthodontics*: Aligners, designed using CBCT data and artificial intelligence extrapolation of tooth movement over time, are 3D-printed.
- *Endodontics*: The pioneering 3D-printed endodontic access guide, utilising CBCT data, translates pre-surgical planning into clinical success.
- *Maxillofacial surgery*: Custom-designed bone grafts and fixation plates expedite both the surgical procedure and the healing process.
- *Periodontics*: 3D-printed guides that relieve and retract gingival margins offer aesthetic gingival correction. Soft-tissue printing is currently in the research phase.

3D-printing techniques and procedures are high-quality, high precision and accurate and significantly lower in cost than conventional treatment options. Dentists save money: many desktop printers cost between US\$3,000 and US\$10,000, and dental 3D-printing materials cost pennies per tooth. Patients save money, by the elimination of intermediate procedures and transportation costs. Treatment is faster, typically same-day services. Welcome to 3D printing! Welcome to the future of dentistry.

Dr George Freedman
Editor-in-chief



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Marina Grigorivna/Shutterstock.com



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YES ! THIS YEAR WE GO DIGITAL. SO MUCH DIGITAL: SCAN, PLAN, PRINT, MATERIALS,
DIGITAL SMILE DESIGN, PINGPONG.BLUE ... AND THEN ... SUPER ANALOG ... MATERIALS, TOOLS
AAAND MORE MATERIALS. ALL IN BEST *******ANAX**QUALITY. FULL STOP. BRIGHT SMILE.

How 3D printing has transformed dental care

By Iveta Ramonaite, Dental Tribune International



3D printing offers a high level of customisation of dental products, is highly efficient and cost-effective, and has many applications across a wide range of industries, including dentistry. (Image: © Formlabs Dental)

Dentistry has come a long way since the first introduction of digital technology. Georgio Haddad is an intrapreneur who is in charge of the development of dental strategic partnerships and initiatives at Formlabs. Haddad spoke to Dental Tribune International about the various applications of 3D printing in dentistry, reflected on how 3D printing has reshaped the dental industry and weighed the risks associated with embracing the technology.

How has the introduction of digital dentistry facilitated the carrying out of dental procedures, and why should dental professionals consider investing in new technology?

Digital technology has changed the way we deliver dental care. With advanced imaging, case diagnoses have improved significantly, and treatments are now more predictable. With milling and 3D printing, professionals can produce extremely high-accuracy dental products in order to offer their patients the best results. As technology continues to evolve, these products are produced faster and become more cost-effective, improving the end result for the patient.

Dental professionals are lucky to be in such a dynamic field. Staying curious and investing in new technology is a must in order to keep up with the increasingly high standards of patient care.

3D printers offer an infinite number of applications. How is 3D printing used in dentistry, and what are some of the advantages of 3D printing for dentistry?

3D printing is used in many areas of dentistry. There are three basic categories:

- *Applications that would not be possible or would not make sense without 3D printing.* These products cannot efficiently be made differently and include surgical guides, models for aligner thermoforming and indirect bonding trays.
- *Applications for which 3D printing improves on traditional manufacturing methods.* These products can be made without 3D printing, but printing offers increased accuracy and control, and shorter delivery times. This category includes castable and pressable frameworks, temporary restorations, splints and custom trays.
- *Novel applications for which 3D printing offers a disruptive alternative.* These are the real cutting-edge use cases, such as fully 3D-printed dentures and permanent restorations. They are not the most common uses, yet, but indeed some of the most exciting.

3D printing offers advantages beyond opening up new applications. Products are more accurate, turnaround time is shorter, and it allows for a more flexible and open communication between the practice and the laboratory.

3D printing is a powerful technology on its own, but the real impact comes from the people who use it. We see new 3D printing applications all the time, whether they are born of necessity or innovation. That is why Formlabs is committed to increasing access to powerful digital technology.

What are some of the criticisms of dental 3D printing, and do the benefits offered by using 3D printing outweigh the associated risks?

Ten years ago, the biggest problem with 3D printing was the prohibitively high cost of a printer. Luckily, with the success of manufacturers such as Formlabs in the market, printers are more affordable, more reliable and easier to use than ever before.

Now, the only risk lies in having false expectations. A 3D printer is a piece of equipment, and learning to use a desktop unit like the Form 3B is easy, but it does take some time. Those who choose to adopt digital technology should embrace the learning curve, ask for advice from their peers and seek out professional development opportunities.

Moving forward, 3D printing needs to overcome the dental industry's skepticism about novel printing materials and applications such as printed dentures and permanent restorations. Manufacturers like Formlabs need to be proactive about teaching experts and validating new technology in the industry in order to achieve a mindset shift. But it will eventually happen. We have already seen it many times in the dental industry. Implants, zirconia, intraoral scanners, chairside milling and many other materials and technologies overcame the initial skepticism. I am glad to be part of the movement that is leading and revolutionising digital dentistry.



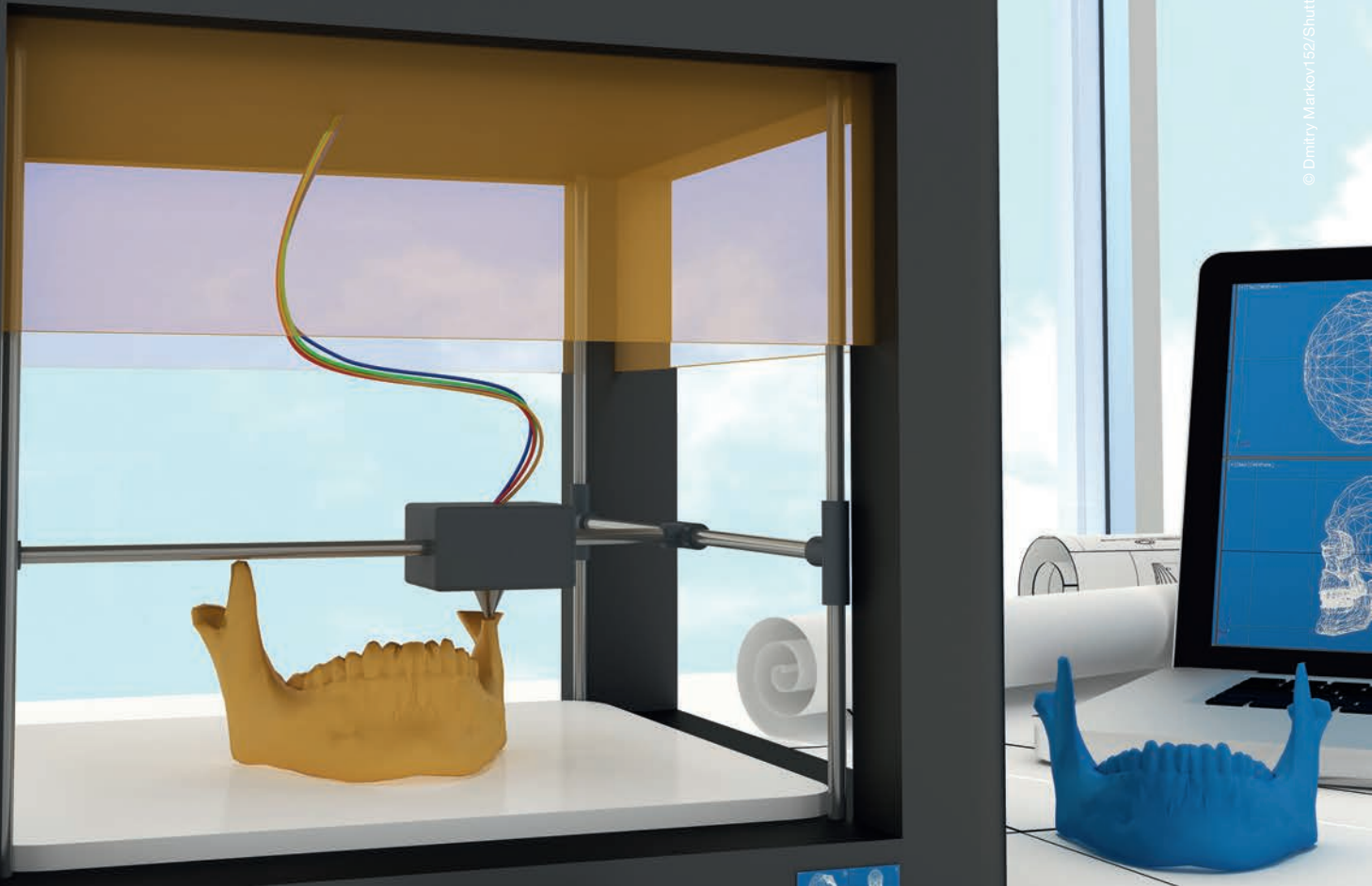
Georgio Haddad, dental strategic partnerships and initiatives lead at Formlabs, a 3D-printing technology developer and manufacturer. (Image: © Georgio Haddad)

“3D printing is a powerful technology on its own, but the real impact comes from the people who use it.”

Editorial note: The Formlabs Dental webinar, titled “Revolutionizing digital dentistry with 3D printing—accessible solutions and new applications,” is available on demand at www.dtstudyclub.com. Registration is free of charge.



Formlabs' Form 3B printer. (Image: © Formlabs Dental)



3D printing continues to revolutionise dentistry, and recent evidence suggests that dental professionals can greatly benefit from printing 3D dental prostheses in-house.

Study highlights benefits of in-house 3D printing for immediate dental implant placement

By Iveta Ramonaite, Dental Tribune International

Owing to the growing popularity of point-of-care 3D printing and the subsequent creation of 3D-printing laboratories, a recent study aimed to compare the benefits of printing dental prostheses for fibula and implant reconstructions in-house with those of using traditional techniques that involve outsourcing to dental laboratories. The researchers found that in-house printing offers considerable benefits, such as reducing the waiting period before surgery, but that it requires an initial investment in 3D-printing equipment.

3D printing has recently helped to save the lives of many health care professionals fighting on the front line against COVID-19. It was seemingly impossible to comply with the updated

recommended infection control practices in light of the shortage of proper personal protective equipment, and 3D-printed masks and face shields were produced to assist in this situation. Dental Tribune International (DTI) has also previously reported on the advantages of using a fully digital workflow and printing clear aligners in-house. The benefits of 3D printing are manifold, and so are its applications for medical use.

The present study included 12 patients who underwent free fibula reconstruction of the mandible or maxilla with immediate implants and immediate restoration. The restorations were created before surgery, and the first five patients each received a prosthesis that was fabricated by a dental labo-

ratory after virtual surgical planning. The remaining patients each received a prosthesis that was designed by a surgeon and 3D-printed via the in-house laboratory.

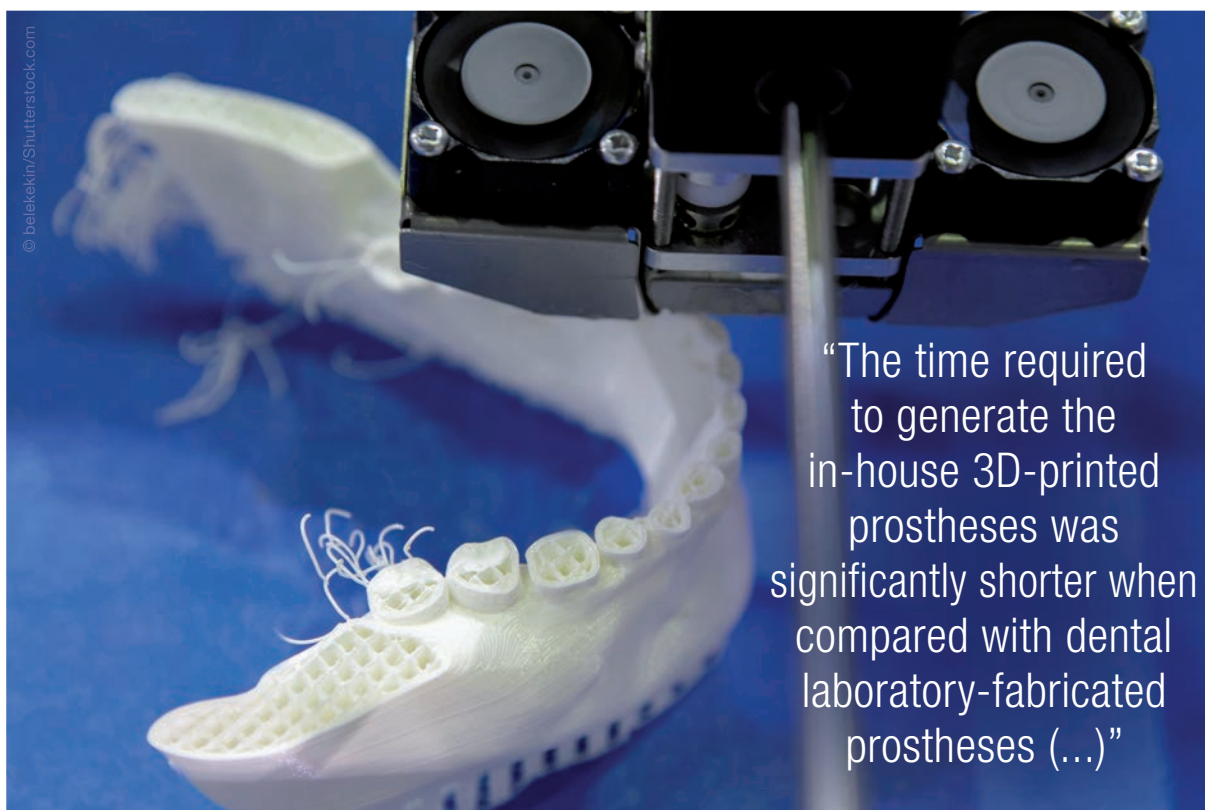
The researchers fabricated a dental prosthesis using point-of-care 3D printing within 24 hours of the virtual surgical planning session. The time required to generate the in-house 3D-printed prostheses was significantly shorter when compared with dental laboratory-fabricated prostheses, which typically take weeks. Additionally, the procedure was more cost-effective. Whereas the prostheses created by an off-site dental laboratory averaged \$617.00, each in-house 3D-printed prosthesis cost an average of \$8.34 for resin, and the researchers noted that a full-arch prosthesis 3D-printed in NextDent Micro Filled Hybrid costs under \$50.00. The price includes the costs for the resin and the export fee for Blue Sky Plan, a 3D-printing software.

“The study describes a digital workflow to design and 3D-print an immediate provisional dental prosthesis to be placed during jaw reconstruction when using a fibular free flap. This surgery has been called ‘Jaw in a Day.’ Previous methods involved third-party dental laboratories which require additional time, laboratory expertise and are more expensive. Our technique allows surgeon-guided virtual planning, just like we do with the jaw and fibula,” Dr Fayette C. Williams, fellowship director in the Division of Maxillofacial Oncology and Reconstructive

Surgery at John Peter Smith Health Network, told DTI. “Creating a 3D-printed dental prosthesis in-house allows more control for the surgeon to create the occlusal scheme. It is also much quicker. I can generate this prosthesis in one day, whereas dental laboratories can take two or more weeks,” he added.

According to the researchers, outsourcing dental prostheses to a dental laboratory has previously created a delay in the treatment, which has limited its usefulness to benign conditions. In the present study, the digital workflow used allowed for immediate dental restoration for patients with malignant disease. “This time is significant for a patient with cancer waiting to get their surgery to remove their jaw and tumor,” Williams explained. Despite its clear advantages, the researchers believe that the digital workflow presented in the study is most suitable for patients with teeth in place pre-operatively that will be removed with their tumor. For more complex cases, it is necessary to familiarise oneself with image manipulation and prosthesis planning. Additionally, the researchers calculated that the total initial cost of a 3D printer and post-processing supplies can reach around \$3,000.00, plus additional costs associated with using the software.

Editorial note: The study, titled “Immediate teeth in fibulas: Planning and digital workflow with point-of-care 3D printing,” was published on 1 August 2020, in the Journal of Oral and Maxillofacial Surgery.



A recent study found that printing dental prostheses for fibula and implant reconstructions in-house eliminates the additional waiting period before surgery, making the treatment suitable for patients with malignant disease.