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1/21

3D printing

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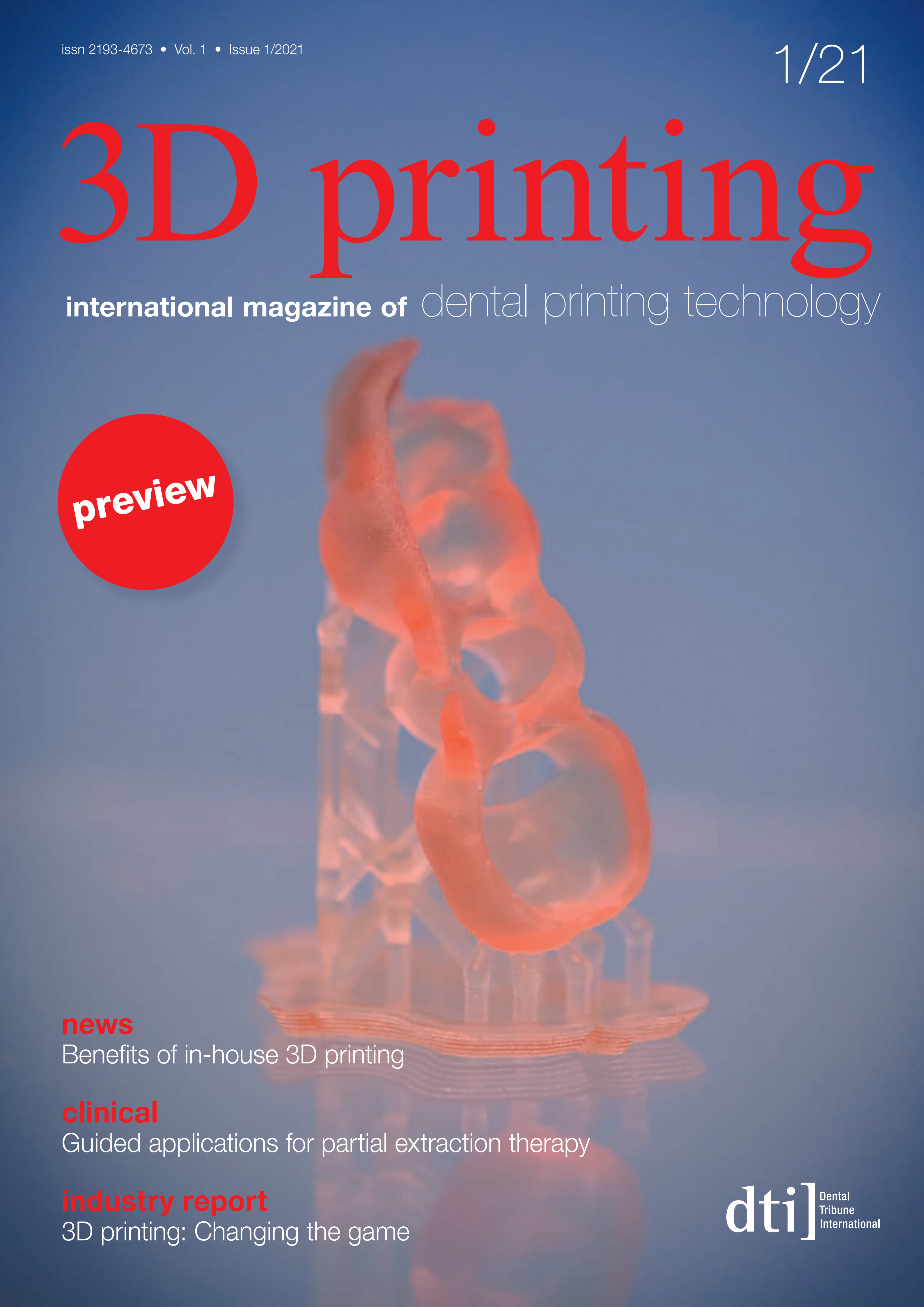


preview

news
Benefits of in-house 3D printing

clinical
Guided applications for partial extraction therapy

industry report
3D printing: Changing the game

dti Dental Tribune International

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, intraoral 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:

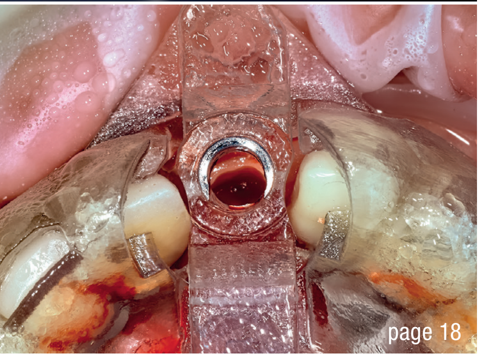
- *Fixed prosthodontics:* Permanent and provisional indirect restorations (crowns, onlays, inlays, bridges) and permanent monobloc direct restorations can all be custom-fabricated chairside within minutes of scanning the preparation.
- *Removable prosthodontics:* Both complete and partial dentures, including 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


page 6

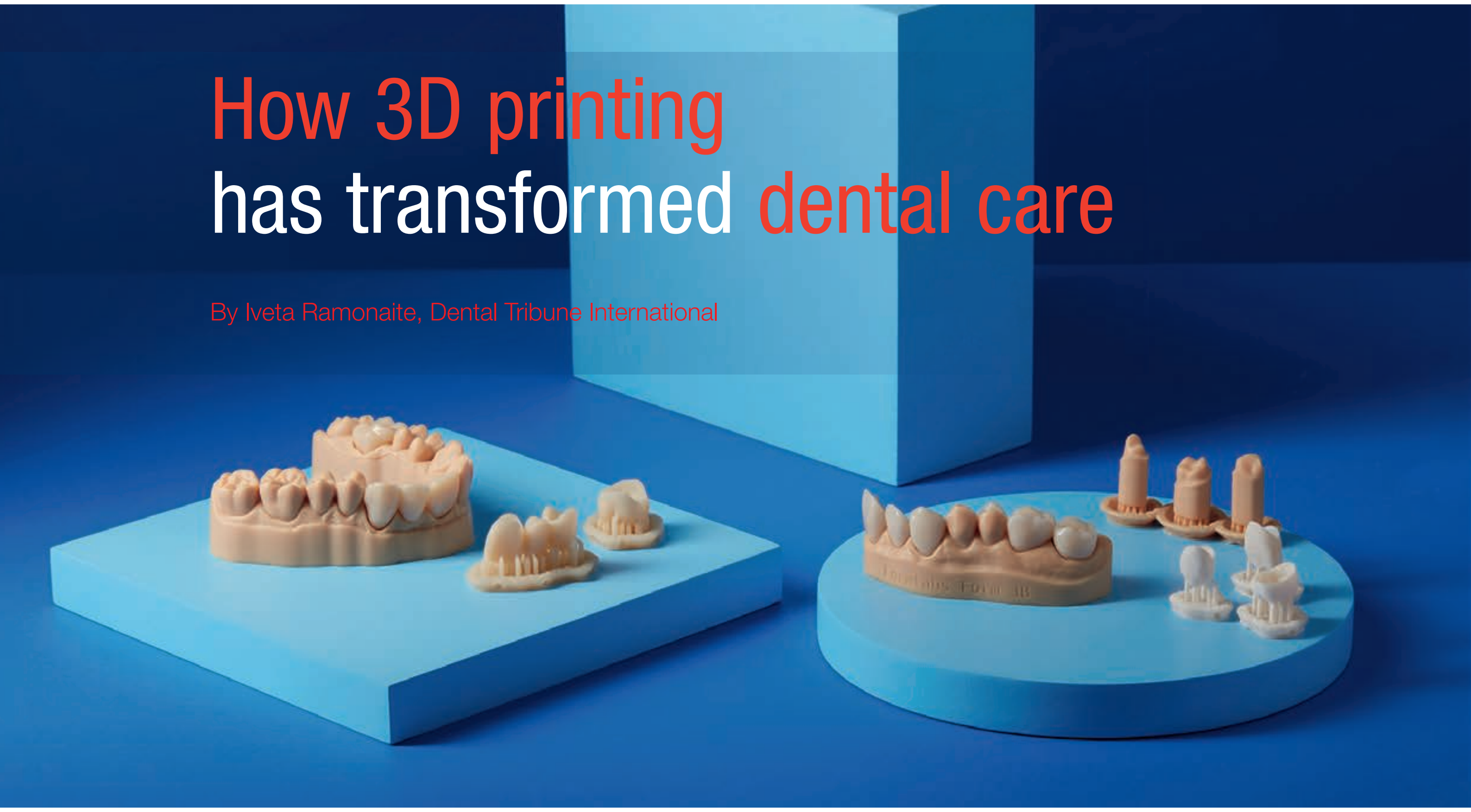

page 10


page 18

Cover image courtesy of Marina Grigorivna/Shutterstock.com

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.

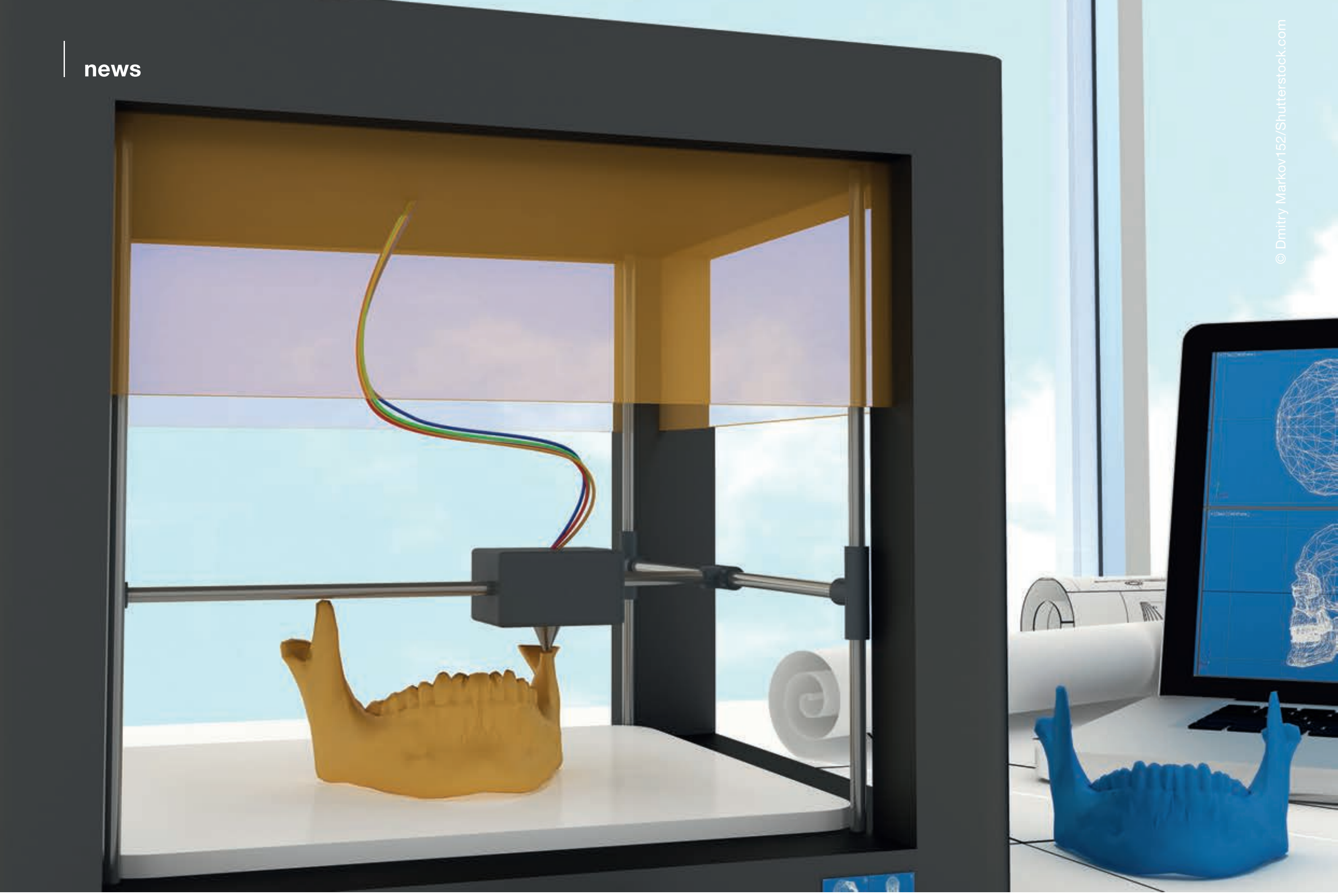
Moving forward, 3D printing needs to overcome the dental industry's skepticism about novel printing materials and applications such as printed dentures and permanent restorations. Manufacturers like Formlabs need to be proactive about teaching experts and validating new technology in the industry in 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.

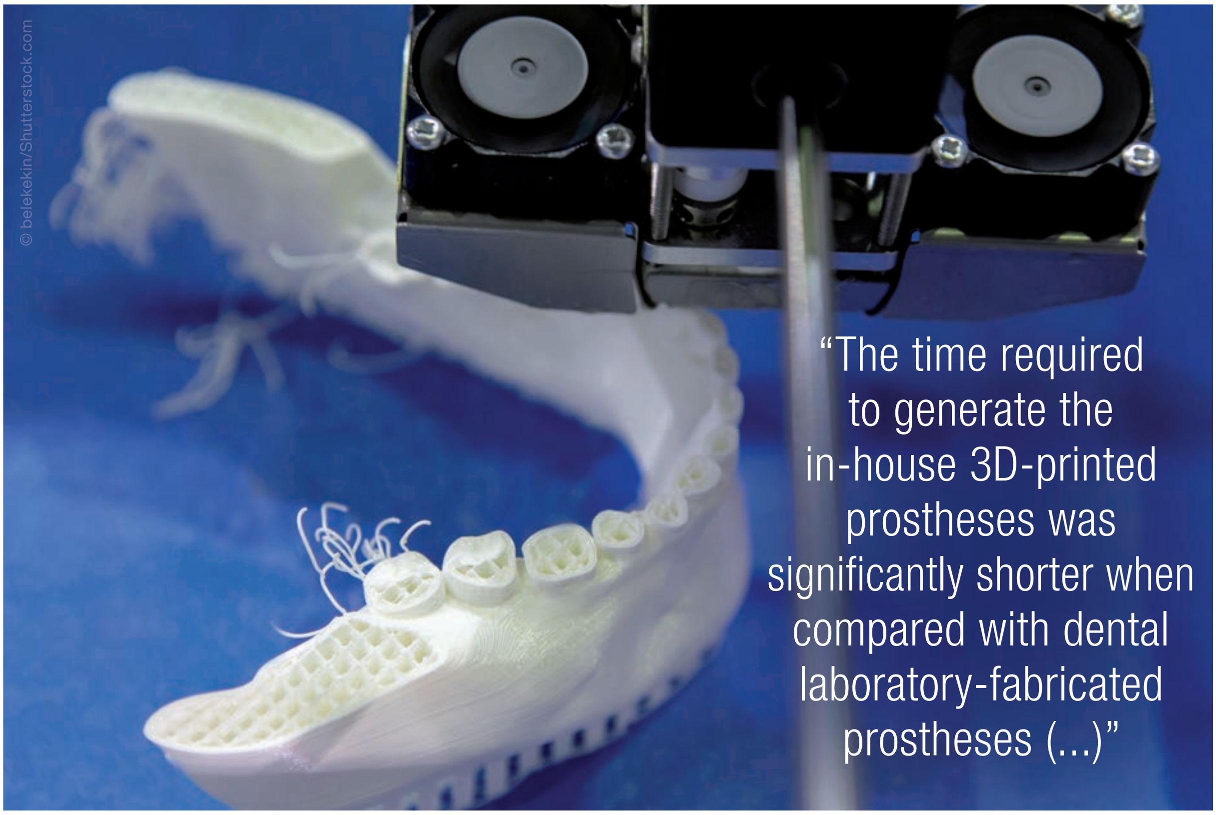
The present study included 12 patients who underwent free fibula reconstruction of the mandible or maxilla with immediate implants and immediate restoration. The restorations were created before surgery, and the first five patients each received a prosthesis that was fabricated by a dental laboratory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

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Printing clear aligners in-house—how accessible is it?

By Jeremy Booth, Dental Tribune International

A growing number of dental practices are choosing to manufacture their own clear aligners in-house using 3D-printing technology.

Bellevue Orthodontics says that its patients can walk out of their first appointment with a set of fully customised clear aligners. Utilising an all-digital workflow, Bellevue has joined the 3D-printing revolution that has seen private dental practices begin producing clear aligners in-house. The founders of the practice have also launched an educational community to help dentists and team members incorporate 3D-printing technology into their workflow. But what exactly is required and what advantages does in-house production offer?

The clear aligner market leader Invisalign is facing increased competition from smaller, localised manufacturers. Dentists wishing to offer clear aligner treatment have a number of options. Manufacturing and selling an in-house brand directly to patients is one option that a growing number of practices are choosing.

A dental practice requires an intra-oral scanner, a suitable 3D printer and photopolymer dental resins for 3D-printing applications, a thermoforming machine for adapting the aligner material to printed models, and a digital workflow in order to bring it all together. Practice owners need to invest in material resources, but they also need to invest in education to help their team implement a 3D-printing workflow.

3D printing offers workflow control

Dr Christopher Riolo founded Bellevue Orthodontics in 2019 after a decade of providing orthodontic treatment to patients in the Seattle area from his downtown Riolo Orthodontics clinic. In the clear aligner category, Bellevue offers its patients Invisalign but also its own in-house product.

According to the practice, the benefits offered by making its own aligners in-house include a lower treatment cost for patients owing to factors such as the ease of making 3D-printed retainers. A lifetime retainer policy is offered to patients, for example, which lowers the overall cost of treatment. The practice also points out that many patients nowadays are conscious of the impact of their treatment on the environment and that its in-house aligners result in a lower environmental impact because shipping and handling are not required. It says that having a better understanding of the materials used to make its own aligners means that staff can offer patients greater peace of mind.

Clinic Manager Cali Kaltschmidt told Dental Tribune International that the benefits of offering an in-house brand also include an expedited start to treatment, the possibility of same-day replacements and improved compatibility with fixed appliances for hybrid treatments. “The ability to provide aligners on the same day or even in the same week is huge. Our busy adult clientele love it,” Kaltschmidt explained. She said that integrating 3D printing is inevitable once a practice has begun using intraoral scanners and that doing so has allowed Bellevue to take control of its workflow.

“3D printing has allowed us to be in control of our own workflow, and with that, the possibilities are endless. We are able to provide aesthetic treatment options for our patients and keep the cost down by not accruing large laboratory fees from third-party companies. This includes in-house clear aligners, lingual braces and hybrid treatment using a combination of both. 3D printing has truly changed the way we practice,” Kaltschmidt said.

“We’re so used to next-day delivery with Amazon and other services, why should straightening teeth be any different?” Riolo asked in a press note. “Orthodontists have the technology and clinical expertise to expedite care in ways that major corporations cannot deliver. This is why we decided to adopt these technologies early on.”

“The investment for orthodontists and dental professionals to get started (with a 3D printer) can be anywhere from $500 to $20,000 or more,” Kaltschmidt said. “Technology is advancing so quickly, and the cost of 3D printers will continue to come down. Our advice for those interested in getting started with 3D printing is to spend less on the printer and invest more time into refining your digital workflow. You will begin to notice the differences when you go from analog to digital.”

“Orthodontists can definitely brand their own aligners and they absolutely should,” Kaltschmidt continued. “The product you design and manufacture in your office as an orthodontist is a superior product in the end, and you should package and brand your aligners to reflect that. In-house aligners give the practitioner full control over workflow, time to delivery, trim line and choice of aligner materials.”

Last year, Riolo and Kaltschmidt founded the Tooth Movement 3D-printing educational community in order to share their expertise on using 3D-printing technology for orthodontic applications like clear aligner therapy. Kaltschmidt said that demand from within the dental community for the limited courses on offer has been significant and that she and Riolo have worked mostly with orthodontists, members of the treatment team and recent graduates. “Many residents do not have any exposure to 3D printing while in their schooling,” she pointed out.

Manufacturers are bullish on adoption of 3D printing in dentistry

Advancements in 3D-printing technology have seen the quality of desktop models for dentistry climb while costs have fallen.

According to Dr Baron Grutter, who owns a dental practice in Kansas City, being able to offer clear aligner treatment at a lower cost has improved case acceptance at his practice for a product that is known for its high earning potential. Grutter was an early adopter of 3D-printing technology in the dental practice and has manufactured his own clear aligners in-house for some time. He told the manufacturer SprintRay in its Practice Insights series last year that a return on the investment of a 3D-printing workflow can be made by selling as few as three or four cases.

“Orthodontists have the technology and clinical expertise to expedite care in ways that major corporations cannot deliver”— Dr Christopher Riolo, Bellevue Orthodontics

Growing demand for this technology from dentists is being met by companies manufacturing solutions that are tailored to a number of dental applications, including making clear aligners. Manufacturers predict that sales will climb this year and that integrated digital workflows will make the technology even more accessible.

Lee Kwang Min, vice president of the Korean 3D-printer manufacturer Carima, told the online trade journal *3D Printing Industry* in 2019 “[2020] will be a full-scale digital dentistry year. The emergence of a variety of 3D scanning solutions with an affordable price range, which has been an obstacle to the spread of digital dentistry, will replace the milling machines in the market and, furthermore, (will accelerate) the rapid adoption of 3D printers.” Min said that he expects that a collaborative approach between individual manufacturers of 3D printers, software and scanners will act to increase the accessibility and adoption of the technology by dentists.

3D-printed indirect bonding tray resin aims to halve orthodontic chair time

By Jeremy Booth, Dental Tribune International

Launched this year Formlab's new indirect bonding tray (IBT) resin is Class I compliant and biocompatible. *(Image: © Formlabs)*

Formlabs has launched a new indirect bonding tray (IBT) resin that it says will bring the benefits of 3D printing to orthodontic practices by streamlining workflows and drastically reducing patient chair time. The company's dental product manager, Sam Wainwright, says that the IBT resin provides an attractive alternative to traditional methods of placing brackets.

An appliance found in most orthodontic practices, the IBT allows dentists to place in one procedure multiple brackets that precisely fit a patient's dentition and prescription. The process of individually placing the brackets can be time-consuming, and Formlabs says that orthodontists can drastically reduce patient chair time by using 3D printing and its new resin when working with IBTs.

Speaking to Dental Tribune International (DTI), Wainwright said: "With 3D printing and the new IBT resin, the time-consuming process of individually placing the brackets can now be done with a custom appliance that saves the orthodontist's time by cutting patient chair time in half."

He explained that the company had worked with leading orthodontists during the development of the IBT resin. Trays made using the resin are flexible and provide for easy insertion and removal, but are firm enough to hold the brackets in place, Wainwright said. "The superb fitment and ease of 3D printing these appliances on the Form 3B, Wash and Cure make efficient orthodontic bracket placement accessible to any orthodontic practice," he added.

The IBT resin offers a completely digital workflow, and treatment planning is done using advanced orthodontic CAD software. Wainwright says that the workflow can result in a more efficient process, that it improves communication and that it can result in an easier exchange between dental practices and laboratories.

"Once the appliance has been designed, the file is ready to print, and the Form 3B's industry-leading ease of use makes this process as simple as possible. And once the appliance is ready to use, the process of placing brackets becomes so much easier than traditional methods. The brackets can be inserted into the appliance before the patient arrives, the appliance is easily inserted over the teeth, and every bracket is then held precisely in position," Wainwright said.

Launched on 16 February, the IBT resin is Class I compliant and biocompatible. DTI recently reported on a study that called into question the safety of 3D-printable resins used to manufacture oral retainers, including certain resins marketed by Formlabs as biocompatible. According to company information, Formlabs' biocompatible resins are developed in accordance with a number of ISO standards, and pass the requirements of those standards.

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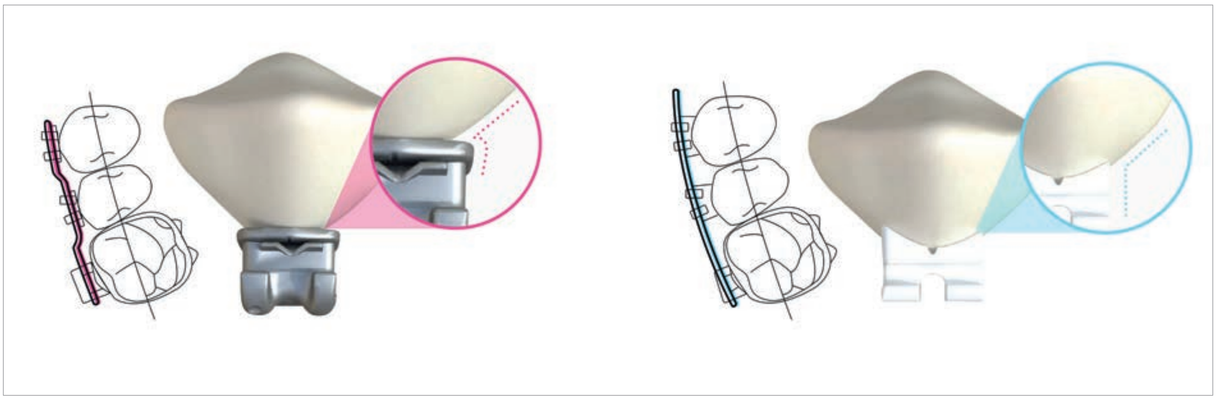
Digital orthodontics company raises funds for 3D-printed brackets

By Jeremy Booth, Dental Tribune International

Dr Alfred Griffin III said that LightForce brackets reduce practice visits—a crucial factor for patients and orthodontists and their teams during the pandemic.

LightForce Orthodontics is a digital dentistry platform that provides orthodontists with fully customised 3D-printed tooth-moving tools. Its customisable 3D brackets are the first of their kind on the market, and they are designed to reduce patient visits and treatment duration. The company launched LightForce this year, after five years of research and development, and has now raised $14 million (€12 million) in funding for the further development and commercialisation of the system.

The LightForce treatment process begins with the orthodontist sending a scan of a patient's teeth and a treat-



3D-printed brackets that can adapt to achieve a desired final tooth position for that unique patient. *(All images: © LightForce Orthodontics)* ment plan to the company's technicians, who then create customised brackets and trays. The system uses ceramic material that is specially formulated for 3D printing, but which is otherwise virtually identical to that used in injection-molded brackets.

The founder of the company, Dr Alfred Griffin III, told Dental Tribune International that the digital workflow resembles that used in clear aligner therapy. "LightPlan is the proprietary treatment software developed by LightForce that enables mass-customised braces," he said. "Doctors have complete control over every aspect of the treatment plan and can utilise a simple cloud-based interface for adjustments and approvals."

"Our treatment plans are unique to each individual patient and largely follow the clear aligner workflow," Griffin continued. "Where our technology diverges is when the orthodontist uploads the patient's scan to our LightPlan software, which enables the doctor to adjust the teeth virtually in order to create a perfect smile and bite for that unique patient, enabled by automatically designed braces."

Griffin explained that the LightPlan software generates bracket files, which are then printed at LightForce's centralised manufacturing plant in Cambridge. The brackets are then delivered to the orthodontist's office about a month later.

LightForce says that orthodontists should "move teeth, not brackets."

Increased personalisation using digital tools

LightForce aims to provide treatment for malocclusion, which is as individual as each patient is. "A person's lips, jaws, teeth and smile are individual, and it's important to customise the tools that impact his or her face," Griffin explained. "3D printing provides the ideal solution for patients, as it allows for customisation and uses modern technology to address an age-old problem. We've found 3D printing to be the best solution for orthodontic applications because it enables complete personalisation for each patient—it can print complex geometries, in this case unique tooth morphology that would otherwise be unavailable to patients."

He added: "On the one hand, we believe that the days of bracket prescriptions are numbered; on the other hand, we welcome the days of 'tooth prescriptions' for mass-customised appliances like aligners and 3D-printed brackets that can adapt to achieve a desired final tooth position for that unique patient." Griffin said that, in the future, he expects that there will be a rapid expansion of 3D-printing technology within the dental industry.

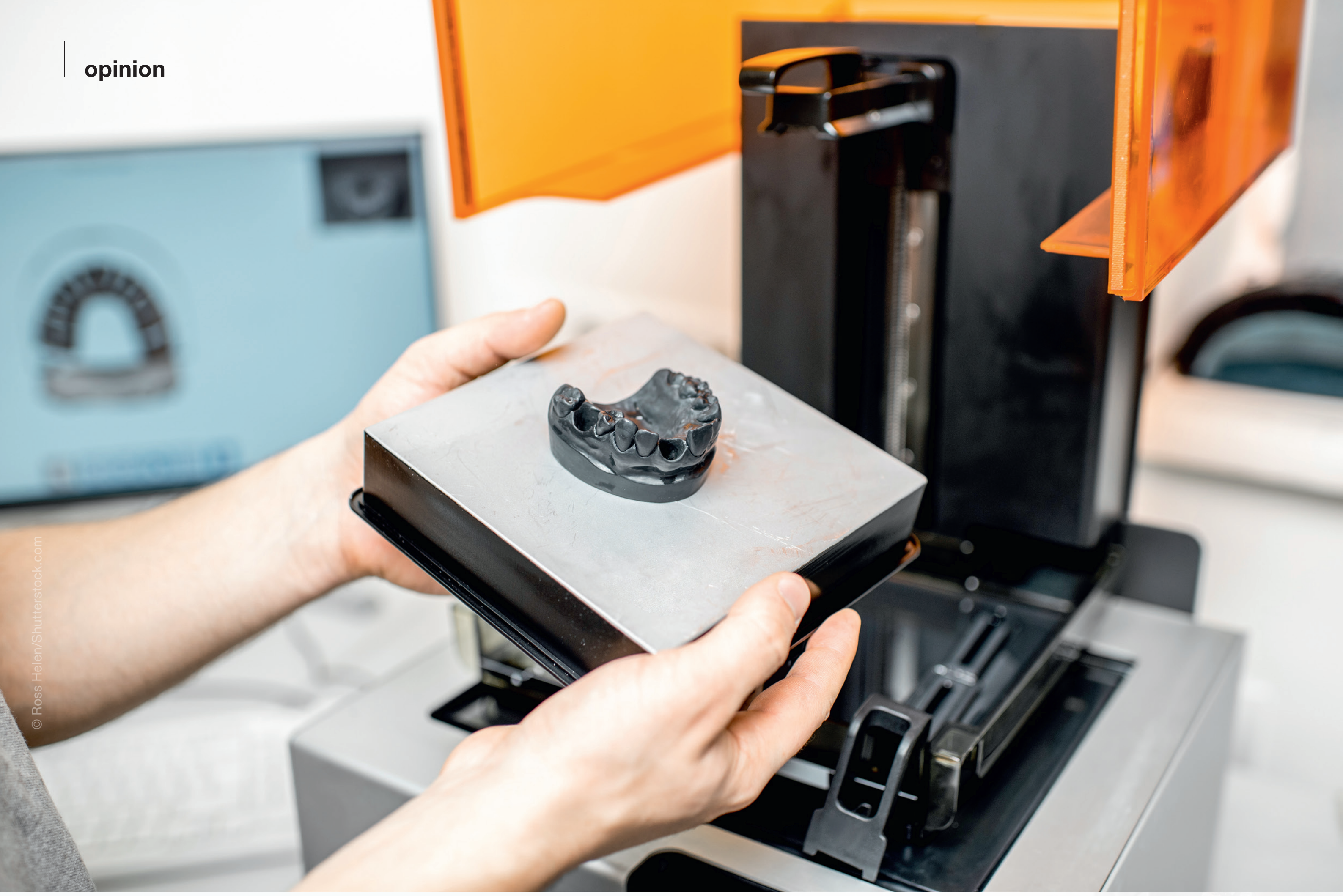
LightForce Orthodontics was founded in 2015. Over the last five years, Griffin and his team have undertaken extensive research and development for what is now the company's eponymous treatment platform. No one could have predicted that the 2020 launch of the bracket system would take place in the midst of a global pandemic, but it seems that the outbreak of SARS-CoV-2 has not hampered the company's plans.

> "Our treatment plans are unique to each individual patient and largely follow the clear aligner workflow."

"In light of the ongoing pandemic, technology that reduces in-person dental visits is crucial not only for patients but also for the orthodontists and their teams that are caring for them," Griffin said.

Hundreds of orthodontists throughout the US are already providing treatment using LightForce brackets. Griffin said that the company will use its newly acquired funds to further develop its technology and product offerings and to scale its operations in order to meet what he called a recent surge in demand for more efficient dental technologies.

The funds were raised in a Series B funding round that was led by investors Tyche Partners, Matrix Partners and AM Ventures.



3D Printing: Changing the game

Dr Florin Lăzărescu, Romania

When I discovered CAD/CAM technology more than 10 years ago, I was amazed at the technological world that I was entering. It was novel and it was creative; but it was also rather daunting. My student years had provided some abstract images of various scanners and milling machines that were available at that time, but no actual cases employing these technologies. Once I graduated, the systems were far too expensive for the small office where I was practicing initially.

After I made the decision to purchase a complete in-office system, I discovered an exciting new world, one that I could not have imagined previously. As suggested, I allowed myself a comfortable learning curve at the beginning, starting with easy cases, gradually gaining experience and familiarity with the process, until I was confident enough to push for more. CAD/CAM systems have evolved rapidly, and during the past 10 years I have been witness to an accelerated evolution of three generations of scanners and milling machines. Today, I would not even consider opening a new office without, at the very least, a scanner, and preferably, a complete in office CAD/CAM system.

I remember that when I explained the benefits of CAD/CAM technology to my patients a decade ago, I could not help wondering what lay ahead for dentists, and where the future of the profession would lead us.

As I look at the rapidly developing field of 3D printing, I get the same game-changing feeling that I had when I first discovered CAD/CAM technology. The mainstream dental 3D printing boom began in 2015, following important technological milestones such as the first dental 3D printing in 2000, digital impressions for an analog world in 2005, and the introduction of all-ceramic restorations and desktop scanners in 2010.

There are 3 distinguishable types of 3D printing that can be categorised from a technological perspective[1]:

1. Photopolymerisation with thermoset plastics. A thermosetting polymer, resin, or plastic is a polymer that is irreversibly hardened by curing from a soft solid or viscous liquid prepolymer or resin. Curing is induced by heat or suitable radiation and may be promoted

by high pressure or mixing with a catalyst. It is also known as Stereolithography, and commonly referred to as SLA.
2. Laser sintering with both for metals and thermoplastics is an Additive Manufacturing process that belongs to the Powder Bed Fusion family. A laser selectively sinters the particles of a polymer powder, fusing them together and building a part, layer-by-layer. It is known as Selective Laser Sintering and commonly referred to a SLS or SLM. Laser sintering is very expensive, with high maintenance costs, but delivers amazing results.
3. Extrusion is a 3D printing process that uses a continuous filament of a thermoplastic material. It is known as Fused Filament Fabrication or Fused Deposition Modeling and commonly referred to as FDM. This technology is based on feeding a modelling filament through a heated nozzle, and printing layer by layer. While very affordable, FDM's accuracy and service quality are quite limited with respect to dental applications.

Various companies utilise differing photopolymerisation technology categories:

1. SLA—Stereolithography printing exposes the liquid resin to a laser light source.
2. LFS—Low Force Stereolithography can be described as SLA's successor. It uses a flexible tank and linear illumination to polymerise liquid resin.
3. DLP—Digital Light Processing exposes the liquid resin to a DLP projector light source.
4. LED—New technology that uses LED instead of laser light sources for the additive manufacturing of metal parts and optimises 3D metal printing.

However, the underlying principle is the same: a polymerising light hardens the resin to a solid-state layer by layer. DLP or LED techniques offer faster results, while SLA and LFS modes provide smoother and finer details, but the process is significantly slower.

There are numerous dental applications for 3D printing.[2] In fact, there are many applications that are not possible without 3D printing (aligner thermoforming models, indirect bonding trays). 3D printing can enhance traditional techniques such as surgical guides, custom impression trays, diagnostic models, splints, restorative models, and provisionals. And there are novel 3D printing opportunities such as full dentures and permanent indirect and direct restorations.

In my daily practice I find many situations where 3D printing allows me to offer existing services more predictably and rapidly. Currently available options include: provisional crown and bridge restorations, inlays, onlays and veneers.

The ability to print splints represents a tremendous advantage; a reliable inhouse splint can be completed in a single appointment whereas sending the case to a dental laboratory is far less efficient and much more expensive. The routine use of rapidly printed surgical guides improves the patient's perception of surgical procedures, speeds treatment, and assists in predictable results for every case. 3D inhouse printing reduces the waiting time before surgeries.[3]

In the past, it was extremely difficult to treat totally edentulous patients with significant bone loss. Ultimately, the limitations of dentist–technician communications made the process long and tedious, and results were often less than satisfactory. It was also frustrating that during this time-consuming ordeal the patient had no access to provisional dentures. 3D printed full dentures, available the same day, offer a practical solution to both patient and dentist. Scanner, 3D printer and an in-house technician are the ideal.

As with any new technology, 3D printing has a learning curve. It is highly recommended that the practitioner begin with simpler procedures, and then tackle more complex ones as experience and confidence are accumulated. 3D printing technology is a game changer in the dental industry that will greatly influence and modify patient treatment in the years to come.

3D printing, taken together with CAD/CAM and CBCT, creates a comprehensive shift to digital dentistry, a trend that is rapidly redefining the dental profession.

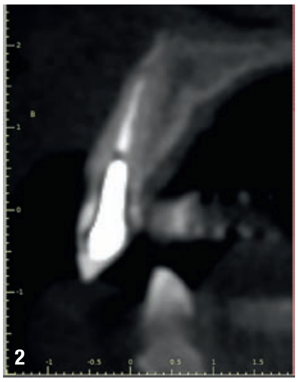
Editorial note: A list of references is available from the publisher. This article originally appeared in Oral Health Magazine*, and an edited version is provided here with permission from Newcom Media.*

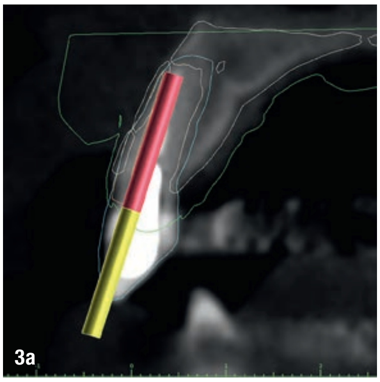
about

Dr Florin Lăzărescu owns a private dental practice in Bucharest in Romania and in his work focuses on aesthetic dentistry with an emphasis on all-ceramic and implant restorative procedures. He is the author of numerous publications on dentistry, and he is the editor of and a contributing author to the *Romanian book Incursiune în Estetică Dentara* (Immersion in Esthetic Dentistry, Society of Esthetic Dentistry in Romania, 2013)—republished in English as *Comprehensive Esthetic Dentistry* (Quintessence, 2015) and in Chinese (Qiuntessence China, 2017). He is editor-in-chief of *Dental Tribune* Romanian Edition. Dr Lăzărescu is the president of the European Society of Cosmetic Dentistry and a founding member and director of the Society of Esthetic Dentistry in Romania.

Guided applications for partial extraction therapy

Drs Scott D. Ganz & Isaac Tawil, USA





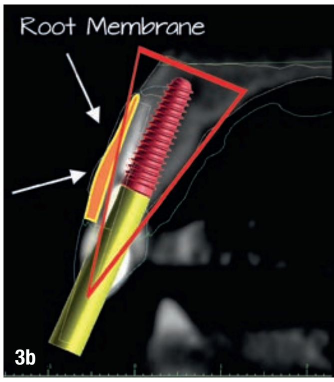
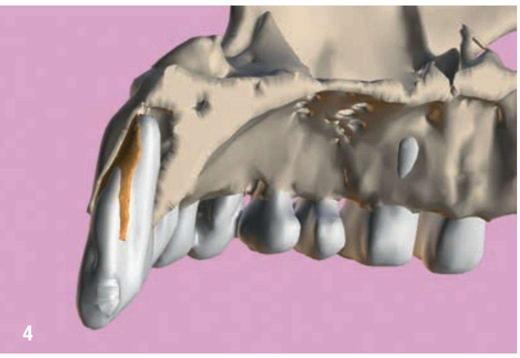


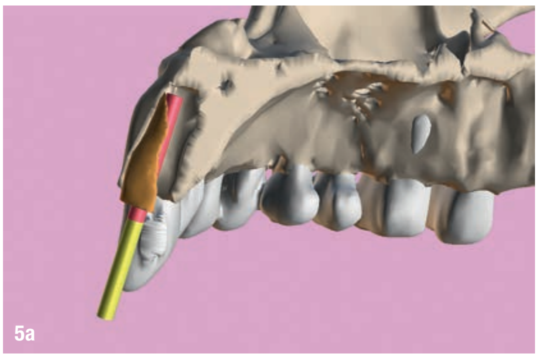
Fig. 1: The patient presented with a horizontally fractured clinical crown, an indication for a partial extraction therapy procedure. **Fig. 2:** The trajectory of the root in relation to the alveolus can be visualised with a cross-sectional image. **Fig. 3a:** Planning the initial drill path using a custom implant design (red) to match the diameter of the initial drill to reach the tooth apex. The abutment projection is shown in yellow. **Fig. 3b:** The simulated implant within the Triangle of Bone (red), placed to avoid the root fragment seen in yellow (white arrows).

Dental implants to replace missing teeth have become an integral part of current conventional dentistry. Accepted protocols now include two-stage delayed loading, one-stage delayed loading, immediate loading in a healed receptor site, tilted implant placement, immediate loading in fresh extraction sites, partial extraction therapy (PET), socket shield technique and root membrane concept.

Technology has provided clinicians with enhanced tools for diagnosis and treatment planning, instrumentation for surgical intervention, improved implant surface treatments and thread design, improved abutment-to-implant connections, sophisticated dental laboratory software and CAD/CAM applications, a greater selection of transitional and definitive restorative materials, static and dynamic navigation, and changes in drill designs and drilling protocols. Dental implant procedures are predictable, effective and essential to address the needs of patients.

Partial extraction procedures in their various formulations have been demonstrated to be proven methodologies for preserving bone and soft-tissue volume.[1–7] Our 2017 article (The Root Membrane Concept: In the Zone With the "Triangle of Bone", Dentistry Today CE, October 2017) reviewed 3D diagnostic tools for planning and executing root membrane and PET procedures based on the





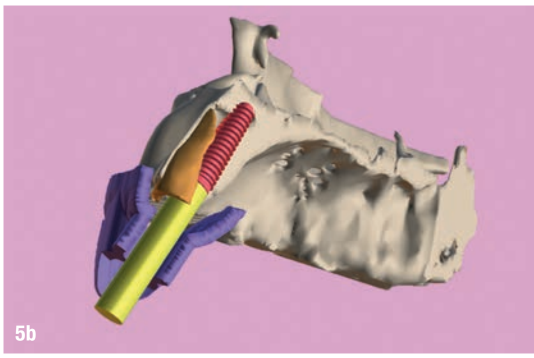
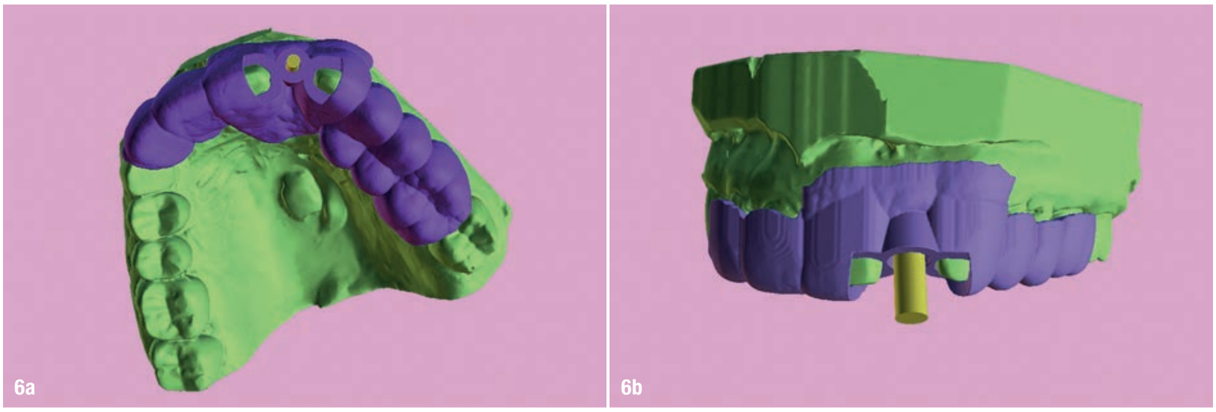


Fig. 4: The segmented root (white) and the root fragment (brown) within the sectioned maxillary surface model. **Fig. 5a:** Virtual sectioning of the segmented root using Meshmixer with a simulated custom implant to reach the root apex. **Fig. 5b:** The apical portion of the simulated AnyRidge implant can then be positioned so as not to touch the root fragment while engaging in host bone for stability.



Figs. 6a & b: Two 3D-printed templates designed on the digitised model (green): one for the initial drill to section the tooth at the root apex **(a)** and the second for using sequential guided drills to drill through the root itself **(b)**.

"Triangle of Bone" concept and specific instrumentation to achieve successful outcomes.[5]

The ability to perform the procedures requires careful diagnosis, treatment planning and excellent control of the drilling process to ensure that the root fragment will be maintained while maximising implant stability. In many cases, it may also be possible to provide immediate transitional restorations when high implant stability is achieved. However, complications can also arise when the root fragment is lost or the implant fails to integrate. It should be noted that PET has mainly been accomplished with a diagnostic freehand method for sectioning roots, osteotomy preparation and implant placement. The current article describes methods of providing PET procedures using full-template guidance based on a thorough appreciation of the existing anatomical structures utilising advanced state-of-the-art treatment planning tools, 3D design software, 3D printing and/or CAD/CAM surgical templates.

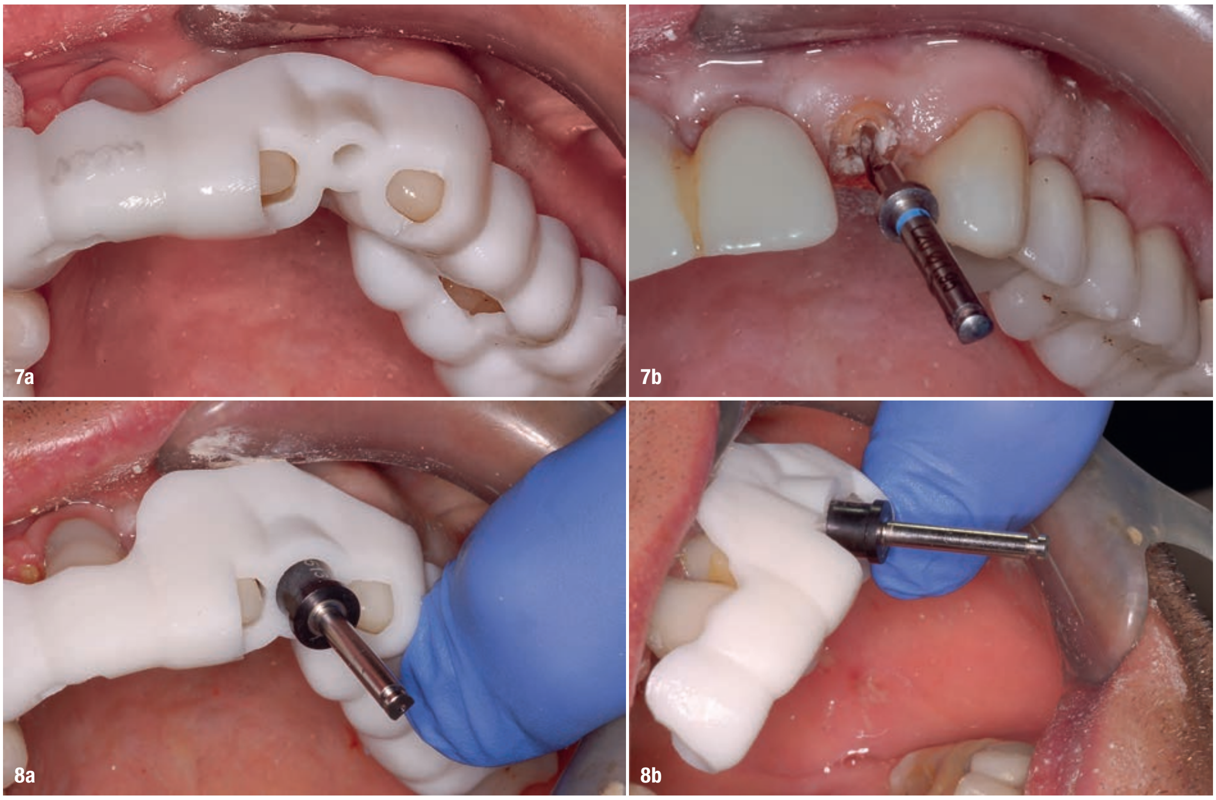


Fig. 7a: A sleeveless guide to accommodate a 2 mm long pilot drill that was used to reach the root apex. **Fig. 7b:** Removing the guide allowed for inspection of the drill embedded within the tooth. **Figs. 8a & b:** Using drill guides with long shanks to engage the sleeveless template allowed for sequential and accurate drilling of the tooth and subsequent bone for implant placement.

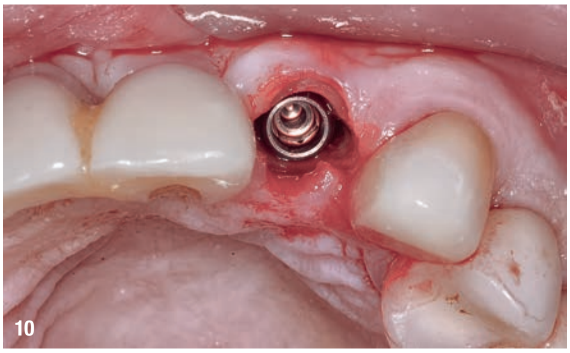
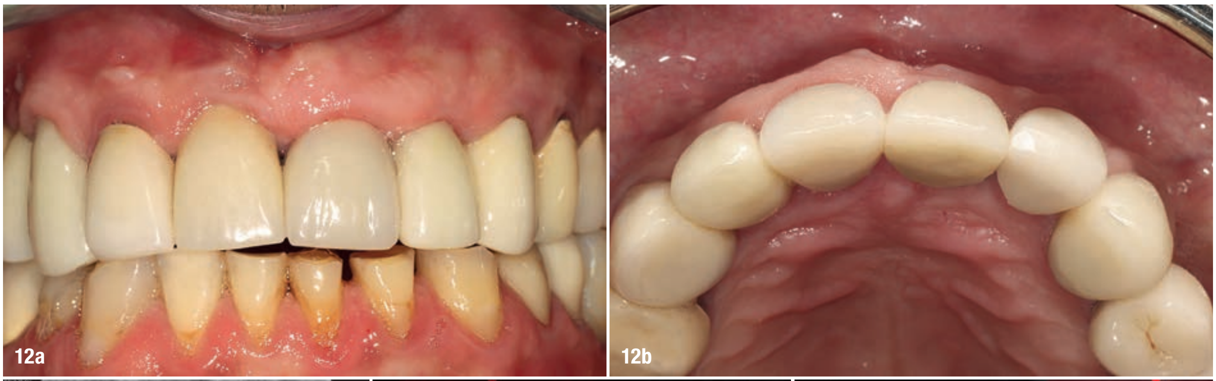
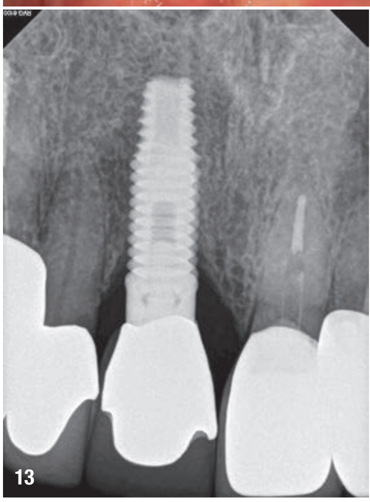


Fig. 9: The cylindrical tooth preparation resulted in the desired crescent shape of the root fragment to provide adequate space for the implant. **Fig. 10:** The implant was placed into the osteotomy through the template using a special manufacturer-specific carrier. **Fig. 11:** The stackable tooth-borne guide and the three other separate components seen in Figures 15a–c.

One indication for PET is when a patient presents with a horizontally fractured clinical crown (Fig. 1). While a 2D radiograph will reveal the extent of the horizontal fracture, length of the remaining root and approximation of the bone apical to the root, there is not enough information to plan for a PET procedure. A CBCT scan is recommended in order to fully appreciate the root position within the alveolus and the potential difference between the trajectory of the bone and the trajectory of the root as can be visualised with a cross-sectional image (Fig. 2).

Utilising interactive treatment planning software makes it possible to plan the initial drill path to accurately section the root to its apex (Fig. 3a). This can be accomplished by creating a custom implant design to match the diameter of the initial drill with an abutment projection in order to





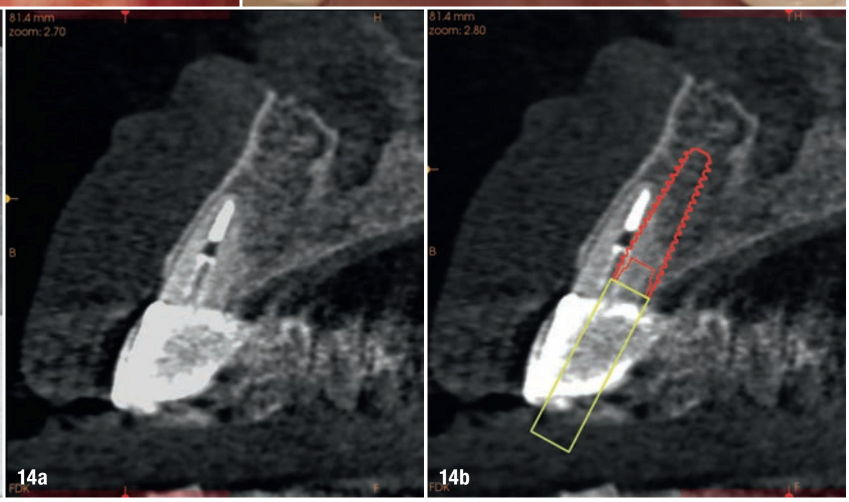


Fig. 12a: A post fracture presenting in the left central incisor, requiring extraction. **Fig. 12b:** The occlusal view illustrated the cervical tissue volume and contours. **Fig. 13:** The pre-op periapical radiograph revealed an existing implant-supported metal–ceramic restoration for the adjacent region #11. **Fig. 14a:** The CBCT cross-sectional image revealed a favourable pre-op condition for a PET procedure. **Fig. 14b:** Using the native Carestream 3D Imaging Software, a simulated implant (red outline) and abutment projection (yellow outline) was positioned within the available bone to avoid the root fragment.

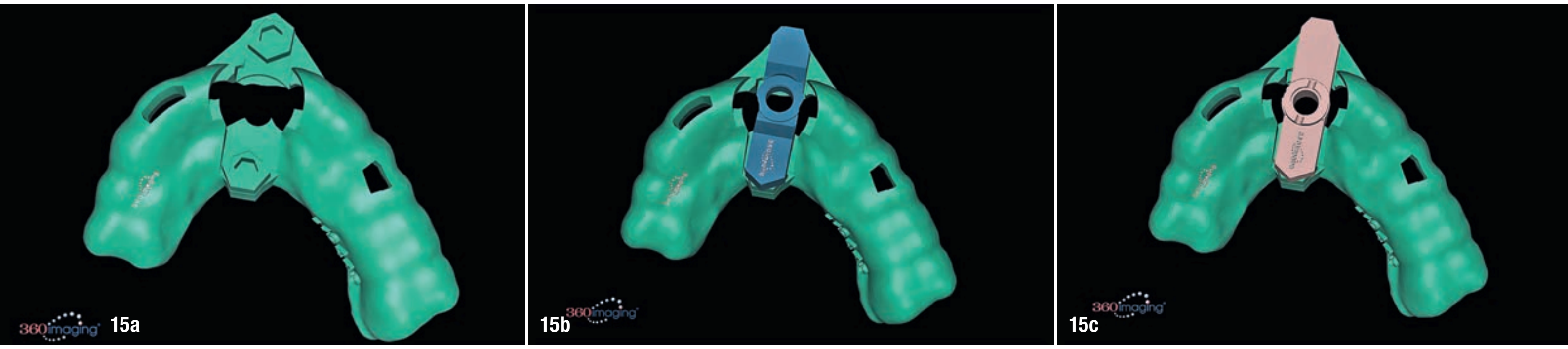


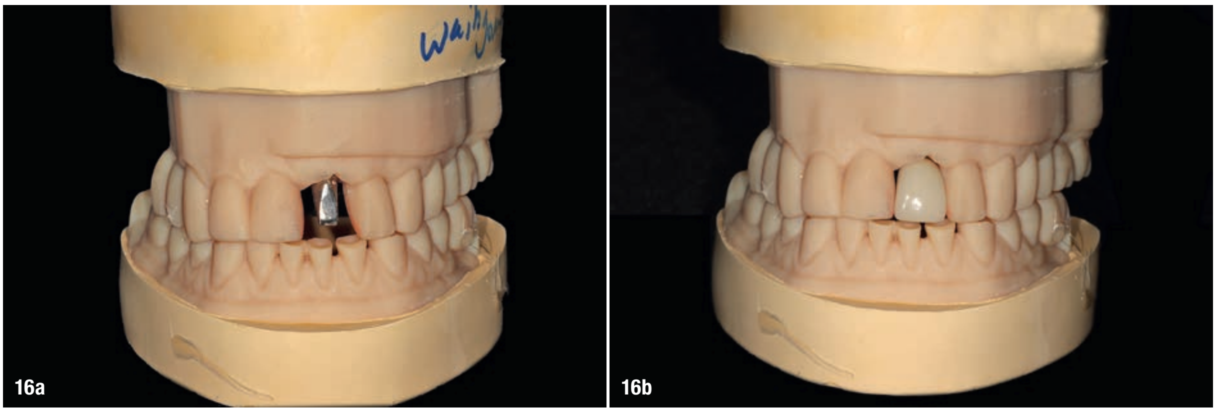
Fig. 15a: The base template was designed to seat firmly on the adjacent teeth, incorporating buccal and lingual hexagonal offsets to engage the different drill guide inserts. **Figs. 15b & c:** Separate inserts were fabricated for the initial drill guide to reach the root apex to accommodate sectioning, followed by a second guide for final osteotomy drilling and implant placement.

fully appreciate the trajectory through the clinical crown (Blue Sky Plan, Blue Sky Bio). It is important to visualise the root fragment that will remain in order to properly simulate the position of the implant in the alveolus (Fig. 3b). The apical portion of the implant can be positioned to gain stability in host bone using the Triangle of Bone. It is important to note that a cross-sectional slice may only be 0.125 mm in thickness based on the CBCT acquisition, and therefore all images in all views must be visualised to confirm the plan. Utilising 3D segmentation (separating objects by density values), it is possible to define each root and further assess the simulated position of the implant with a sagittal cut through the 3D reconstructed volume (Fig. 4).

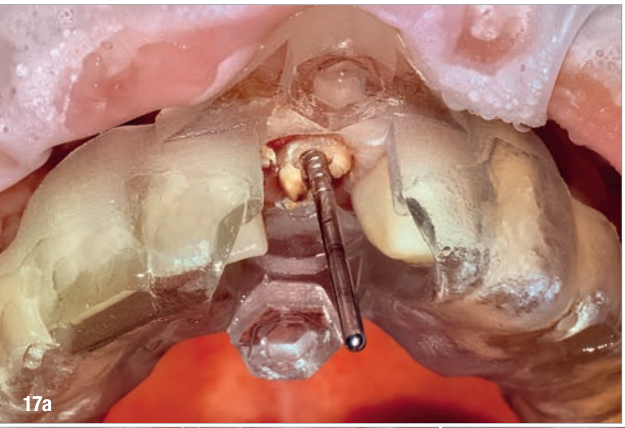
The ability to export volumes in STL format allows these objects to be edited and utilised in other software applications, such as Meshmixer (Autodesk). The STL file of the root image was imported into Meshmixer, and the root was virtually sectioned using Boolean difference to mimic the crescent shape for PET (Fig. 5a). The apical portion of the simulated implant can then be positioned so as not to touch the root fragment while engaging in host bone for stability (Fig. 5b).

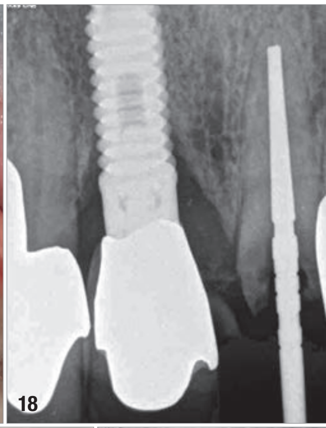
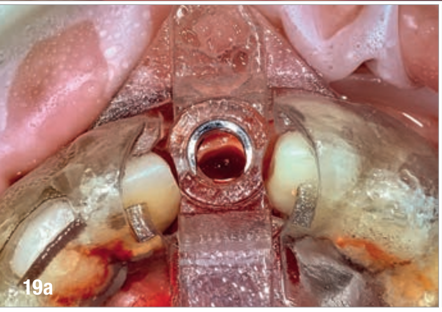
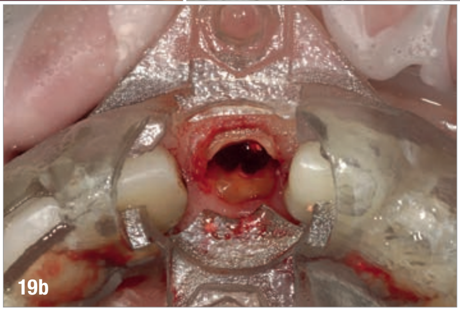
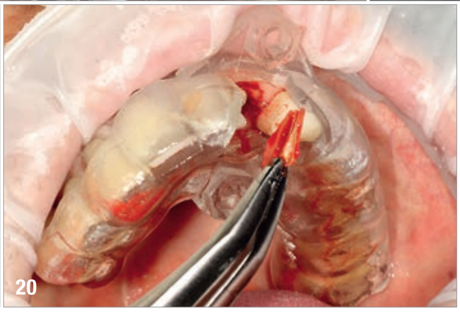
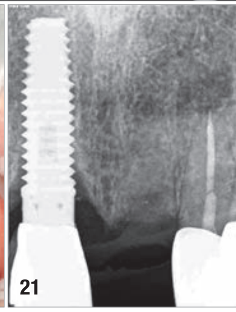
Planning with such precision is predicated on the acquisition of a satisfactory CBCT scan with a proper field of view and the incorporation of occlusal surface data STL files of the arch form, digitised through either an intra-oral scan or a desktop scanner imported into the software. Two 3D-printed templates were then designed on the accurate digitised surface model, one for the initial drill to section the tooth at the root apex and the second to use sequential guided drills to drill through the root itself (Fig. 6).

A 2 mm pilot drill, which was long enough to reach the root apex with the tooth-borne surgical guide in place, was utilised with a sleeveless guided approach (Fig. 7a). Removing the guide allowed for inspection of the drill through the tooth (Fig. 7b). Using guided drills with long shanks in a sleeveless guide allowed for sequential and accurate removal of the tooth and subsequent bone beyond the apex of the natural tooth root (R2Gate, MegaGen; Fig. 8). The cylindrical tooth preparation/osteotomy resulted in the desired crescent shape to provide space for the implant (Fig. 9). The root was then sectioned mesiodistally using specialised drills (Root Membrane Kit, MegaGen) and the palatal section removed. Utilising

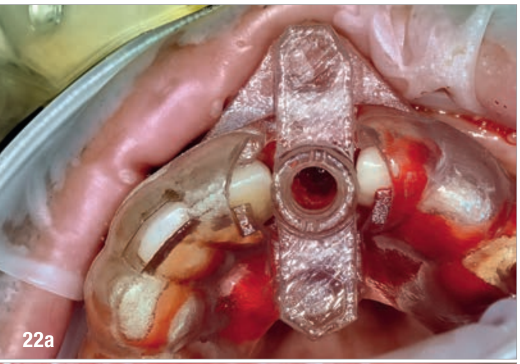
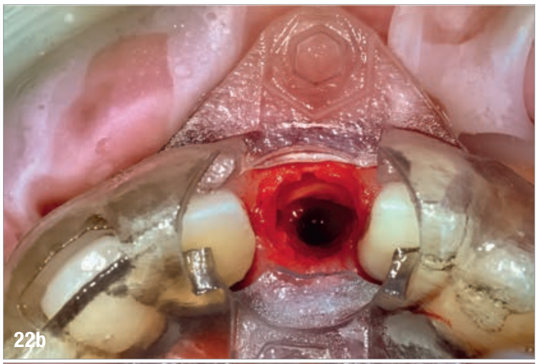
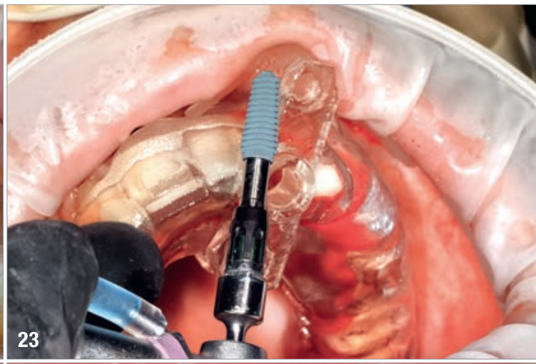
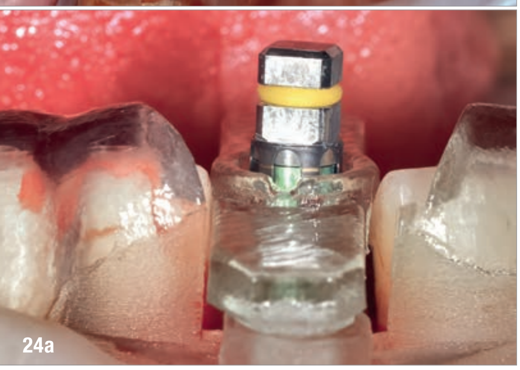
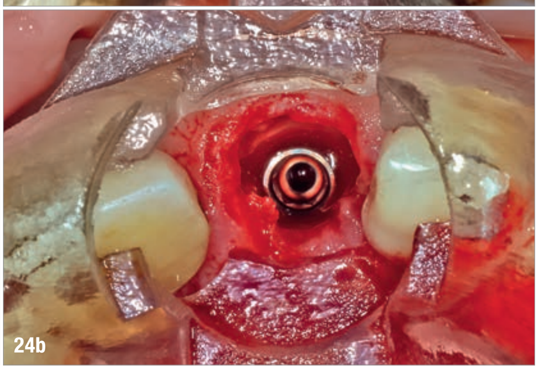


Figs. 16a & b: The accuracy of the implant and template design allows for true restoratively driven planning combined with CAD/CAM applications for the design and fabrication of a patient-specific abutment and transitional restoration.

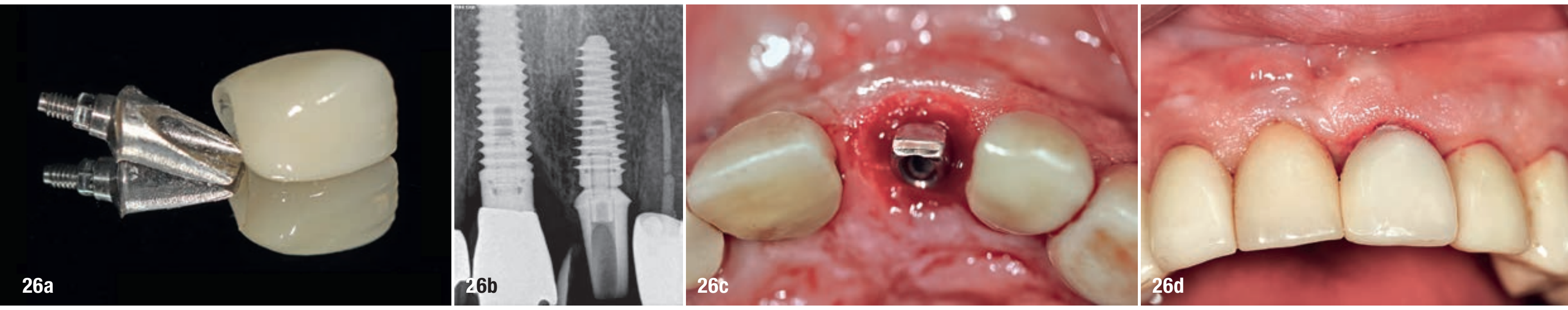


Figs. 17a & b: Utilising the tooth-borne template and the first insert, initial long shaper drills were used to reach the apex of the root. **Fig. 18:** A periapical radiograph with a drill in place confirmed that the apex length had been reached and that all the gutta-percha had been removed. **Figs. 19a & b:** The second metal cylinder insert allowed for the long, round diamond drills to shape the root into the desired crescent shape **(a)**. The insert was removed to access the palatal root **(b)**. **Fig. 20:** The sectioned palatal root was carefully removed. **Fig. 21:** A periapical radiograph confirmed that the palatal root and all the gutta-percha had been completely removed.


Figs. 22a & b: The final insert was designed to receive the guided sleeveless drills for accurate osteotomy preparation **(a)**. The osteotomy was prepared to avoid proximity to the remaining root fragment while leaving sufficient restorative space as previously planned **(b)**. **Fig. 23:** The implant, seen prior to placement, using the R2Gate surgical carrier for full-template guidance through the sleeveless guide. **Figs. 24a & b:** Depth control and rotational positioning were accurately confirmed with the notch indicator on the template corresponding with the insertion tool **(a)**. The occlusal view illustrated that the anti-rotational internal conical–hexagonal connection was positioned towards the facial aspect **(b)**. **Fig. 25:** Using an implant-specific SmartPeg, a baseline ISQ value of 76 confirmed sufficient initial stability to place an immediate restoration.



Figs. 26a–d: The prefabricated CAD/CAM abutment and transitional crown **(a)**. A post-op periapical radiograph confirmed successful sub-crestal placement of this platform-switched design **(b)**. The abutment in place **(c)**. The soft-tissue contours were excellent; no sutures were required for the transitional restoration **(d)**.

the template, the implant was placed into the osteotomy using the correct implant carrier to achieve full-template guidance and stability measured using resonance frequency analysis (RFA) to obtain the implant stability quotient (ISQ; Fig. 10).

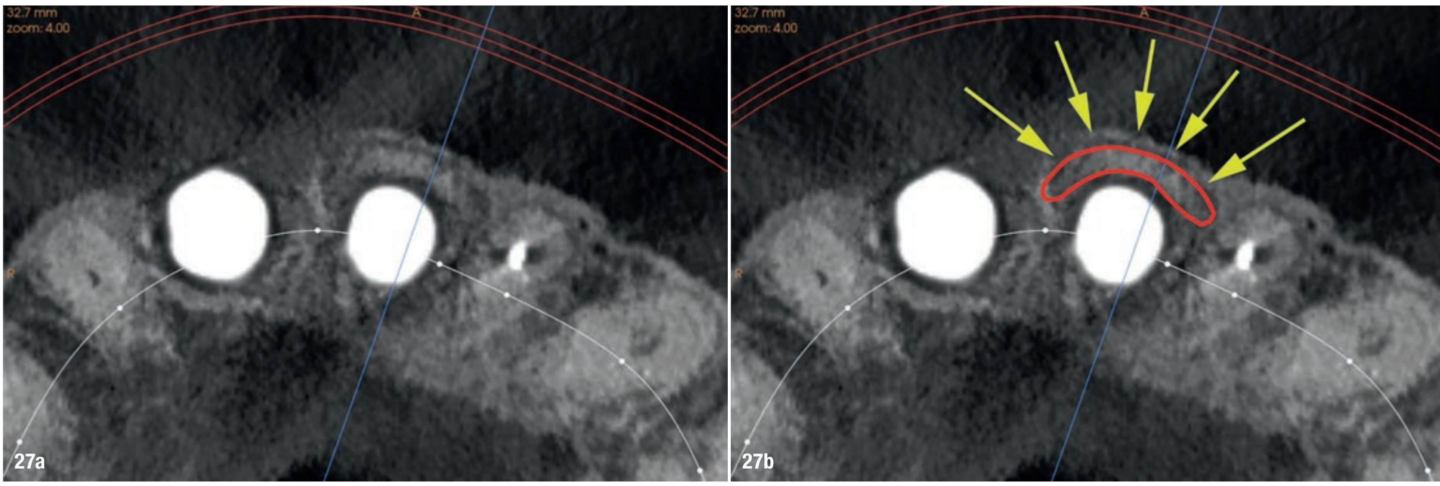
The concept of drilling through the root is not new and has been reported in the literature.[8] Using guided methods for the socket shield technique has also been reported using a CAD/CAM-fabricated template.[9] However, the ability to use technology to plan and execute a fully guided procedure for a PET, socket shield technique and root membrane technique illustrates additional methodology to aid clinicians in successful outcomes.

The first concept described the use of two separate templates, one for separating the root at the apex and the second for drilling through the tooth and placing the implant. Continuing the evolution, we present a second option, which does not require the removal of the base template, but has inserts to allow for the different drills and angulation required for the PET technique: the stackable tooth-borne guide. The new technique has four separate components: (1) a base template (stackable tooth-borne guide); (2) a pilot drill guide for the root apex (APEX STACK); (3) a crescent-shaped guide for shaping root fragments (PET Shaper STACK); and (4) a guide for osteotomy drilling and placing the implant through the guide (Surgical Guide STACK; Fig. 11).

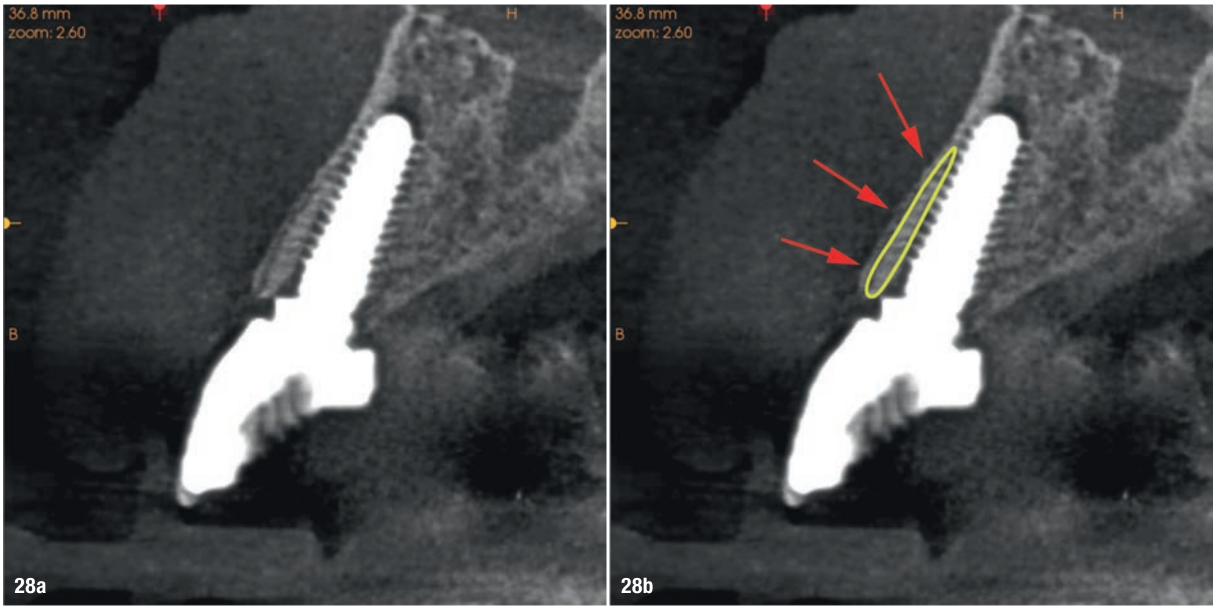
Case report

A 62-year-old male patient presented with a hopeless prognosis for a post fracture in the left central incisor requiring extraction (Figs. 12a & b). The preoperative periapical radiograph revealed an existing implant supporting a metal–ceramic restoration for the adjacent region #11 (Fig. 13). The CBCT (CS 9600, Carestream Dental) cross-sectional image revealed a favourable preoperative condition relating to the trajectory of the endodontically treated root to the alveolus for a PET procedure (Fig. 14a). Using the native Carestream 3D Imaging software, a simulated implant and abutment projection was positioned within the available bone to avoid the root fragment (Fig. 14b).

The final positioning of the implant, as determined by the restorative requirements, and design and fabrication of



Figs. 27a & b: The post-op CBCT scan axial view revealed the intact crescent shape of the root membrane **(a)**, as outlined in red in facial to the opaque implant position **(b)**.



Figs. 28a & b: The post-op cross-sectional view clearly illustrated the position of the implant **(a)**, the definitive restoration located palatal to the root membrane **(b)**, as outlined in yellow (red arrows).

the tooth-borne stackable surgical template, was accomplished using dedicated interactive treatment planning software (360dps, 360Imaging). The base template was designed to seat firmly on the adjacent teeth, incorporating buccal and lingual hexagonal offsets to engage the different drill guide inserts (Fig. 15a). Separate inserts were then fabricated for the initial drill guide to reach the root apex to accommodate sectioning, followed by a second guide for final osteotomy drilling and implant placement (Figs. 15b & c). The accuracy of the implant and template design provides the opportunity for true restoratively driven planning, which can then be combined with CAD/CAM applications to also design and fabricate a patient-specific abutment and transitional restoration in advance of the surgical intervention (Fig. 16).

Prior to the guided drilling, a Gates–Glidden drill was used to remove any gutta-percha within the root. Utilising the tooth-borne template and the first insert, initial long shaper drills (IS1, IS2 from the Root Membrane Kit, MegaGen) were used to reach the apex of the root (Root Membrane Kit; Fig. 17). A periapical radiograph confirmed that the apex length had been reached and that all the gutta-percha had been removed (Fig. 18). The second insert had a metal cylinder that allowed for the long, round diamond drills to shape the root into the desired crescent shape (Fig. 19a). The insert was removed to access the palatal root (Fig. 19b). Using appropriate instrumentation such as periotomes, elvatomes or FRINGS forceps (both TBS Dental), the palatal portion of the root was carefully removed (Fig. 20). A periapical radiograph confirmed that the palatal root had been completely removed (Fig. 21). The next insert contained the final diameter to receive the guided sleeveless drills for osteotomy preparation (Fig. 22a). The osteotomy was prepared to avoid proximity to the remaining root fragment while leaving sufficient restorative space, as previously planned in the software simulation (Fig. 22b). Implant placement

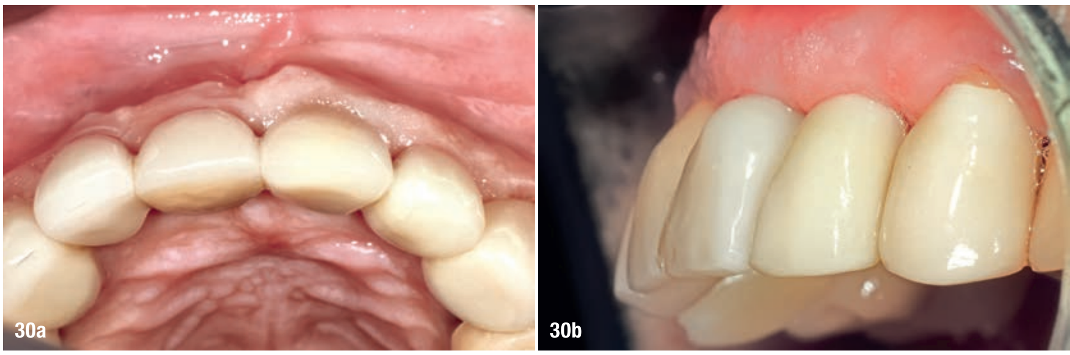


Fig. 29: The definitive restoration exhibited excellent retention of the soft-tissue profile. **Figs. 30a & b:** The occlusal view revealed the volume maintained with the soft-tissue cervical contours **(a)**, and the lateral retracted view revealed an excellent soft-tissue emergence profile **(b)**.

(AnyRidge, MegaGen) was facilitated by the R2Gate surgical carrier for full-template guidance at the appropriate torque values (Fig. 23). Depth control and rotational positioning were accurately confirmed with the notch indicated on the template to correspond with the insertion tool (Fig. 24).

The initial plan was for immediate extraction, immediate placement and immediate restoration. Therefore, it was essential to measure the implant's stability with an objective technology, RFA, which provides an ISQ value utilising an implant-specific SmartPeg (Osstell; MEGA ISQ, MegaGen). The baseline ISQ value (76) confirmed sufficient initial stability to place an immediate restoration (Fig. 25). The prefabricated CAD/CAM abutment was then secured to the implant, and a postoperative periapical radiograph confirmed successful sub-crestal placement for this platform-switched design (Fig. 26a). The transitional acrylic restoration was then placed and examined for any occlusal interferences (Fig. 26b). It was important that the restoration be out of occlusion to avoid premature forces that could complicate integration. The soft-tissue contours were excellent, and no sutures were required, since no flap was raised (Figs. 26c & d). After a period of eight weeks, the implant stability was measured to be at 80 ISQ, confirming that the integration process had continued to progress successfully and that the implant was ready for the definitive restoration. An intra-oral scanner and scanning abutment were then utilised to capture the position of the implant and soft-tissue emergence profile. The postoperative CBCT scan revealed the intact crescent shape of the root membrane (Figs. 27 & 28). The definitive restoration was then delivered and exhibited excellent retention of the soft-tissue profile (Figs. 29 & 30).

Conclusion

PET, root membrane and socket shield concepts have gained popularity as the techniques have been refined and their efficacy proved in published long-term studies. The purpose of retaining the root is to maintain the periodontal ligament attachment to the bony walls of the socket in order to prevent subsequent resorption and loss of tissue volume which often occurs after tooth extraction. PET has been proved to preserve bundle bone and tissue volume with and without immediate implant placement, yet this minimally invasive treatment modality is highly technique-sensitive and may result in complications if proper protocols are not followed. Therefore, a complete understanding of the 3D anatomical presentation is essential for preliminary diagnosis, treatment planning and execution of the procedure. The present article has described two alternatives that maximise the diagnostic phase using state-of-the-art CBCT imaging and planning software to provide full-template guidance with a new stackable tooth-borne guide with specific inserts for the root preparation as well as the osteotomy preparation and delivery of the implant. As with most techniques, further clinical trials are recommended to provide additional long-term data to validate these treatment modalities.

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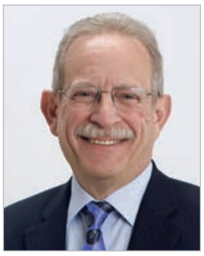

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Dr Isaac Tawil sits on the Digital Dental USA Society Board of Directors, and is a diplomate of the International Academy of Dental Implantology, the IADFE, a fellow of the Advanced Dental Implant Academy, and the ICOI. He is one of Dentistry Today's Top Leaders in CE, a faculty member of the Osseodensification Academy, Brighter Way educational director (Phoenix, Arizona), and digital director of Guided Smile. Dr Tawil is an ambassador of MegaGen International Network of Education and Clinical Research, a member of MINEC USA and an ambassador for the Slow Dentistry initiative. A recipient of the Pierre Fauchard award and the Presidential Service Award for outstanding achievements in dentistry. He is the founder and co-director of Advanced Implant Education, a partner in TBS instruments, and Universal Shapers LLC, and a new product consultant for dental industry. Dr Tawil has held main podium sessions and workshops globally and maintains a private practice in Brooklyn, New York. He can be reached at iketawil@mac.com.

Dental 3D printing adoption across Asia Pacific

Top three trends and forecast

By Kiavash Bakrani & Dr Kamran Zamanian, Canada

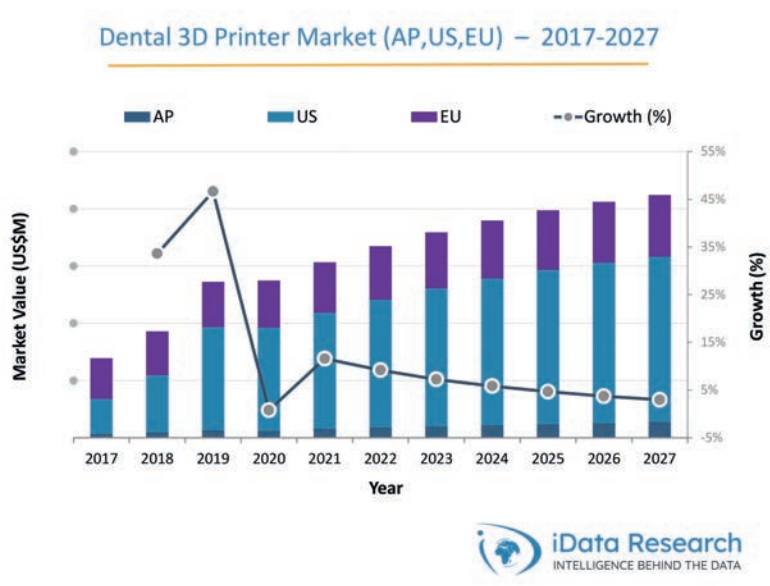

Fig. 1: Asia Pacific, US and European 3D printer markets.

The digital dentistry market in Asia Pacific has started to gain traction because of technological advances and the demand for improved precision, although the markets lag severely behind North America and Europe.

Dental 3D printing has rapidly become an important part of many digital dentistry workflows in countries such as Australia, Japan and South Korea. Dental 3D printers are now an increasingly popular tool in dental laboratories, dental practices and orthodontic practices and have many uses, including the production of crown and bridge models and final prostheses. Whereas the dental 3D printer segment is the smallest segment of the digital dentistry market, it has grown the most rapidly in recent years. Countries such as China and India, who lag behind in terms of novel technology, have not seen nearly as much advancement.

Trend #1: Technological advancements lead to growth opportunities

Dental 3D printing allows for significant time savings for a variety of applications, which is a common feature of most digital dentistry technology. Production of models, surgical guides, night guards and other products is extremely rapid and requires minimal labour. Models, in particular, are often quite laborious to produce traditionally, making this a significant opportunity for time savings. The enhanced productivity offered by digital workflows will continue to drive growth in the dental 3D printing market. Ongoing regulatory approvals of materials for new indications will result in significant growth in the dental 3D printer market. Whereas 3D-printed dental prosthetics are not yet available in many Asia Pacific countries, such approval is likely to induce significant market value growth when it occurs. A single dental 3D printer from a major manufacturer is generally capable of producing surgical guides, models, night guards, dentures and temporary crowns; the technology is, therefore, very versatile, and growth hinges largely on the materials approved for use.

Trend #2: Technological learning curves and regulatory approvals delay market growth

Dental 3D printers are still relatively new technology and tend not to be overly user friendly. A steep learning curve is often involved in the incorporation of dental 3D printing into a digital workflow, limiting access for less technologically adept dentists and dental laboratory technicians. Similar issues limited the growth of the chairside CAD/CAM system market in Asia Pacific; significant time must be invested in learning the technology, and strong customer support from manufacturers is key to success. As dental 3D printers become more user-friendly, this issue will be mitigated, but for the time being, it limits the potential for growth in the Asia Pacific market.

Regulatory approvals for new indications are required for products in the Asia Pacific market. Currently, many of the newest innovations in the CAD/CAM material market are unavailable in Asia Pacific, and it is unknown when they will be approved. This uncertainty limits the potential for market growth.

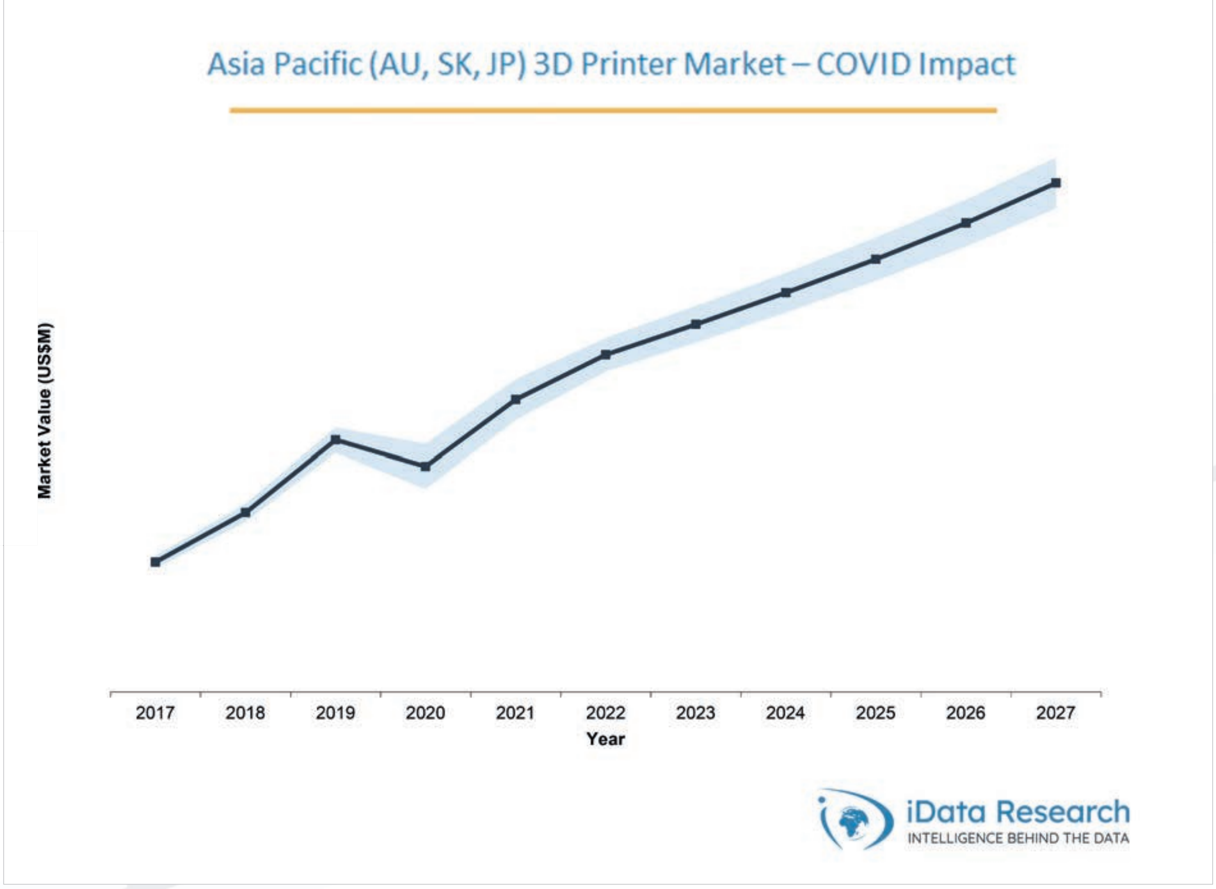

Fig. 2: Impact of COVID-19 on the 3D printer market in Asia Pacific.

Trend #3: COVID-19's impact on the Asia Pacific market

The global dental market was significantly affected by the COVID-19 pandemic, and Asia Pacific was no exception. The markets for dental prosthetics as well as CAD/CAM devices and materials are interdependent and have, therefore, also been similarly affected. The overall market value for dental prosthetics decreased dramatically compared with the previous year because of the elective nature of the procedures and the tight regulations that led to the closure of many dental clinics. Owing to its high price point, the premium market was impacted the most notably. The total market is expected to recover in 2021 and continue to grow at a moderate pace.

3D dental printers market forecast

Overall, the dental 3D printer market in Asia Pacific experienced a decline in 2020 because of reduced dental spending across the nation. This decline is temporary, and the market will return to normal unit sales forecasts by 2022. For the remainder of the forecast period, the dental 3D printer market in Asia Pacific is expected to experience strong unit sales growth; as more laboratories go digital and more CAD/CAM materials receive regulatory approval, the demand for 3D printers will increase.

Sources:

iData Research. 2021 China Market Report Suite for Digital Dentistry | MedSuite | With impact of COVID-19 (https://idataresearch.com/product/digital-dentistry-market-china/)

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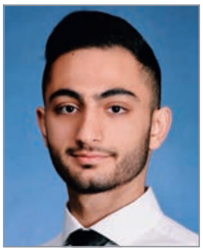

Kiavash Bakrani is a senior research analyst at iData Research. He has been involved in the global research of dental prosthetics and digital dentistry markets, publishing the reports on the Asia Pacific market.

Dr Kamran Zamanian is the CEO and founding partner of iData Research. He has spent over 20 years working in the market research industry with a dedication to the study of dental and medical devices used in the health of patients all over the globe.

International events

IDS—International Dental Show

22–25 September 2021
(on-site and online event)
Cologne, Germany
www.ids-cologne.de

FDI World Dental Congress

26–29 September 2021 (online event only)
Sydney, Australia
www.fdiworlddental.org/fdi-world-dental-congress

Dental-Expo

27–30 September 2021
Moscow, Russia
www.en.dental-expo.com/dental-expo-en

CEDE—Central European Dental Exhibition

7–9 October 2021
Łódź, Poland
www.cede.pl/en

31st Annual NYU/ICOI Implant Symposium

9–10 October 2021
New York, US
www.icoi.org/events

EAO Digital Days

14–16 October 2021 (online event)
Italy
www.eao.org/congress

Dentex—International Dental Equipment Exhibition

21–23 October 2021
Brussels, Belgium
www.dentex.be/en

AAP Annual Meeting

4–7 November 2021
Miami, US
www.perio.org

ADF—Conference and Exhibition

23–27 November 2021
Paris, France
www.adfcongres.com/en

GNYDM

28 November–1 December 2021
New York, US
www.gnydm.com

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Questions?

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