issn 2193-4673 • Vol. 2 • Issue 1/2022

1/22

3D printing

international magazine of dental printing technology

interview
"Having a digital practice will be vital for practice growth"

practice management
Five key elements to get your dental team on board with in-house 3D printing

case report
3D-printed maxillary premolar inlay restorations

dti] Dental Tribune International

Dr George Freedman

Editor-in-chief

3D printing in dentistry: The need for standards

3D dental printing is in its formative stages; the major distinction between the comparable developments of dental cosmetics and implants is that printing is progressing much more rapidly, much more internationally and in a far more open-source environment. The exciting expectation is that 3D printing promises to bring the functional and artistic control of the restorative process back to the chairside setting. The daunting concern is that the wide spread of research and multiple technical developmental lines will lead to mutually incompatible nomenclatures and technologies.

The digital transformation of dentistry is firmly established. It promises to transform the practice and delivery of dentistry within a decade or two. It remains essential that dentists and the dental industry continue to develop a setting where communication is enabled by corresponding software platforms and technologies have both backward and forward flexibility, and most importantly, a research and development space where the terminology is standardised and mutually comprehensible.

Current 3D printers can manage the increasing demand for temporary, transitional, and permanent restorations and appliances. They can decrease delivery costs for these services, enhancing patient accessibility and dentist practice viability. To speed general practitioner acceptance worldwide, there must be a defined set of clinical standards that ensure treatment predictability and success, and a suitable lexicon of readily understood terms for this innovative area of dentistry.

At the level of researchers, developers and manufacturers, this requires the establishment of a broadly recognised and accepted framework of measurements, standards and guidelines. These paradigms should encompass most of the existing leadership of 3D printing at various levels, serving to delineate a basis for compatibility, providing adequate space for flexibility and growth, that can reasonably accommodate foreseeable (and perhaps unforeseen) upcoming development. These foundational definitions will establish the future guidelines for applications that are yet to be developed and will institute continuity between the present and the future.

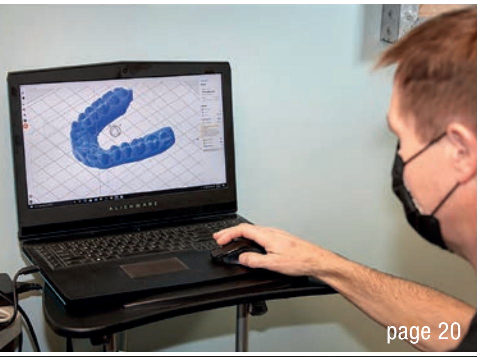
For the practising dentist, 3D dental printing is a wonderful addition to the clinical armamentarium. It is also something new, something different and something with its own vocabulary. The most important step to achieving universal chairside acceptance of this technology is to make it easy to understand; every technology brings its own wordlist, and every new technology has many competing wordlists that only serve to confuse the practitioner. It is impossible to explore innovative treatments without innovative words and meanings; we should attempt at the very least, however, to standardise these new terms and meanings to minimise the confusion as much as possible.

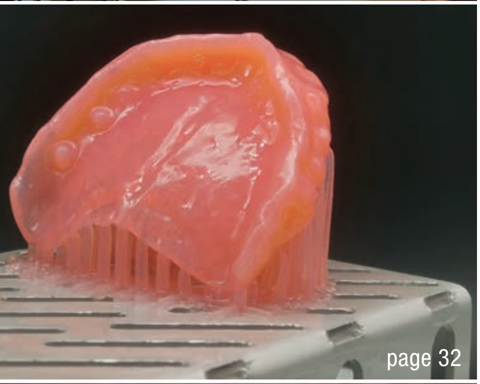
This editorial is a call to create 3D dental printing standards groups for defining:

1. a set of clinical, research, development and manufacturing guidelines; and
2. standardised nomenclature.

3D printing is the future of dentistry. Let us begin by creating the proper foundations.

Dr George Freedman
Editor-in-chief





Cover image courtesy of Formlabs (www.formlabs.com).


SprintRay X Usain Bolt
Global Brand Ambassador
Want Aligners Fast?
Offer clear aligners in-practice to give patients the treatment they want at a price they can afford.
When used in conjunction with a thermoforming machine and orthodontic CAD software, full cases of aligners can be fabricated in a single day with 3D printing.
Reach out to us and fill out the Contact form on our Webside
SCAN ME
www.sprintray.co.uk

Dental 3D-printing market to reach almost US$8 billion over the next few years

By Anisha Hall Hoppe, Dental Tribune International

3D printer manufacturers have a period of substantial market growth to look forward to in the coming years. A global forecast published in March prophesied significant changes for the dental 3D-printing market, including a complete doubling of market value by 2027. This exponential boom is fuelled by patient demand for same-day 3D services that require in-house printing, by increasing rates of clinic consolidation, by a growing geriatric population around the world, and by a skyrocketing incidence of caries and related diseases.

More in-house services offered

Valued at US$3.2 billion (€2.9 billion) in 2022, the dental 3D-printing market is expected to reach US$7.9 billion in value in the next five years. Printers utilising light-curing processes continue to provide the most popular 3D-printing method for dentistry, as medical standards require detailed products produced with high precision.

A comprehensive product round-up by 3Dnatives confirmed that major printer manufacturers are prioritising the development of printer solutions that provide not only high-quality custom deliverables to patients but also product lines that are tailored to a clinic or laboratory's unique size and set-up. This means practices can offer patients same-day solutions that are printed on-site, and laboratories can save dramatic amounts of space, as models are now saved digitally instead of being stored for future reference.

The consolidation effect

According the American Dental Association, group practice affiliation managed by large dental support organisations (DSOs) is on the rise. Over one-tenth (10.4%) of dentists in the US in 2019 were part of a DSO, a 2.4% increase in just two years. These figures coincide with a steady drop in practice ownership, down to 73.0% in 2021 from 84.7% in 2005. This trend is likely to continue as a survey of students leaving dental school in 2020 showed that 30% planned to join a DSO, up compared with 12% who planned to join one upon leaving dental school in 2015.

Henry Schein cites a 14% rate of growth for large dental groups over the last ten years, far outpacing general dental spending which grew at just 2–4% per year. Market research confirms that a continual push to digitise practices and the growth of corporate chains are still promoting growth in the 3D-printing market.

In addition, the Association of Dental Support Organizations explains that many dentists are choosing to join a group practice instead of striking out on their own. It says: "Greater buying power and the ability to negotiate with vendors helps DSOs lower dentists' supply costs. DSOs also help provide access to the capital dentists need for the most modern equipment, and to help support their practices." Initial investments in 3D-printing equipment can be more than what new dentists and small private practices are able to afford, particularly when many are already shouldering the costs of digitising their practices in other ways. Joining a larger practice or group means access to more capital for innovation and more manpower to manage new 3D-printing programmes.

A digital tooth fairy

Research by the American College of Prosthodontists (ACP) indicates that, at the present time, at least 36 million Americans are edentulous. Global rates of edentulism, whether partial or complete, are difficult to calculate, but a paper published in *Nature* holds the global prevalence to be about 7.6% and states that numbers vary dramatically depending on the country. Age is a significant factor; just 2.8% of individuals under 50 suffer some form of tooth loss and 14.0% of those over 50 suffer from the condition.

Heightened rates of oral disease around the world are to blame, in addition to poor oral hygiene and bone loss. Because these diseases also degrade existing teeth, 3D printers are crucial for providing solutions for restoring the dental structure with patient-specific dental prostheses and implants. It makes sense that 3D printer sales are on the rise, and ACP reported that about 2.3 million implant-supported crowns are manufactured just for Americans each year.

nexa3D

Unmatched Speed. High Throughput. Steadfast Accuracy.

Nexa3D's ultrafast dental 3D printing technology along with integrated workflows and validated Keystone™ materials deliver fast, accurate dental 3D printing solutions at the lowest cost of ownership. Maximize your dental lab productivity with the NXD 200, or create dental models right at your clinic with the XiP Desktop 3D printer faster than ever before.

Request a free sample model

keyprint COMPATIBLE

Models

Custom Trays

Surgical Guides

Nightguards/ Splints

The global dental 3D market is projected to double in size in the next five years.

Changing population make-up

In addition, edentulism is on the rise owing to the growing geriatric population, and the World Health Organization predicts that the global number of people aged 60 and older will double to 2.1 billion by the year 2050. The incidence of dental diseases and the need for supplementary dental fixtures are directly connected to the health effects of ageing.

To more efficiently address the needs of their ageing clientele, many dental practices are making the transition to 3D-printed options like digital dentures, thus completely eliminating the need for nuisance moulding, messy manufacturing and long wait times. From the first 3D scan to the final 3D print, the change to digital also means that dental laboratories can completely reconfigure their formatting, as 3D printers take up far less space than prep rooms and storage areas for bulk materials.

Beauty is a priority

As the world transitions out of pandemic mode and back to safe in-person interactions, more dental practices are once again offering procedures that, for the past two years, have been deemed non-essential, such as cosmetic adjustments. Aesthetic solutions like whitening, veneers, recontouring and tooth alignment are more frequently requested by patients the world over as well.

Preventative dental care treatments are being sought by patients in tandem with cosmetic procedures and appliances. More dental practices are beginning to offer aligner solutions and are either opting to outsource orthodontic consultations to a larger company or are handling treatment in-house, including production and self-branding of aligners, thanks to their own 3D printers.

The growth is not universal

According to the global forecast, there is already ample evidence that the dental 3D-printing market is recovering in North America and Europe, but the Asia Pacific area is struggling to regain footing. However, as more practices are turning to digitalisation everywhere, even the slowdowns experienced in China and India are expected to abate in the next couple of years.

One drawback that practice owners have noticed is that, even though they may have invested in a 3D-printing set-up, it is difficult to find employees having the skills needed to run it or to provide the appropriate training for existing employees. In response, more 3D printer companies are aiming to provide improved training resources in addition to their product lines.

Editorial note: The global forecast was published by MarketsandMarkets and can be accessed online at www.marketsandmarkets.com/Market-Reports.

3D printing: Study examines dentists' user experiences and spending

By Jeremy Booth, Dental Tribune International

The use of additive manufacturing in dentistry is widespread in dental markets; however, there is a lack of information about the practical aspects of how dental specialists are using 3D printing and the amount they are spending on it. A study led by researchers at Semmelweis University in Budapest sought to establish the facts about 3D printing in dentistry in order to characterise its use.

According to the study, additive manufacturing experienced a price revolution around 2010. The technology had already existed for nearly two decades, but lower prices brought 3D printing within reach of consumers and professional groups, and dentists and dental laboratories were some of the core investors in early compact 3D-printing solutions.

More than a decade later, 3D printing is being used in every field of dentistry, including in prosthodontics, orthodontics, implantology and maxillofacial surgery. The authors stated, however, that "little knowledge has been collected from the specialists in this technology's physical usage". The researchers therefore investigated key aspects of use, such as the types of 3D printers and software being used, the number of units on hand in dental settings, and the accessibility and cost of the technology for dental professionals.

They found that respondents mostly used their 3D printers to create models for designing prosthetics. The second most common use was in the area of orthodontics, followed by the creation of sectional cast models, surgical guides, castable waxes and splints. At the lower end of the usage spectrum, dental professionals used the technology to create restorations such as dental bridges, crowns, inlays and permanent restorations.

The majority (63.3%) of respondents said that 3D-printed models were more accurate than those made using cast model techniques. Most respondents (72.5%) said they used their printing device at least every two days, and 92.5% used it at least once per week. More than one-quarter (25.8%) of respondents used more than 20 l of additive printing material every year, and 55.0% said that they had spent US$5,000 (€4,500) or less on their printing device.

The most common 3D printers owned by the respondents were those made by Formlabs, NextDent and Asiga, and the top three criteria that respondents looked for when choosing a 3D printer were accuracy, price and recommendations. When it came to satisfaction with the potential of their 3D printer, respondents were most satisfied with devices made by Asiga and NextDent. On the topic of price and material, devices made by Anycubic scored the highest. When it came to speed, users of NextDent

© samuel perales/Shutterstock.com

Researchers have found that most dental professionals use their 3D-printing device at least every two days and the vast majority use it at least once per week.

devices were the most satisfied. Only three respondents said that they were dissatisfied with their device.

For CAD processes, the most commonly used software was made by exocad, followed by those made by Meshmixer and 3Shape. The respondents used intra-oral scanners almost as often as they used their 3D-printing devices, and the two technologies were often used together. Among the intra-oral scanners used by the sample group, those made by 3Shape were the most preferred, followed by those made by Medit, Dentsply Sirona, Align Technology and Planmeca.

One of the surprise findings of the research was that only 51.7% of respondents had received training on how to use their 3D printer from the device manufacturer, and it was highlighted that most respondents had not been able to familiarise themselves with 3D printing during their dental education. Regarding becoming adept with the technology, the researchers noted that social media was a significant source of information, problem-solving and networking opportunities related to 3D printing in dentistry. They wrote: "Social media is essential. It is currently having a significant impact on the healthcare industry, and it is also an excellent tool for helping specialists exchange experience and knowledge. In addition, if one needs help, it seems to be a faster method for receiving it than the official support system."

It was found that newly graduated dentists and younger dentists were faced with fewer technical obstacles when adopting the technology. The researchers wrote: "They learn the critical steps of digital dental treatment during their education, including digital impression taking, intra-oral scanning, and additive manufacturing. This new generation of dentists has enormous potential to develop digital dentistry. The working process and patient experience can be created together, as the patient can follow the whole treatment via digital dental tools."

The study identified environmental factors related to additive manufacturing as a concern within the dental community. They said that there was a lack of studies that investigated the full ecological footprint of digital dental workflows, including the complete life cycle of additive manufacturing processes, in comparison with more traditional dental technologies.

"One of the surprise findings of the research was that only 51.7% of respondents had received training on how to use their 3D printer from the device manufacturer."

The findings were based on an online survey that was conducted between 1 January 2020 and 1 January 2021 and completed by 120 dental professionals from 20 countries. This sample was comprised of 68 dentists, 29 dental technicians and 23 CAD/CAM specialists who were mainly based in Hungary (23.7%), the US (18.4%) and the UK (7.9%). Most of the respondents owned one 3D printer and the study participants, on average, had more than three and a half years of experience using the technology.

Editorial note: The study, titled "User experience and sustainability of 3D printing in dentistry", was published online on 9 February 2022 in the International Journal of Environmental Research and Public Health*.*

Nexa3D utilises its proprietary Lubricant Sublayer Photo-curing (LSPc) technology for accurate, consistent and faster part production. *(All images: © Nexa3D)*

"Having a digital practice will be vital for practice growth"

An interview with Jim Zarzour

By Anisha Hall Hoppe & Claudia Duschek, Dental Tribune International

Dental Tribune International (DTI) had the opportunity to speak with Jim Zarzour, head of dental solutions at Nexa3D, a company specialising in the development of ultra-fast polymer 3D printers. Zarzour shared with DTI information about the impact of 3D-printing trends on the dental industry and indicated which Nexa3D products he thinks are going to make in-house 3D printing more feasible for more practices. DTI has previously covered the achievements of Nexa3D and its latest technologies, which are aimed at bringing innovation to the orthodontic industry.

Mr Zarzour, it is expected that the need for smoother clinical workflows, faster turnaround times and fewer dental appointments will boost the growth of the dental 3D-printing market, as dentists may be more likely to invest in digital technologies in order to cope with increasing demands. What trends do you foresee overall for this market?
Having a digital practice will be vital for practice growth. Same-day dentistry is the buzz in the industry right now. Being able to have a patient walk out of a practice with a device, while limiting the number of office visits, is critical to the overall experience for the patient.

Nexa3D's large-format NXD 200 3D printer was designed specifically for high-throughput dental 3D-printing applications and utilises the company's

proprietary Lubricant Sublayer Photo-curing (LSPc) technology. Could you please explain the system's advantages in comparison with other digital light processing (DLP) and stereolithography (SLA) systems on the market?
LSPc is a type of masked stereolithography (mSLA) technology, which cures resins by exposing them to ultraviolet light. Instead of tracing each layer with a laser beam, as in DLP, it uses a larger area ultraviolet light source that is masked with an LCD screen. This allows the patterned light to expose the resin consistently and simultaneously across the curing plane—think micro-patterned flood lamp, rather than tracing with a pencil-like beam. This makes mSLA much faster than conventional SLA. Additionally, with our patented ultraviolet light array, we are able to achieve complete light uniformity across the entire build area, ensuring part accuracy and consistency.

What exactly can be printed and with which materials?
NXD 200 is validated for use with all of the Keystone Industries' dental resins—KeyTray, KeyModel Ultra, KeySplint Soft, KeyGuide and KeyOrtho IBT—as well as with Nexa3D's xMODEL 2505 powered by BASF Forward AM. A few examples of what can be printed are patient-specific dental models, surgical guides, splints, trays and nightguards.

Last year, Nexa3D announced the XiP, a desktop 3D printer suited for use in dental offices of all sizes and for delivering chairside prints. What are the distinctive features of XiP and when will it become available?
XiP will be commercially available in the second quarter of 2022, and customers can place pre-orders simply by visiting our website. XiP is a simple-to-use desktop unit with a fairly large build volume of 4.8 l and an integrated workflow. XiP is a solid machine, and its ease of use is going to be critical for a dental/orthodontic practice. Dental clinics are busy and having a simple-to-use 3D printer is important. The smart resin dispenser, quick connect build plate and stackable vat storage unit make it easy for anyone in the clinic to use. Don't forget the price point of under US$6,000 (€5,450) makes it very affordable for a practice, whereas the desktop size makes it more accessible from a footprint perspective.

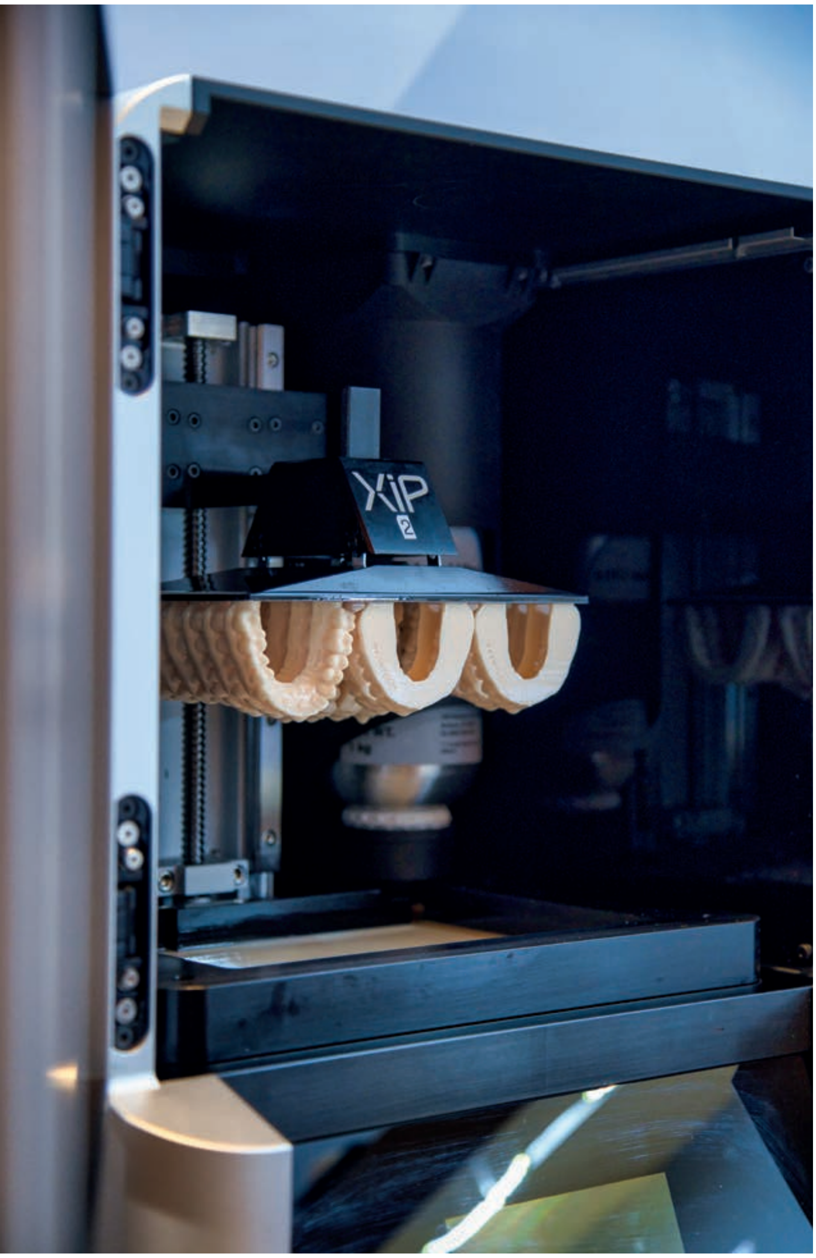
At Formnext 2021, Nexa3D announced a new partnership with artificial intelligence-powered manufacturing software start-up Oqton and a new dental software. Could you please explain how users of your 3D printers can benefit from this collaboration?
Oqton software is an automated production system with artificial intelligence and a fully integrated application programming interface with the NXD 200. It is a cloud-based solution, so from a production standpoint it provides ease of use for the customer. It allows the setup of multiple print jobs at once. The user can order, prepare, schedule, monitor, analyse and track. Moreover, it enables one-click data preparation in order to import, nest, label, and add supports, etc. This integration is critical for large laboratories and manufacturers, and we are excited to see this in action for our customers.


Jim Zarzour, head of dental solutions at Nexa3D.

Owing to growing demand for additively manufactured dental models, restorations and aligners, dental laboratories have been part of the digital revolution for some time already. Now, with new, more affordable and user-friendly 3D printer models on the market, dental offices are able to print devices at the practice too. What factors should practices consider when planning to purchase a 3D printer?
Dental practices like the idea of being able to print in the office. It can help them showcase the fact that they are a digital practice, which is important these days for patient experience and, in some cases, same-day dentistry. Allowing the patient to leave the office with his or her device can be important for the overall patient experience. In addition, it can help from a profitability standpoint. Many practices have 3D printers in-house and do not use them for a number of reasons. For example, the workflow for the printer is not easy, and the practice does not have a staff member who is able to use it. Providing a simple and easy-to-use solution such as Nexa3D's XiP could be critical to the success of a practice.

Figures recently published by the ADA's Health Policy Institute provided further evidence that practice ownership is declining, whereas consolidation continues to accelerate. Looking at this as a global trend, how will the shift to large corporate practices, which need to produce large volumes of appliances daily, drive the adoption and use of 3D printers in dentistry?
The demand for in-house printing will continue to increase, as dental support organisations (DSOs) are getting leaner and looking for ways to increase margins and decrease costs. Practice consolidation will continue as DSOs continue to expand their footprints, and a number of larger DSOs are looking for 3D printers to bring solutions in-house. There is also consolidation of dental laboratories. The overall number of laboratories has decreased, but print volumes are sharply increasing, as is overall market growth for the laboratory business. The global market for dental laboratories is about US$27 billion and expected to grow by 2028 to over US$40 billion. All of this really points to an increased need for higher throughput, faster speeds, and easier workflows in order to drive those productivity rates, and ultimately profitability numbers.

Nexa3D's NXD 200 printer for high-throughput dental 3D-printing applications.



Finished parts coming out of Nexa3D's desktop 3D printer.

Although digital dentistry continues to thrive, one of the known barriers for the adoption of new technologies is the lack of skilled personnel and training—a circumstance that could restrain the overall adoption of dental 3D printing. How can companies like Nexa3D help existing and potential customers keep pace with the rapid evolution of 3D-printing solutions?
In any laboratory you talk to, staffing is a real issue, especially the lack of skilled employees. The way Nexa3D helps with this is by providing easy-to-use solutions, complete with validated workflows and improved production economics so that dental clinic and laboratory staff can spend less time on troubleshooting the 3D-printing equipment and more time focusing on patient outcomes.

Editorial note: More information about Nexa3D can be found on https://nexa3d.com.

New online CAD Configurator helps dental professionals find their ideal software package

Three steps to an individual software solution An interview with Inka Müller

By Dental Tribune International

1

2

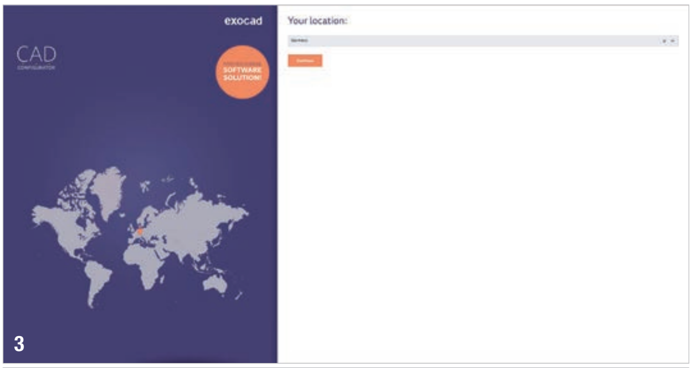
Fig. 1: Inka Müller, product manager at exocad. **Fig. 2:** exocad CAD Configurator. **Figs. 3–7:** With CAD Configurator, dentists and dental technicians can receive an individualised exocad software solution recommendation. In three steps, users can select the country, place of use and planned indication. They also have the option of selecting useful add-on modules. **Fig. 8:** CAD Configurator's recommendation for the ideal exocad software solution is sent by e-mail within a few minutes and includes a list of sales partners with their contact details.

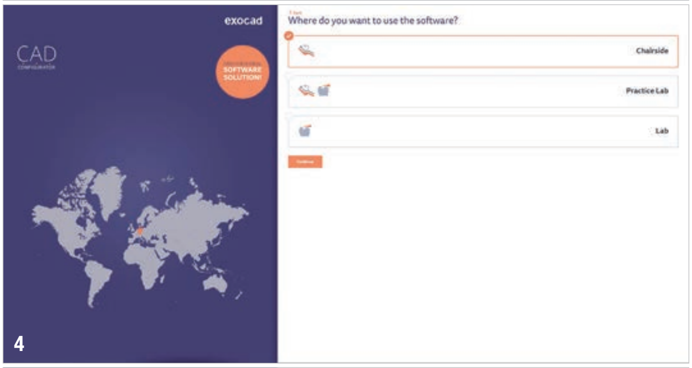
"Our online CAD Configurator asks dental professionals about their needs and then creates a customised software product recommendation,"
—Inka Müller, product manager at exocad.

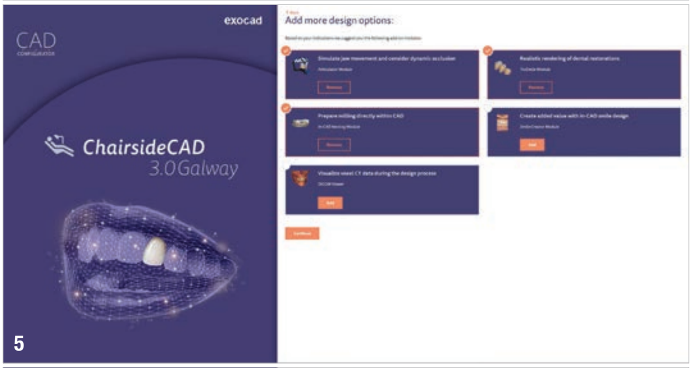
Which exocad software solution will meet my needs? Exocad now answers this frequently asked question with its new CAD Configurator solution. This online tool can help dentists and dental technicians assemble the right exocad software package to meet the specific needs of their practices or laboratories. In this interview, Inka Müller, product manager at exocad, explains how easily CAD Configurator works.

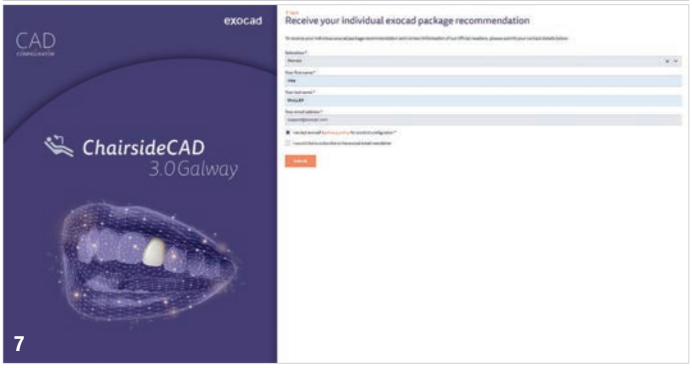
What is the idea behind exocad's CAD Configurator?

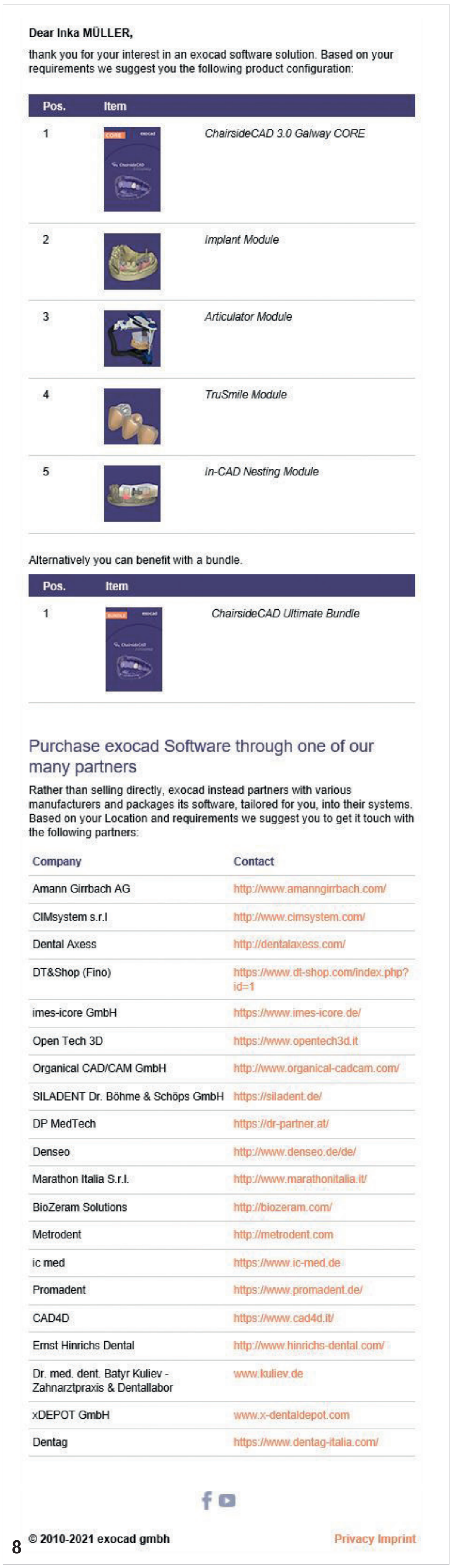
We developed CAD Configurator to help dental professionals easily obtain an individualised software solution from our extensive offering of products. Exocad's DentalCAD and ChairsideCAD provide dental professionals with the necessary tools to handle a multitude of indications.











Dear Inka MÜLLER,

thank you for your interest in an exocad software solution. Based on your requirements we suggest you the following product configuration:

Pos.	Item
1	*ChairsideCAD 3.0 Galway CORE*
2	*Implant Module*
3	*Articulator Module*
4	*TruSmile Module*
5	*In-CAD Nesting Module*

Alternatively you can benefit with a bundle.

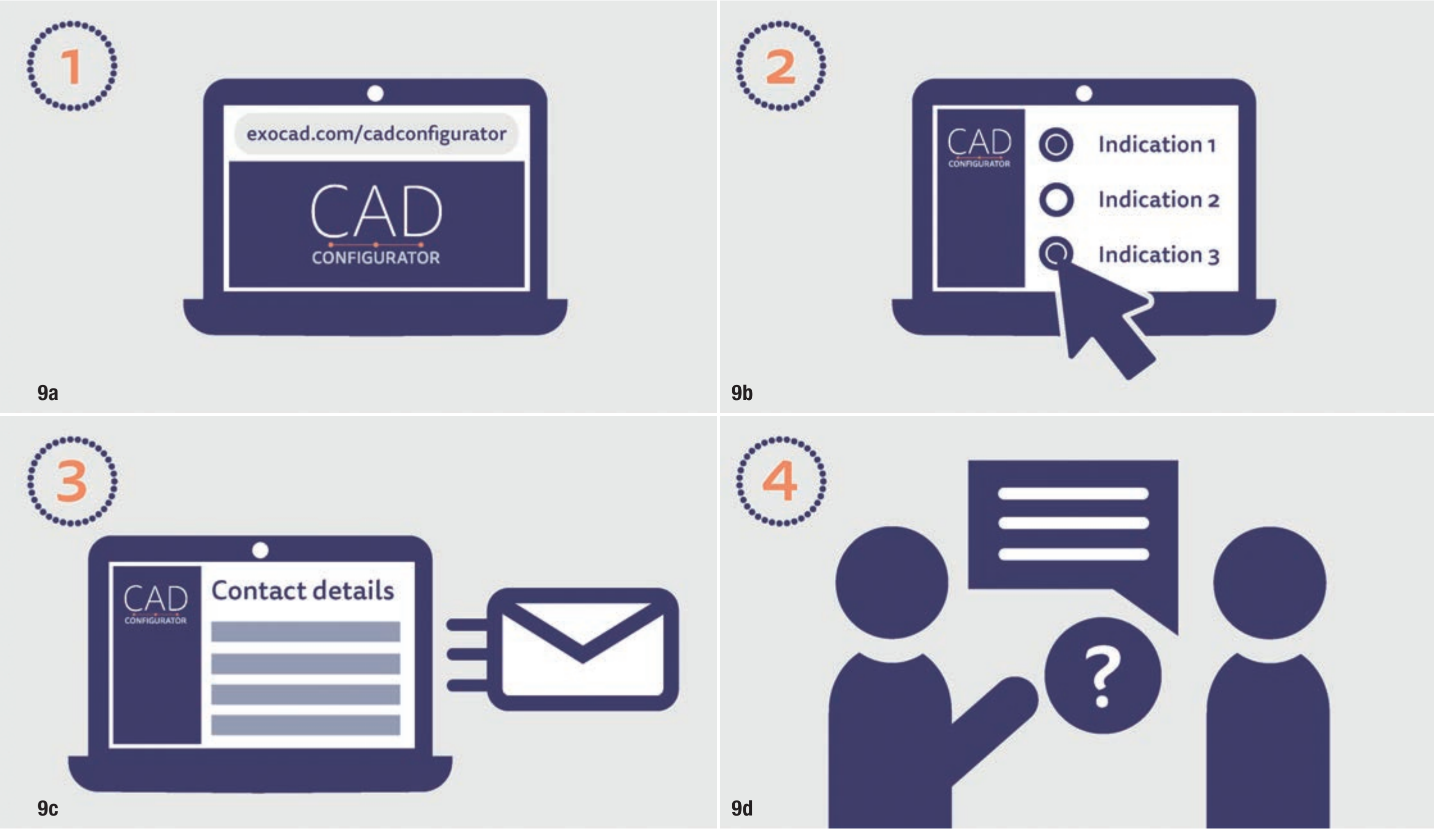
Pos.	Item
1	*ChairsideCAD Ultimate Bundle*

Purchase exocad Software through one of our many partners

Rather than selling directly, exocad instead partners with various manufacturers and packages its software, tailored for you, into their systems. Based on your Location and requirements we suggest you to get it touch with the following partners:

Company	Contact
Amann Girrbach AG	http://www.amanngirrbach.com/
CIMsystem s.r.l	http://www.cimsystem.com/
Dental Axess	http://dentalaxess.com/
DT&Shop (Fino)	https://www.dt-shop.com/index.php?id=1
imes-icore GmbH	https://www.imes-icore.de/
Open Tech 3D	https://www.opentech3d.it
Organical CAD/CAM GmbH	http://www.organical-cadcam.com/
SILADENT Dr. Böhme & Schöps GmbH	https://siladent.de/
DP MedTech	https://dr-partner.at/
Denseo	http://www.denseo.de/de/
Marathon Italia S.r.l.	http://www.marathonitalia.it/
BioZeram Solutions	http://biozeram.com/
Metrodent	http://metrodent.com
ic med	https://www.ic-med.de
Promadent	https://www.promadent.de/
CAD4D	https://www.cad4d.it/
Ernst Hinrichs Dental	http://www.hinrichs-dental.com/
Dr. med. dent. Batyr Kuliev - Zahnarztpraxis & Dentallabor	www.kuliev.de
xDEPOT GmbH	www.x-dentaldepot.com
Dentag	https://www.dentag-italia.com/

8 © 2010-2021 exocad gmbh Privacy Imprint



Figs. 9a–d: Dental professionals can use CAD Configurator to specify their needs and then receive a customised recommendation of the exocad software products that will best meet those needs. The software recommendation includes the names and contact information of exocad resellers active in the customer's region.

"CAD Configurator recommends software packages based on country-specific availability and is accessible to any interested dental professionals globally."

To customise the software solutions according to the specific needs of each practice or laboratory, exocad offers numerous supplementary modules that augment the basic versions of DentalCAD and ChairsideCAD software. Dental professionals can use CAD Configurator to specify their needs and then receive a customised recommendation for the software products that will best meet those needs. Our global distribution partners also use CAD Configurator when advising their customers.

How can interested users get their individual software solution recommendation?
Simple steps guide users through the three selection parts: first, they select their country (Fig. 3); second, they select the setting in which the software will be used, that is, chairside, practice laboratory or laboratory (Fig. 4); and third, they define which indications they want to handle with the software (Figs. 5 & 6). Individual software recommendations and licence models are then sent directly to the interested user via e-mail.

How easy is it to purchase the software after receiving the recommendation?
Very easy. The software recommendation includes the names and contact information of exocad resellers active in the customer's region. We want to make it as easy as possible for dental professionals to contact the reseller of their choice.

Is the online tool available worldwide?
Yes. CAD Configurator recommends software packages based on country-specific availability and is accessible to any interested dental professionals globally.

Where can one try out CAD Configurator?
To try out our CAD Configurator, the dental professional can go to exocad.com/cadconfigurator.

Things you should not shake!

V-PRINT PRINTING MATERIALS: ALWAYS OPTIMALLY HOMOGENEOUS

- **No need to be shaken** – you define the timing of your workflow
- **Efficient** – save time and costs for homogenisation devices, print savely – even overnight!
- **Reproducible** – product properties are reliably achieved, again and again

V-Print

MADE IN GERMANY 100%

VOCO TRUSTED PARTNER

All print partner can be found here
www.voco.dental/3dprintingpartners

VOCO
THE DENTALISTS

VOCO GmbH · Anton-Flettner-Straße 1-3 · 27472 Cuxhaven · Germany · Freecall 00 800 44 444 555 · www.voco.dental

Five key elements to get your dental team on board with in-house 3D printing

Dr Lisa Alvetro & Patricia Mitchell, USA

There is no doubt that implementing digital workflows in the practice is a fascinating experience, but it can also become a challenge. When thinking about adopting a digital workflow, clinic owners need to evaluate several aspects, such as ease of use, materials for their applications, delivery times and return on investment. However, one of the most crucial and often underrated aspects to consider is team support, it being key to success in the implementation of the digital workflow for 3D printing. While clinicians are focused on seeing and treating patients, much of the back-end work, which involves scanning, designing, preparing for printing and post-processing, will be managed by the dental staff in the clinic. Having the team's support will help create more efficient and cleaner workflows and guarantee success with patients.

In this regard, the clinician needs to reflect on how to get the team on board, how to empower the team members and get them excited about change, and what aspects to consider. Based on our experience, we discuss five key elements to motivate the team about the new workflow that will help the practice thrive and distinguish it from others.

1. Identifying key players for the digital team

The clinician needs to learn about and understand the different steps involved in the digital workflow in order to delegate these appropriately to team members, pass the knowledge on and establish effective synchronisation. By doing this, the dentist will understand the level

of complexity of the workflows involved and know how much time the various steps require, which will help in training the team. Based on this knowledge, the next step is to look at the existing team and identify an organised, detail-oriented and open-minded candidate to be the digital specialist in the practice.

Manufacturing in-house allows the production of several appliances simultaneously for multiple cases, thus transforming the practice into a small dental laboratory. Therefore, great organisation skills are crucial and there needs to be a system in place that allows effective tracking of all processes. Moreover, in-house production using 3D printing involves following specific instructions and 3D-printing protocols. A detail-oriented team member needs to be on top of the different steps. For example, he or she needs to learn how to orient parts to print in the 3D-printing space and to be able to follow the post-processing instructions thoroughly. Giving attention to detail and being organised are the key skills for this role. As long as the systems are easy to use, manufacturing can be done by anybody, including someone who does not have clinical experience.

At Alvetro Orthodontics, Patricia started as a clinical assistant, but immediately transitioned into becoming the digital specialist at the clinic. Similarly, the clinician might find that the administrative staff have some downtime and thus can help out and will need to learn the nesting software and printer manipulation. After evaluating the existing team, the next step is to consider whom (and what skills) to bring on the team at a later stage.

2. Convincing the team about the advantages of the digital workflow

To motivate the team, it is necessary to show them the advantages of using a digital workflow, how it is going to work and how it will impact their everyday work. The most evident advantage is that digital workflows are very patient-friendly. For example, patients do not always enjoy a traditional alginate impression being taken. However, a digital intra-oral scan being taken can be considered fun, as patients can see the scan being generated. This creates the “wow” factor for patients and, in turn, motivates them. Similarly, having a 3D-printed model to show to the patient impresses him or her, and the team can say that they created it in their own 3D-printing laboratory, adding value to the patient experience.

Many people are excited just by looking at our 3D-printing laboratory or Formlabs’ PreForm software. Some team members did not realise that 3D printing was an option in the dental world, especially those who did not have dental experience.

The second advantage is that 3D printing in-house opens the door to new treatment possibilities not feasible via the traditional workflow. In our practice, we use Formlabs’ Form 3B printer for digital debonding cases,

for which we scan the patient before removing his or her fixed appliances and the digital specialist then digitally removes the appliances and prints those models for the production of thermoformed retainers. The possibility of printing a model without the appliances before the patient has even had these removed is highly impressive and makes the process more effective, as the retainer is immediately placed after debonding without wasting any time.

A third clear advantage is the great efficiency and cleanness of the workflow compared with the traditional workflow. Alginate impressions have a specific working time, and producing plaster models can be a messy process. Using intra-oral scans, the case is registered permanently and printing becomes a much cleaner and hands-free process. If the practice decides to do the CAD stage in-house as well, it becomes the complete owner of the process, managing timing and outcomes and reducing costs.

3. Ensuring ease of use

The clinician should not scare the team with complex workflows and machinery. There is a common misconception that technical or information technology skills are necessary to be able to use a 3D printer, since such printers can be difficult to use. When selecting the appropriate 3D-printing ecosystem, the dentist needs to look not only at factors such as accuracy, speed, price and reliability but also at the ease of use of the nesting software, printing and post-processing, among other things.

Formlabs' software and printers meet those needs. When employing PreForm, which allows users to orient the parts to print, several aids make the process streamlined and reliable. The software guides the user step by step through orienting the parts, shows warnings when something is wrong, helps to automatically generate support structures and stops the user from making mistakes. For instance, when a particular part has been prepared for printing in one material, but there is a different one set up in the printer, the software will inform the user about it and the print job will not start. This makes the transition exceptionally smooth and learning extremely quick, and it is fairly easy to train other team members.

As for the Form 3B printer, everything is highly automated. Compared with other 3D printers, the resin is automatically dispensed and mixed, which takes the guesswork out of the step and helps to avoid any potential accidents, such as overflow of the resin in the tank.

With this ecosystem, a team member can be trained in an hour and can master the workflow after completing some more prints. Being involved in a digital team in the clinic creates a sense of pride and responsibility and makes team members feel valued. Working with 3D printers is a fun process.

4. Educating the team on materials and applications

There is a large variety of materials available for different indications, and this has expanded the services that can be offered to patients. Materials that have various characteristics, such as biocompatibility, precision, accuracy, durability and cost-effectiveness, are readily available, and the team needs to understand these characteristics and their applications. Formlabs provides excellent user guides for each material with step-by-step guidance, including on print parameters, print orientation and post-processing protocols, to help manage each step successfully.

Regarding 3D-printing applications, orthodontists often tend to focus on models, but 3D printing offers much greater utility. Years ago, we used to make occlusal splints, but the process was messy. It was time-intensive and complicated to create them in-house via the traditional workflow. Today, the digital workflow allows scanning and even outsourcing the design and then printing the appliance in-house. It is an excellent service for our patients. It is much easier to produce and cost-effective, and there are biocompatible materials available for this specific purpose.

The Form 3B printer can 3D-print models, including for the production of thermoformed retainers, and 3D-print indirect bonding trays and splints. Clinicians interested in dental restorative procedures can also print crowns and temporary restorations in different resins. The materials for model production and the biocompatible resins for end-use appliances guarantee that the printed part can safely come into contact with the patient's tissue—which we consider a great advantage. If the team is trained and follows the instructions in the manufacturer's guides, any one of the team members should be able to manufacture these indications.

It is also vital to keep track of the time and costs needed to produce each appliance. PreForm software allows the team to track material consumption and evaluate the clinic's return on investment per application, which becomes critical when deciding which procedures should be adopted in-house and which ones should continue to be outsourced to an external laboratory or design service. An indirect bonding tray requires only 7–8 ml of resin and splints just a bit more than that. When calculating the costs per part, it will become clear for which applications 3D-printing will be cost-effective.

5. Establishing a post-processing protocol

Once the part has been printed, it needs to be washed, dried, polymerised and sometimes polished. These stages should be implemented thoroughly, as the mechanical properties and biocompatibility standards are achieved by following specific washing and polymerising times and temperatures. To avoid any mistakes, it is important to have defined steps and automated processes.

In our orthodontic practice, we use Form Wash and Form Cure, which are highly effective and automated stations. In the past, we did the washing process manually using other systems, which involved pouring in propan-2-ol, swishing the models around and letting them sit in the isopropyl alcohol for a little. With Form Wash and Form Cure, the user can set the desired time and temperature at which the parts will be washed and polymerised. The machines will stop at those pre-established times, avoiding any risk of over-washing or over-polymerising, which would deteriorate parts. Automation combined with ease of use makes 3D printing a hassle-free and fun process.

> "Being involved in a digital team in the clinic creates a sense of pride and responsibility and makes team members feel valued."

Bonus: The team will become the experts

Clinicians need to keep in mind that after learning these steps they will delegate these to the team, who will then become the experts. The 3D-printing process should be an advantage for clinicians but also, more importantly, for the dental team and patients. It is going to be exciting for them. In the beginning, it might take more of the dentist's time, but the team will eventually come up with new applications for 3D printing in the office. At our practice, Patricia is very knowledgeable and can train other team members on 3D-printing processes. Once the team becomes expert, the clinician can be largely hands-off.

3D printing provides great advantages for clinical procedures and patients and has a positive impact on the dental team. The learning process can be exciting for everyone involved when these five key elements are considered. We are certain that your team will be happy to jump on board and help your practice thrive.

about

Dr Lisa Alvetro is an orthodontist and Patricia Mitchell is a digital specialist at Alvetro Orthodontics in Ohio in the US.

A novel workflow for indirect restorations without digital design

Dr Les Kalman, Canada

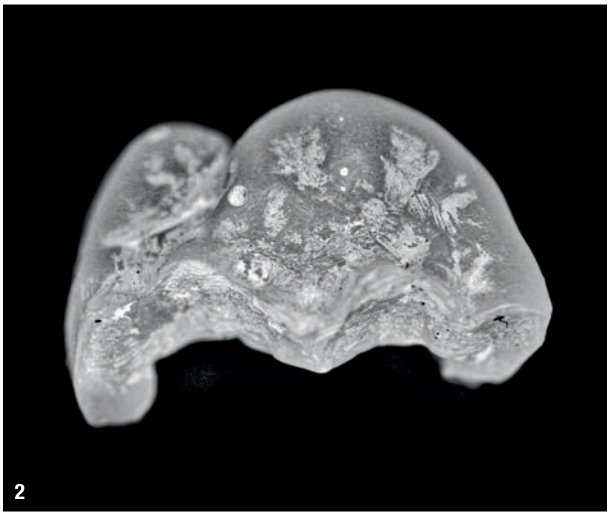
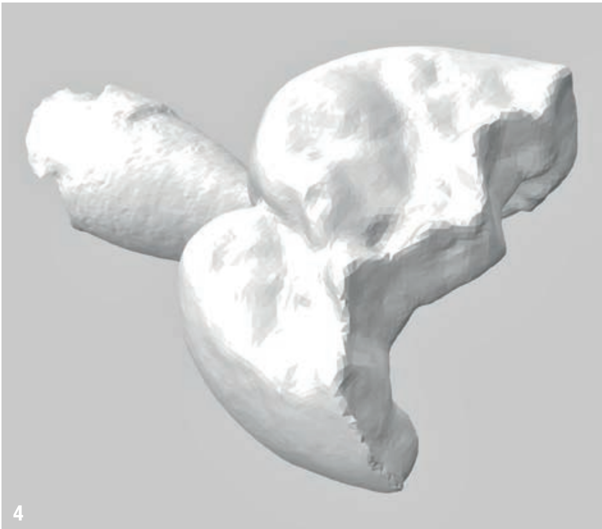



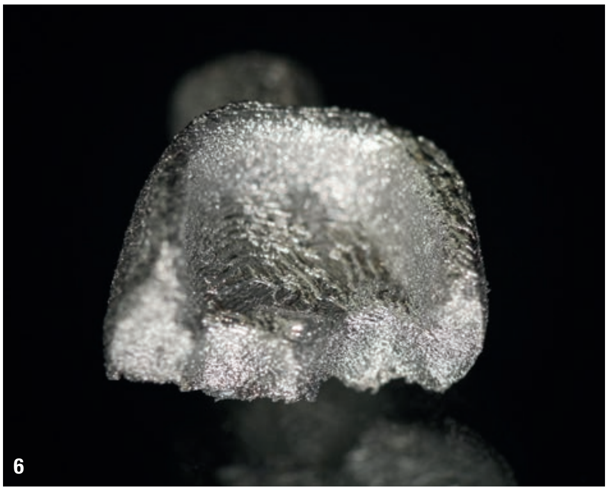
Fig. 1: Preparation of tooth. **Fig. 2:** Provisional restoration.

Introduction

Over the last decade, the impact of technology on dentistry has increased significantly.[1] This impact has been well documented in the field of prosthodontics, where the use of digital impressions and digital design for indirect restoration has had substantial improvements.[2,3] Although the technology used in this field has evolved, the workflow has not changed significantly. The workflow typically consists of tooth preparation, digitisation, digital design and restoration fabrication.[3] The workflow can prove to be challenging in terms of time, cost and complexity, limiting both its application and availability.[4] This preliminary *in vitro* investigation explored the use of additive manufacturing for the fabrication of cobalt–chromium onlays without the use of digital design.

Figs. 3 & 4: STL of onlay.



Figs. 5 & 6: Additive manufactured onlay.

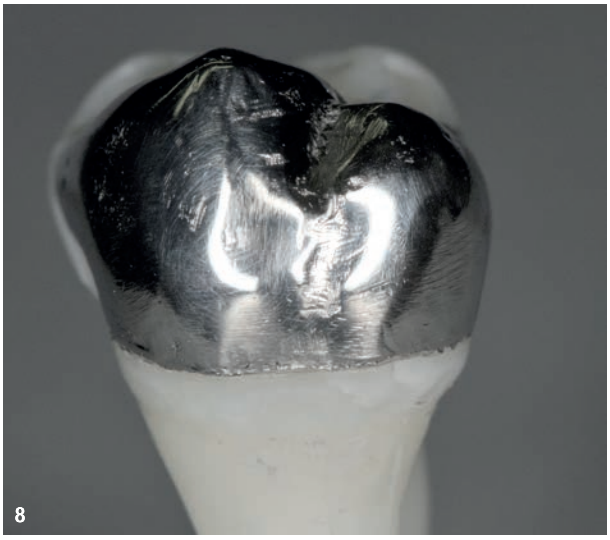
Material and methods

Three extracted and undamaged human molars were selected at random. A handheld tool was used to support each molar. To impress each tooth, a sectional tray (TempTray, Clinician's Choice Dental Products) and provisional material (Template, Clinician's Choice Dental Products) were used. Preparation of the teeth was performed for a four-surface onlay, either mesial-occlusal-distal-lingual or mesial-occlusal-distal-buccal (Fig. 1). The provisional matrix was loaded with a bis-acrylic composite resin (Integrity, Dentsply Sirona) and was placed on the prepared tooth. A standard four-surface provisional restoration was fabricated, shaped and polished (Fig. 2).

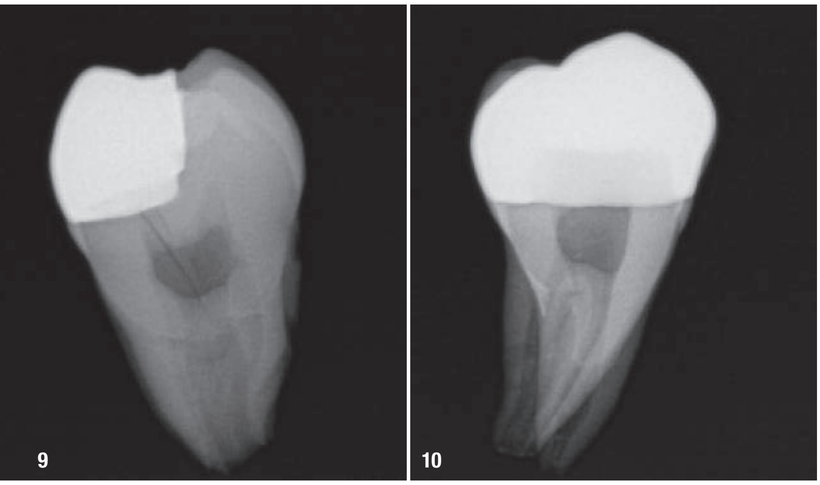
The provisional restorations were fixed with a Pic-n-Stic (PULPDENT) and sprayed with titanium dioxide (3M ESPE). The restorations were digitised (True Definition, 3M ESPE)

"The print quality of the definitive restoration is dependent upon the quality of the provisional restoration."

and STL files of the restorations were created (Figs. 3 & 4). The STL files were digitally sent to ADEISS. The files were then imported into Fusion 360 software (Autodesk) and printed in cobalt–chromium (Figs. 5 & 6) with an AM 400 laser melting system (Renishaw). The printer used selective laser melting technology, melting and fusing layers of metallic powder (average diameter: 30–50 µm) using a 400 W laser. All restorations under-



Figs. 7 & 8: Cemented onlay.



Figs. 9 & 10: Radiograph of cemented onlay.

went the usual post-processing, except for surface polishing.

Each onlay was bonded to the prepared tooth using resin cement (GC) according to the manufacturer's protocol.[5] The restorations were polished with high-speed diamond burs and slow-speed finishing discs. Post-cementation photographs (Figs. 7 & 8) and radiographs (Figs. 9 & 10) were taken.

Results

The digital scanner provided an STL file of appropriate resolution for metal additive manufacturing or 3D printing. The indirect onlays were successfully printed in cobalt–chromium with the morphology, dimensions and fit that were clinically acceptable for cementation. Cementation was completed without issue and with suitable retention, similar to previous investigations.[6] The marginal adaptation was generally acceptable, except for one area, owing to an open margin. The surface finish was generally acceptable, but could be improved in some places, especially on the occlusal surface.

Discussion

This preliminary investigation suggests that the workflow for additively manufacturing cobalt–chromium onlays exclusive of digital design is possible. For predictability, the scanner and printer are required to have a sufficient resolution. The print quality of the definitive restoration is dependent upon the quality of the provisional restoration; therefore, a highly morphologically accurate, ideally adapted and polished provisional restoration is necessary, as polishing of cobalt–chromium is challenging. The tooth preparation seemed appropriate for the material.

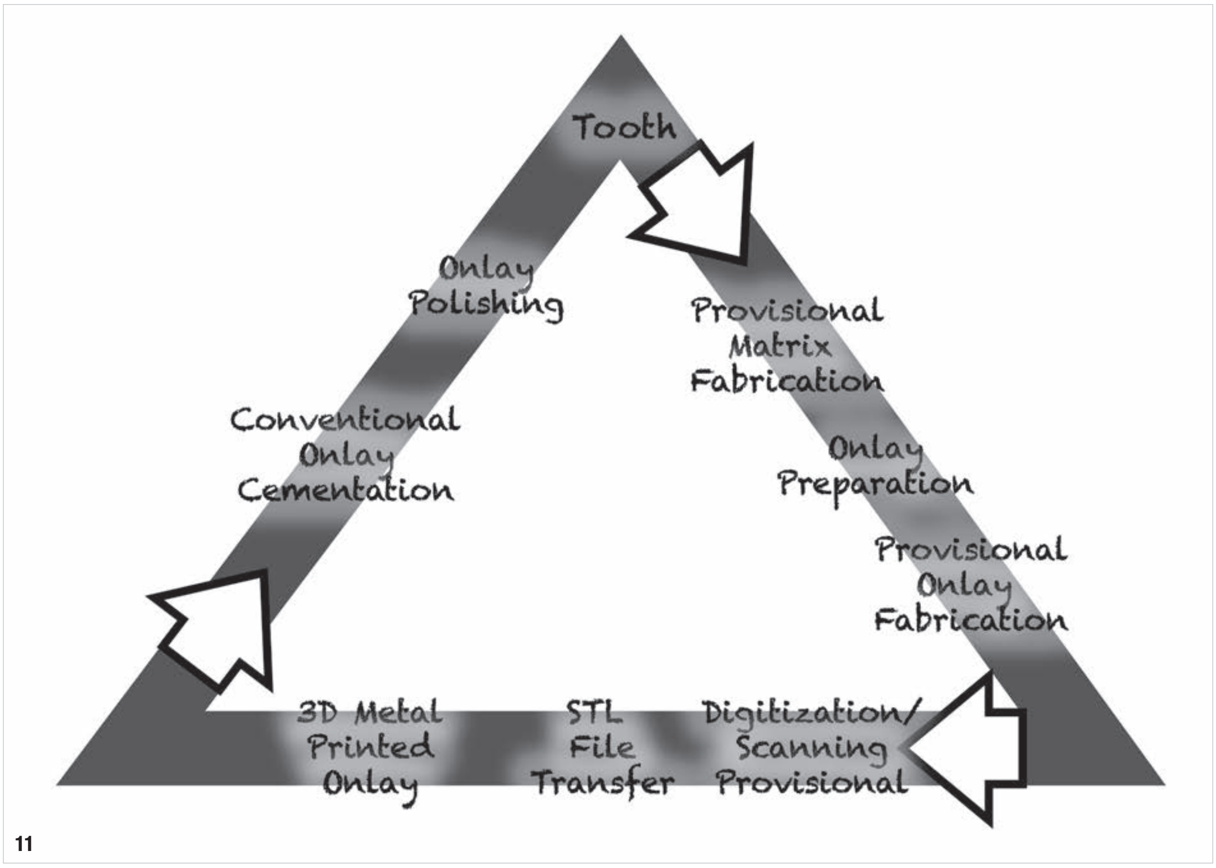


Fig. 11: Novel workflow proposal.


Figs. 12 & 13: Zirconia onlay.

A novel workflow (Fig. 11) has been proposed that provides a simple, efficient and inexpensive alternative to the traditional workflow. The new workflow circumvents the need for digital design, which would greatly reduce the time and cost, compared with the traditional workflow. The approach may also provide a more sustainable treatment option.

This study investigated cobalt–chromium indirect restorations, but other metal powders currently used in additive manufacturing, including stainless steel and titanium, could be employed.[7] In addition, the novel workflow could be applied to non-metal, aesthetic materials such as zirconia and lithium disilicate. The use of zirconia was also explored in this investigation with a single unit, using the same workflow, and achieved similar results but with milling rather than additive manufacturing (Figs. 12 & 13).

This study had a small sample size and limited assessment, as the restorations were placed on stand-alone extracted teeth and only assessed through photographs, radiographs and a clinical post-cementation checklist. Further studies are required with larger sample sizes, adjacent teeth, antagonists, other materials, physical testing and clinical evaluation.

Conclusion

Digital dentistry will continue to evolve and expand while impacting clinical practice. The novel workflow presented for fabricating cobalt–chromium indirect restorations using additive manufacturing without the use of digital design provides an unconventional alternative. Its simplicity, efficiency and cost-saving seem to indicate that it offers a predictable and successful technique for creating indirect restorations, offering hopes of improved accessibility and sustainability.

Acknowledgements

The author acknowledges the work of Dr Vishal Patel for the onlay preparations on the extracted teeth, Ashwin Baskaran and Megan Checora for their assistance with the polishing and Lyndsay Desimone for assistance with the manuscript. Special thanks go to ADEISS for the metal 3D printing and Alien Milling Technologies for the zirconia restoration.

Funding

Funding for the research was provided by the Schulich School of Medicine and Dentistry of the Western University in London in Ontario in Canada (internal research grant).

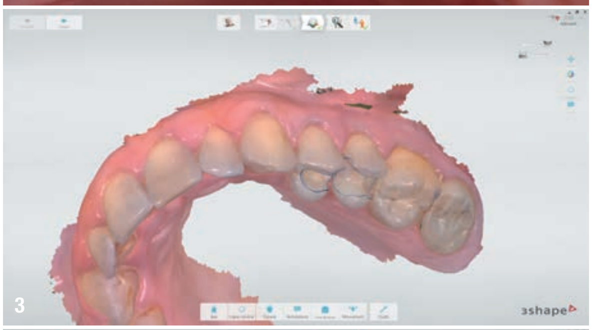
Editorial note: A list of references is available from the publisher.

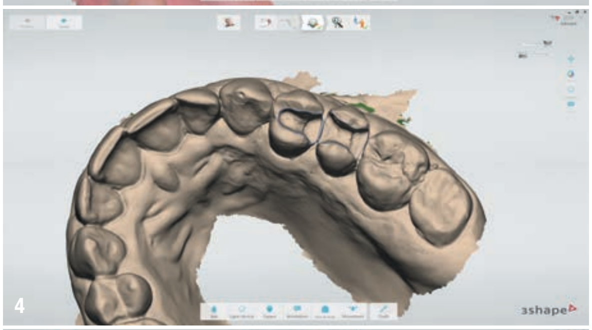
about

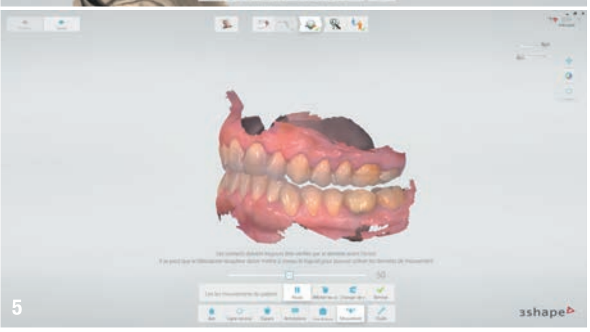
Dr Les Kalman is an educator and medical device researcher focusing on additive manufacturing and software. He is a fellow of the Academy of Osseointegration, American College of Dentists and Academy for Dental Facial Esthetics and a diplomate of the International Congress of Oral Implantologists. He is the recipient of an Alumni of Distinction Award from the Schulich School of Medicine and Dentistry at the Western University in London in Ontario in Canada and a CES Innovation Awards honouree.

3D-printed maxillary premolar inlay restorations of Permanent Crown Resin

Dr Edouard Lanoiselée, France







Introduction

Digital dentistry methods and materials have surpassed traditional ones in many ways. Digital tools particularly enhance interconnectedness and communication between patients, dentists and the laboratory. Additionally, the development of new dental materials for restorative dentistry has opened up a new world of possibilities, since they allow for shorter delivery times and reduced costs while delivering high-quality restorations.

Today, intra-oral scanners and 3D-printing systems are performing at a high level while maintaining simplicity of use. The Form 3B printer (Formlabs) is an excellent example of this; its plug-and-play operation puts it within equal reach of both printing experts and beginners. Permanent Crown Resin (Formlabs) is a restorative material released in 2020 that allows the direct printing of high-quality permanent single-unit dental restorations at a reduced price.

The clinical case presented here shows an indirect CAD/CAM step-by-step workflow for the production of inlay restorations. First, the intra-oral impression was taken in the practice and the data was transmitted to the prosthetic laboratory, where the restorations were designed and 3D-printed in Permanent Crown Resin using the Form 3B. The restorations were then sent back to the practice and prepared for adhesive cementation, and the treatment was delivered to the patient.

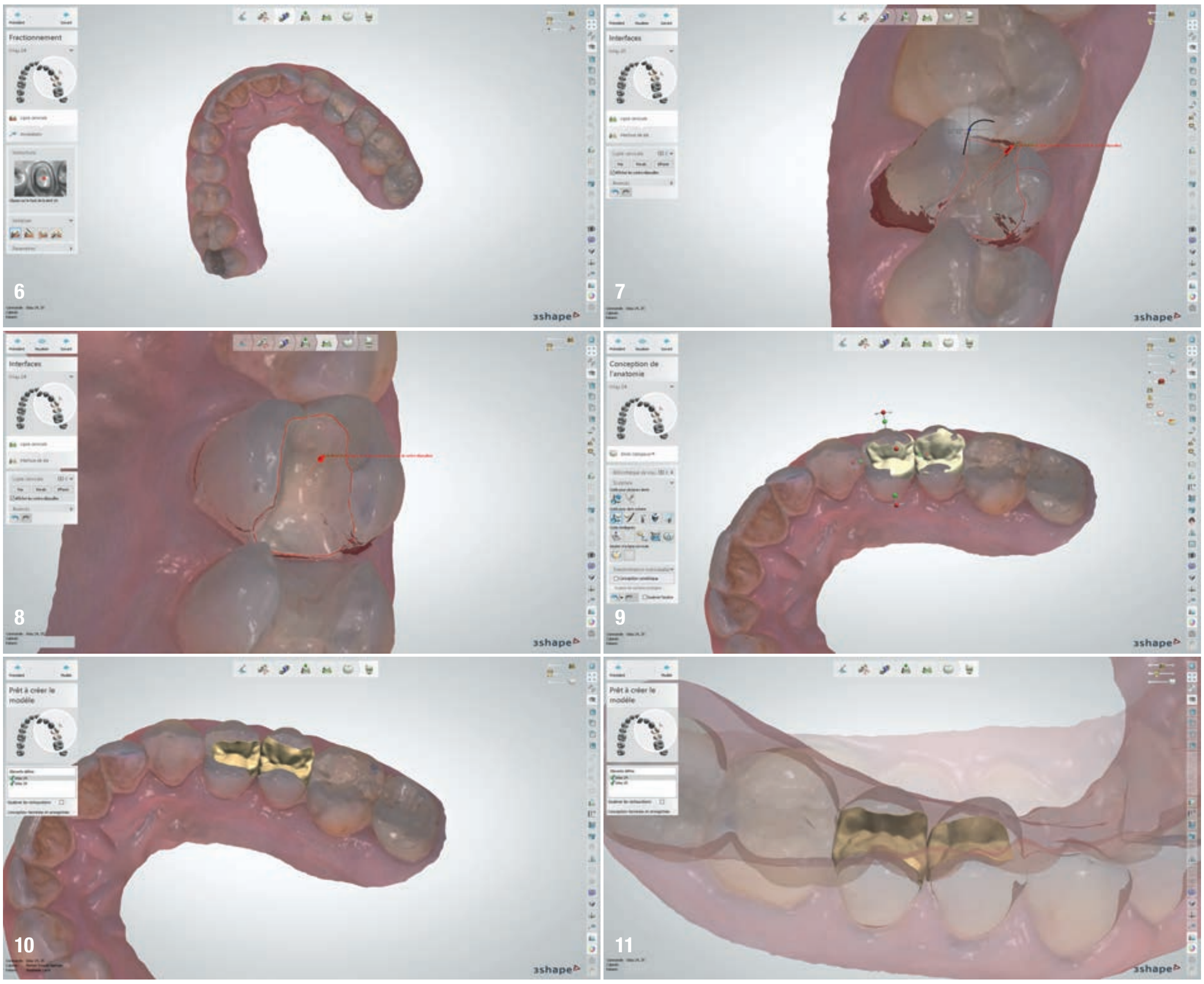


Fig. 1: Initial clinical situation. **Fig. 2:** Teeth after preparation. **Fig. 3:** Maxillary impression with tracings of the limits of the tooth preparations. **Fig. 4:** Black and white imprint control. **Fig. 5:** Dynamic occlusion recording (specific motion). **Figs. 6–11:** Inlay design.

Case report

A 58-year-old female patient with hypothyroidism under treatment consulted us for sensitivity to cold in the area of tooth #24. During the clinical examination, we identified an occluso-distal fracture of the dental amalgam of the tooth 24 (Fig. 1). The restorations on teeth #25 and 26 had been carried out at the same time and appeared to have been infiltrated. After testing, we diagnosed reversible pulpitis of tooth #24. Teeth #25 and 26 did not exhibit any pulpal signs.

The treatment plan consisted of the removal of the amalgam restorations and the transition to a direct composite restoration on tooth #26 and indirect 3D-printed composite resin restorations (inlays) on teeth #24 and 25. The treatment would be carried out in two sessions: a preparation session and a cementation session.

The amalgam fillings were removed. In order to conceal the residual discolouration caused by the amalgam and to fill undercuts, the cavities were filled with composite. Tooth #26 was filled using the direct composite resin technique. The shade of the indirect restorations was determined by the shade selected to fill the cavities in teeth #24, 25 and the filling of tooth #26. The composite filling protects against the risk of bacterial contamination and prevents possible pulpal sensitivity.

The teeth were then prepared using calibrated burs for inlays (Fig. 2). After polishing, an intra-oral impression was taken using TRIOS 4 (3Shape), both statically and dynamically (Figs. 3 & 4). The patient's mandibular movements were recorded to improve the accuracy of the occlusion (Fig. 5). The impression was sent to the prosthetic laboratory (Argoat Prothèses Dentaires) via the secure 3Shape Communicate web portal. The provisional restorations were then fabricated from a flexible composite (Luxatemp-Inlay, DMG Chemisch-Pharmazeutische Fabrik), which was selected for easy removal during the assembly session.

The restorations were modelled in the Dental System software (3Shape; Figs. 6–11). After the digital design had

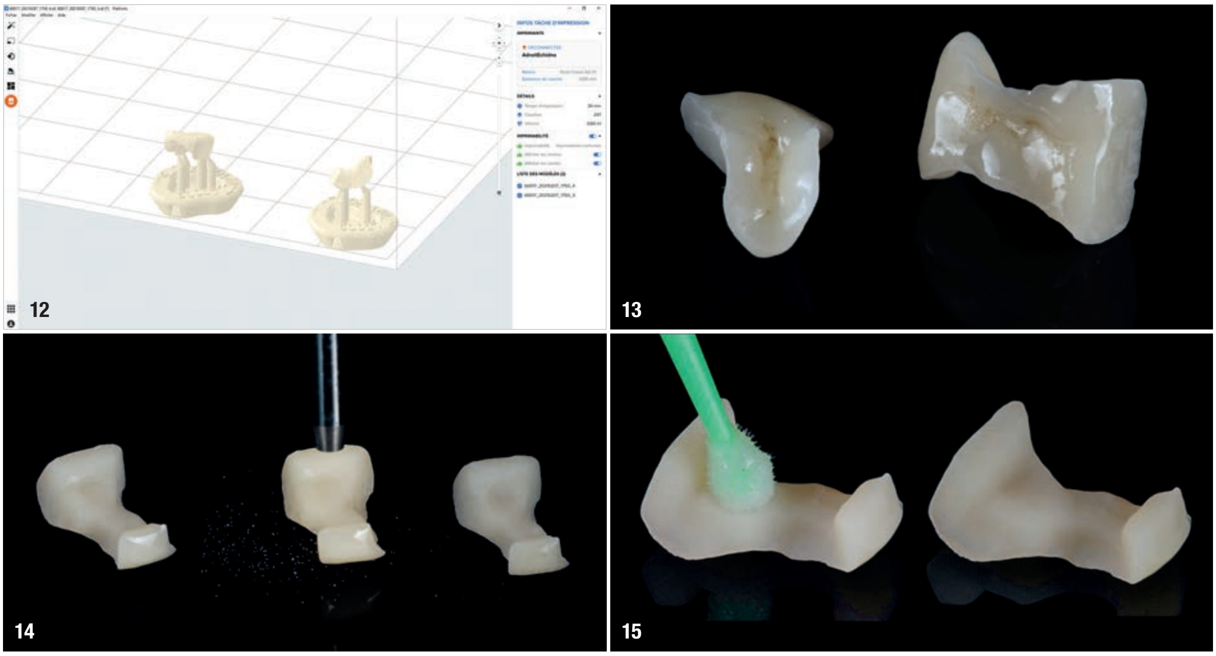


Fig. 12: Print preparation in PreForm. **Fig. 13:** Inlay characterisation. **Figs. 14 & 15:** Surface preparation of inlays.

been completed, the inlays were exported in STL format and imported into the PreForm software (Formlabs; Fig. 12) and printed in Permanent Crown Resin (Shade A2) in the prosthetic laboratory. The restorations were then characterised via staining (OPTIGLAZE, GC) and glazing and sent to the dental practice for cementation (Fig. 13).

After removal of the provisional restorations, the inlays were tried in to validate their insertion and adaptation. Their internal surfaces were then prepared in three steps (Figs. 14 & 15): micro-sandblasting (50 µm alumina) to create mechanical retention; cleaning to remove residual alumina particles; and silanisation (G-Multi PRIMER, GC). After thorough drying, the primer was applied in a single layer and then the excess was evaporated with a blower and the restoration was placed in a heater to activate the silane.

We then proceeded to assembly by cementing. We first set up an operating field using multiple dental dams.

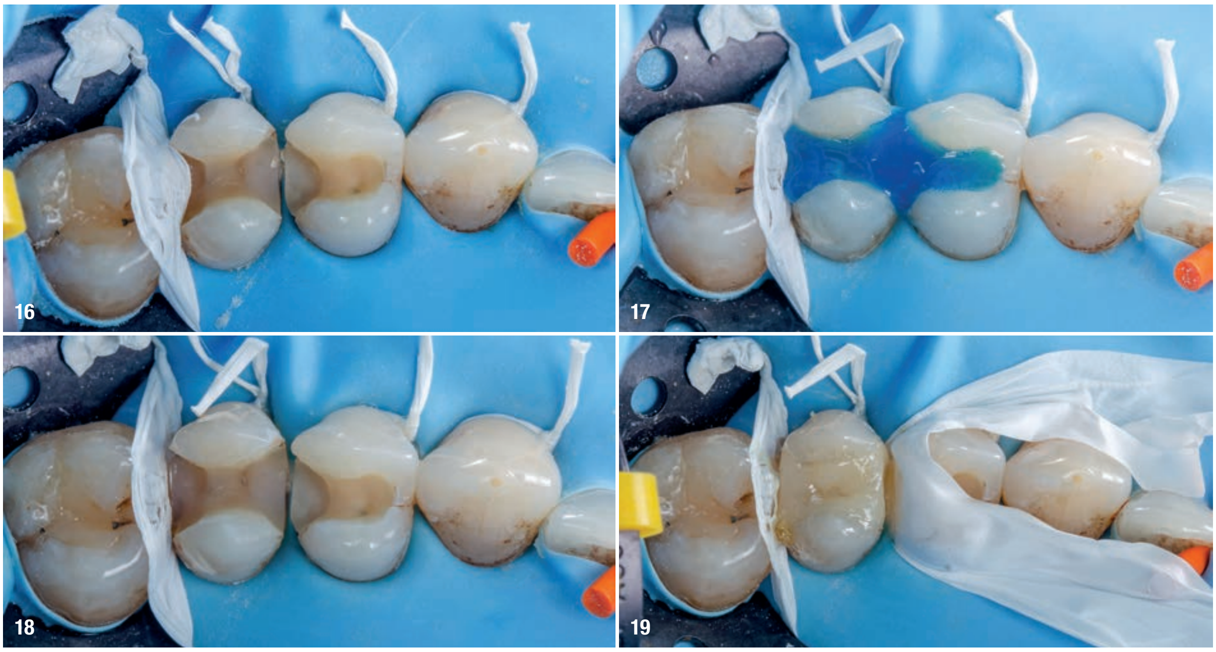


Fig. 16: Preparation of tooth surfaces. **Fig. 17:** Application of phosphoric acid. **Fig. 18:** The tooth preparations after conditioning. The surfaces had a matte appearance as a sign of the conditioning action of micro-sandblasting and acid etching. **Fig. 19:** Cementation of the inlay on tooth #25.




Fig. 20: Cementation of the inlay on tooth #24. **Fig. 21:** Fitting view. **Fig. 22:** Polishing under surgical field. **Fig. 23:** Final view after occlusion check and polishing.

This allowed us to isolate the site from the moisture of the oral cavity and to improve visibility. The cavities were conditioned using a micro-sandblaster (27 μm alumina). The sandblasting reactivates the composite for bonding, cleaning the cavity of possible residues of temporary cementation agent and restoration (Fig. 16). We rinsed abundantly to remove alumina particles, which can decrease the adhesion value. Phosphoric acid was applied for 30 seconds on the enamel and 15 seconds on the dentine (Fig. 17). The etching creates micromechanical keying and helps to finish cleaning the bonding surfaces (Fig. 18).

For cementation, a dual-polymerising (chemical and light) universal cement agent (G-CEM LinkForce, GC) was used. The adjacent teeth were insulated with PTFE to avoid the adhesive and cementing agent reaching other surfaces. The adhesive was applied by actively rubbing it into the surfaces and applying the dry air blower to evaporate the solvents. The adhesive was applied to the prosthetic restoration, which was then gently placed into the prepared cavity (Fig. 19). Excess cementing agent was carefully removed with a brush and then the restoration was photopolymerised for 20 seconds. The second inlay was then placed following the same protocol (Fig. 20). Here again, the excess was removed with a brush before photopolymerisation. The two inlays were then photopolymerised for 1 minute from all sides (Fig. 21). Initial polishing was carried out using silicone polishers (Footsie spiral, Komet; Fig. 22). The dental dam was then removed, the occlusion checked and the final polishing carried out (Fig. 23). The aesthetic integration was satisfactory. The patient would be seen again in six months for follow-up.

Conclusion

Permanent Crown Resin is an excellent alternative to composite blocks for inlay applications. 3D printing allows an economical solution with a satisfactory aesthetic result in terms of both morphology and colour. While a composite block can cost €10–€12 a piece, using 40 ml of 3D-printing material reduces costs significantly, to €4–€7 per inlay. The workflow proposed here in collaboration with the prosthetic laboratory can easily be done within the dental practice in a direct CAD/CAM framework.

about

Dr Edouard Lanoiselée is a general dental practitioner in a group practice in Nozay in France. He graduated in dentistry from what is now Nantes Université in France in 2008 and has received several certificates in prosthetics. He has maintained a link with the faculty since his graduation, whether for clinical supervision of students or for theoretical instruction at graduate level. He is a lecturer in the university diploma programme in aesthetic dentistry at the university, the master's degree 1 programme in biology and health, and higher education certificates. Dr Lanoiselée was formerly a teaching hospital assistant lecturer at the care, research and teaching centre of the Faculty of Dentistry at Nantes Université. He has been a user of CAD/CAM systems since 2009 and regularly speaks on aesthetic dentistry and digital workflows at conferences.

Production of complete maxillary and mandibular dentures using CAD/CAM technology

Dr Francesco Zingari, Dr Eleonora Carozzi & Salvatore Belvedere, Italy

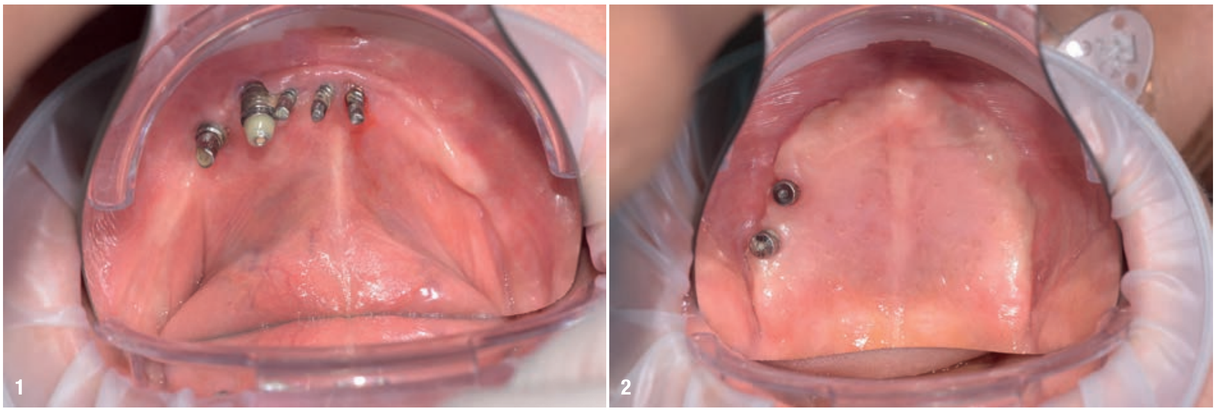


Fig. 1: Situation in the mandible before treatment. **Fig. 2:** Situation in the maxilla before treatment.

Introduction

Digitalisation in the world of dentistry and dental technology is advancing rapidly, and it is now difficult to imagine everyday clinical practice without it. Sophisticated solutions are available in the fields of diagnostics, treatment planning and the production of permanent restorations in particular.[1] Capture of digital radiographs, implant planning and the design of permanent restorations using hardware and software solutions are already well-established procedures in modern dentistry and dental technology. The weak points of solutions available to date included soft tissue and functionally intrinsic structures, which were difficult to integrate into the digital workflow.[2] Furthermore, the production of removable dentures has been widely accepted for many years and is now a firmly established everyday procedure in practices and laboratories alike.[3] Increasingly, however, the production of removable dentures is now also being satisfactorily digitalised thanks to continuous improvement of the system components. This progress brings with it changes for the workflow, especially as far as dental laboratories are

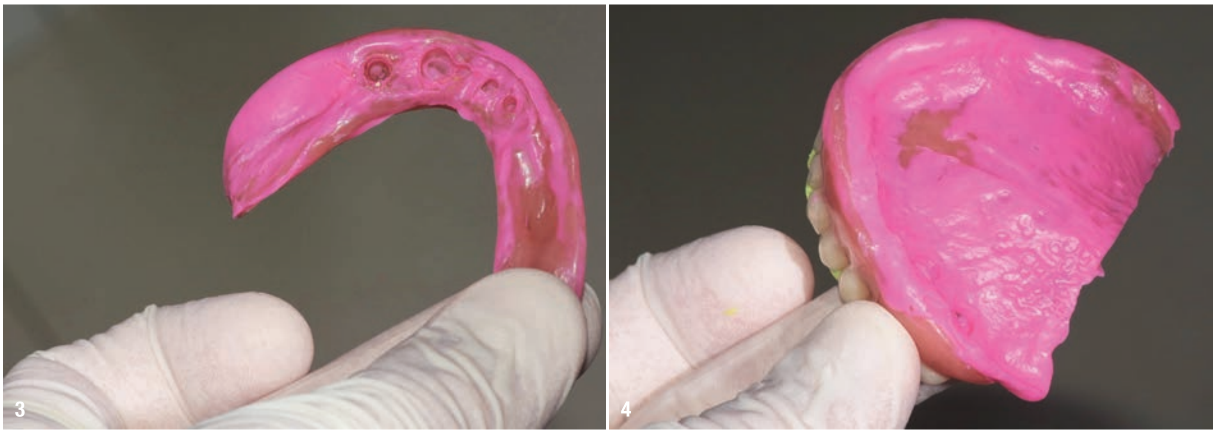


Fig. 3: Taking of the mandibular impression with the existing denture. **Fig. 4:** Taking of the maxillary impression with the existing denture.

concerned, evolving from a predominantly manual into a predominantly digital task.[4] The following case report describes the use of the CediTEC system (VOCO), which allows production of complete dentures in just a few appointments.

Case description

A 62-year-old female patient presented at our practice of her own volition, complaining of serious difficulties when chewing and speaking as a result of poorly fitting maxillary and mandibular dentures. From an aesthetic perspective, the patient also complained that her old dentures bothered her every day and confirmed that she was no longer happy with them at all.

When asked about her medical history, she stated that she was undergoing treatment with bisphosphonates for diagnosed osteoporosis. Many years ago, the patient had also had five implants inserted into her lower jaw and two into her upper jaw, to which the existing removable dentures from her former dentist were attached. The patient's request was for accurately fitting dentures again to improve both her appearance and her ability to chew and speak properly.

Findings

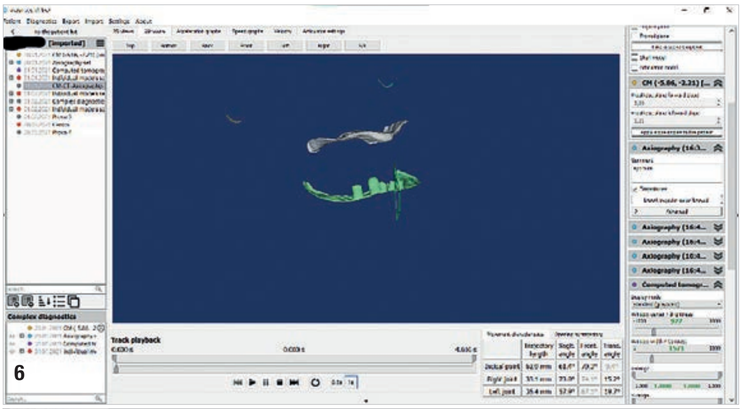
The clinical, instrumental and radiographic findings revealed generalised horizontal and vertical bone loss in the edentulous regions. The mucous membranes did not appear to be irritated. The implant abutments, which had clearly been individualised multiple times, were inadequate for support of the removable dentures. All the implants displayed a degree of loosening and the peri-implant tissue appeared both slightly red and swollen. We found that the complete maxillary and mandibular dentures were inadequate and diagnosed peri-implantitis around all the implants.

Treatment planning

The prognosis for the implants was not predictable at the time the findings were recorded, for which reason the implants were initially left as they were (Figs. 1 & 2). The treatment of the peri-implantitis would be initiated after production of the new complete maxillary and mandibular dentures. With special consideration of the patient's existing condition and medication, replacement of the implants in the upper jaw with zygomatic and pterygoid implants at a later point in time might also have been conceivable. However, this will not be discussed in further detail at this point.

The patient requested that the functional impairments and aesthetic aspects be resolved as quickly as possible. For cost and time reasons, the complete maxillary and mandibular dentures to be produced were designed using CAD/CAM technology. To do so, we decided for the sake of simplicity on the CediTEC system, in which all the necessary components are coordinated.

Fig. 5: Digital maxillomandibular relationship registration and axiography.



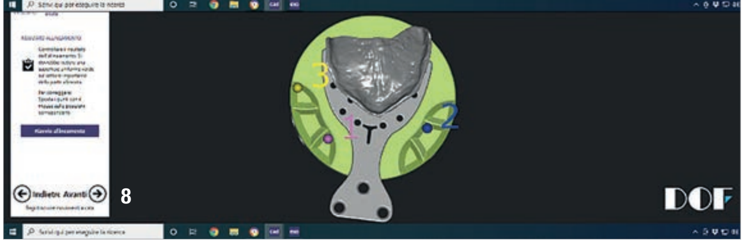
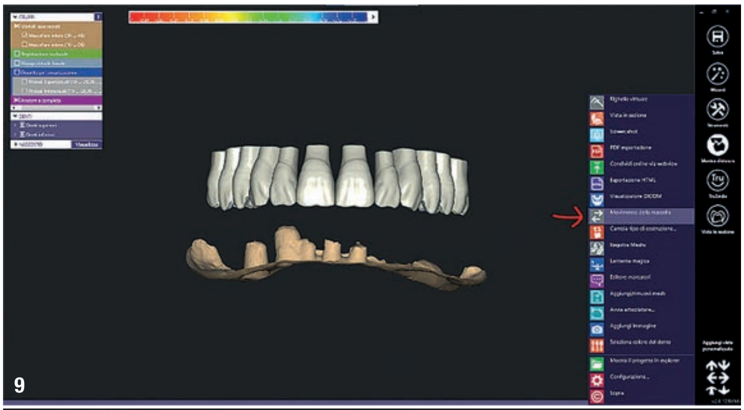
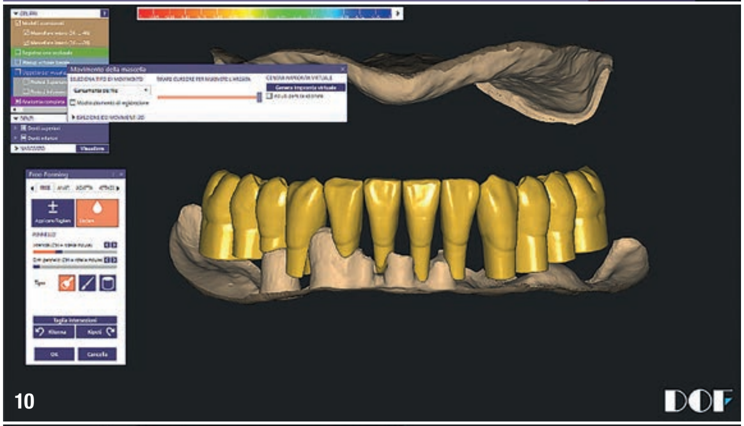


Fig. 6: Visualisation of digital maxillomandibular relationship registration. **Figs. 7 & 8:** Import into the exocad software after scanning of the individual impressions and dentures using the laboratory scanner.





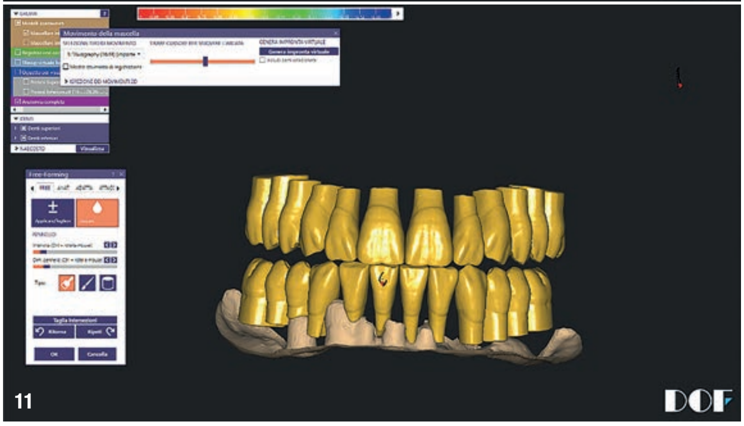


Fig. 9: Diagnostic tooth arrangement in the maxilla. **Fig. 10:** Diagnostic tooth arrangement in the mandible. **Fig. 11:** Digital tooth arrangement with static and dynamic occlusion.

Treatment

Using the existing dentures as customised trays, the situation impressions were taken (Flexitime Monophase Pro Scan, Kulzer; Figs. 3 & 4) and digitalised using a laboratory scanner in the first appointment after the recording of the findings, diagnosis, dental hygiene and treatment planning. At the dental laboratory, the individual impressions and dentures were digitalised with a laboratory scanner (BEGO LabScan, BEGO Medical) and the data was converted to STL format. The individual holders for an intra-oral registration instrument were designed and produced.

In the second treatment appointment, the digital maxillo-mandibular relationship registration and axiography were performed with Prosystom (SDiMatriX; Fig. 5). At the dental laboratory, data sets were imported into exocad software (Figs. 6–8), diagnostic and digital tooth arrangement was performed (Figs. 9 & 10), and digital modelling of the complete maxillary and mandibular dentures was performed (Fig. 11). The data sets were transferred to nesting software (Netfabb, Autodesk) and the files were exported to a 3D printer (SolFlex 170 HD, VOCO).

The dental laboratory printed modified wax try-ins (V Print Try-In, VOCO; Fig. 12). These were tried in (Fig. 13) and the static and dynamic occlusion, phonation and aesthetics were checked at the third appointment.

Next, the dental laboratory 3D-printed (SolFlex 170 HD) and finished the master models (V-Print model fast, VOCO) and the denture bases on the basis of the existing data sets (V-Print dentbase, VOCO; Figs. 14 & 15). Thereafter, the dental laboratory milled the 24 denture teeth from a disc (CediTEC DT, Shade A2), finished them (Fig. 16), fixed them to the printed denture bases (CediTEC Adhesive) and finished the bases (Figs. 17 & 18). The occlusal surfaces on the complete dentures were then individualised (FinalTouch, VOCO; Figs. 19–22).

In the fourth treatment appointment, the final complete maxillary and mandibular dentures were inserted (Fig. 23) and selective grinding was performed.

Result

The complete dentures were produced using CAD/CAM technology. The finished result is in no way inferior to a manually produced workpiece. The patient was also unable to identify any disadvantages. After insertion, the patient's *en face* profile during phonation and smiling had a natural appearance (Figs. 24 & 25). The soft tissue of the face was harmonious and naturally padded. In a before and after comparison, the nasolabial and peri-labial folds were considerably reduced with the new complete dentures. Clinical aspects such as static and dynamic occlusion were normal.

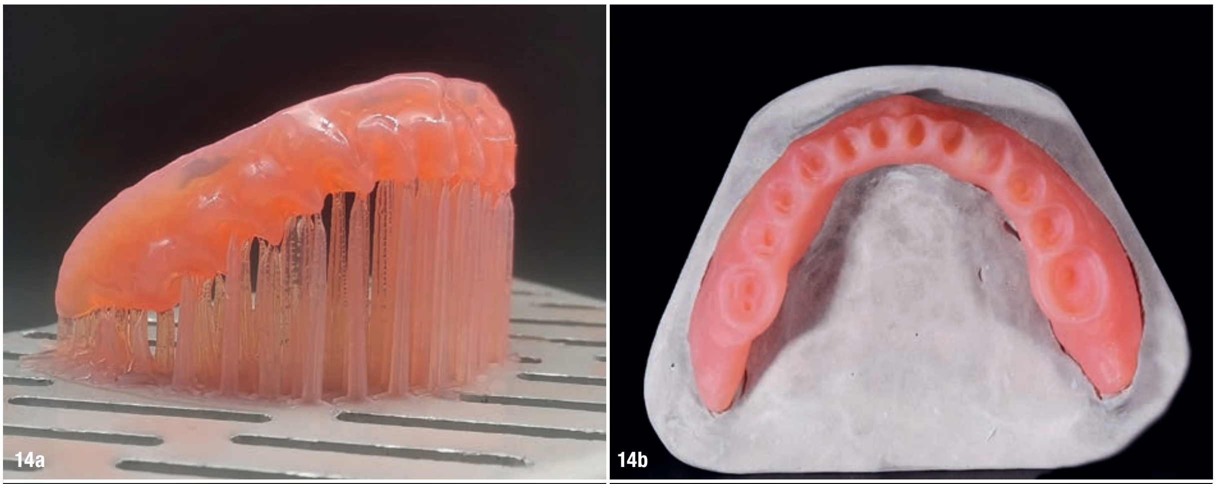
Discussion

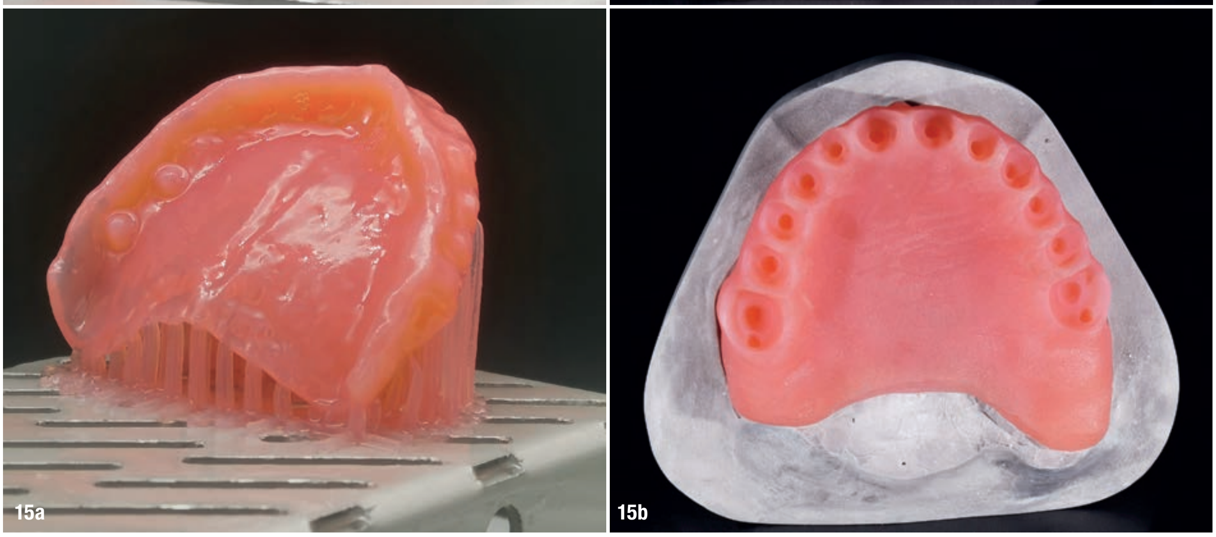
The conventional production of removable dentures and complete dentures in particular may seem somewhat laborious when considering the case described here, as the use of CAD/CAM technology clearly represents an approach which is extremely time-effective and therefore cost-effective. The continuous modification of the clinical approach employing CAD/CAM technologies initiated in recent years, especially with regard to the production of complete dentures, has repeatedly resulted in lower labour costs and fewer clinical treatment steps.[5–7]


3D FREEPRINT®
HIGHCLASS RESINS
NEW 3D CATALOGUE
FREEPRINT® temp
Medical Device Class IIa
Temporary crowns & bridges
Anterior and posterior tooth restorations
MEDICAL DEVICE
FREEPRINT® crown
In process Q3/22
Permanent crowns
Denture teeth
Long-term temporary bridges
FREEPRINT® denture
Medical Device Class IIa
Removable denture bases
Total prosthesis
MEDICAL DEVICE
FREEPRINT® ortho
Medical Device Class IIa
Surgical guides
Orthodontic base components
MEDICAL DEVICE
FREEPRINT® splint 2.0
Medical Device Class IIa
Hard Splints
MEDICAL DEVICE
FREEPRINT® supersplint
In process Q3/22
Flexible splints
Nightguards
FREEPRINT® IBT
Medical Device Class I
Transfer trays
Bracket positioning
MEDICAL DEVICE
FREEPRINT® tray 2.0
Medical Device Class I
Individual impression trays
Functional trays
Base plates
MEDICAL DEVICE
FREEPRINT® tryin
In process Q2/22
Individual functional try-ins
FREEPRINT® model
Model production
Working models
Situation models
Control models
FREEPRINT® model 2.0
Model production
Master models
Working models
Control models
FREEPRINT® model KFO
Model production
Orthodontic models
FREEPRINT® model T
Model production
Thermoforming technique
FREEPRINT® model WW
Model production
Thermoforming technique
FREEPRINT® gingiva
Gingival masks
FREEPRINT® cast 2.0
Casting objects
NEW
FREEPRINT®
denture
3D PRINTING MATERIAL
5kg ecobag
DETAX
#HELLO ECOBAG!
NOW AVAILABLE
3 KG OR 5 KG!
MDR CERTIFIED 2020
DETAX
HIGHEND MEDICAL MATERIALS

Fig. 12: Modified wax try-ins (V-Print Try-In). **Fig. 13:** Try-in of modified wax try-ins.

Another advantage is the uncomplicated and arbitrary reproducibility of the procedure thanks to the data being clinically generated initially and then subsequently digitalised and stored.[8] This allows the repeated production of further, identical dentures on the one hand and the export of the data sets to other software programs, for example for the planning of subsequent implant treatment as in this case, on the other.





Figs. 14a & b: Printing of the denture base for the mandible (SolFlex 170 HD & V-Print dentbase). **Figs. 15a & b:** Printing of the denture base for the maxilla (SolFlex 170 HD & V-Print dentbase).

HeyGears

Hey ChairSide
Hey Future

ULTRACRAFT ChairSide

SMART AND USER FRIENDLY, YOUR ASSISTANT BY YOUR CHAIRSIDE

The UltraCraft ChairSide + AirWash + AirCure combination is a lightweight desktop 3D printing solution designed for chairside use.

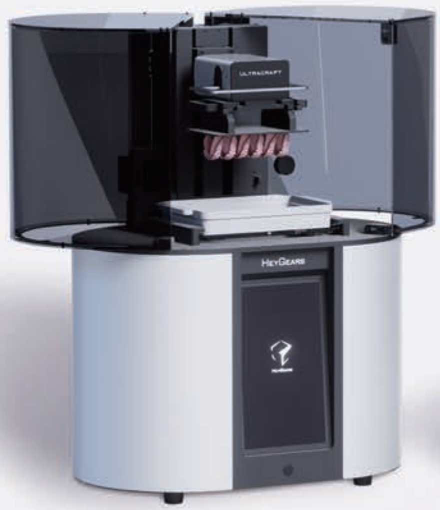
Easy to Use
- CapsulePrint
- Plug–n–play Platform
- Hassle Free “0” Maintenance

Work Smarter, Not Harder
- Multiple Intelligent Sensors
- Thermostatic Module

Industrial–grade Printing Precision
- Leading Optical Engine
- Auto Calibration of Light Path and Optical Engine
- AI–powered Printing Strategy

UltraCraft AirWash
- Zero Contact with Resin
- Auto–configured Washing Strategy
- Minimal Cleaning Agent Use

UltraCraft AirCure
- Auto–configured Post–curing Strategy
- High Efficiency and Performance



ULTRACRAFT ChairSide Pro

INDUSTRIAL DESKTOP 3D PRINTER FOR DENTAL APPLICATIONS

The UltraCraft ChairSide Pro is an industrial–grade desktop 3D printer designed for clinics and small labs to produce multiple dental applications with precision and speed.

High Precision with Higher Speed
- Print 8 Surgical Guides in Just 20 Minutes

As Pro as it Gets
- Long Lasting Calibration
- Instant Application Swap

Improved Small Scale Production Management
- Business Intelligence Analysis
- Intelligent Network for Auto Job Assignment
- Digital Twin and 24/7 Support

Multiple Applications

* Applications depend on the model of printer used.

See the products in person:

Expodental Meeting: Hall C1 — Booth 027, May 19–21, 2022, Fiera di Rimini, Rimini, Italy
LMT® LAB DAY® West: May 20–21, 2022, Hyatt Regency Orange County, California, US
AAO® Annual Session: Hall A – Booth 914, May 21–23, 2022, Miami Beach Convention Center, Florida, US

Contact the HeyGears team to learn more:

www.heygears.com sales@heygears.com Tel: +1 (318) 353–4295

Follow us @HeyGears

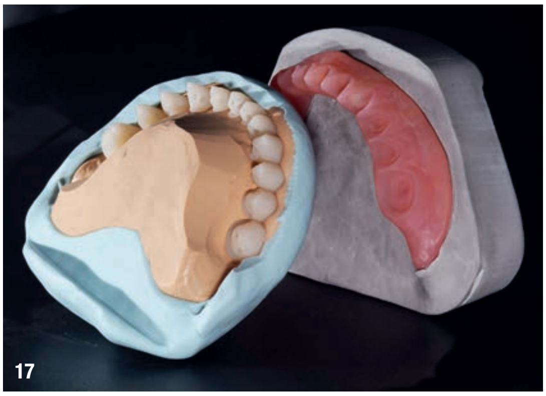


Fig. 16: Production of denture teeth by milling (CediTEC DT). **Fig. 17:** Silicone wall for fixing the denture teeth in their defined positions in the mandibular denture base (CediTEC Adhesive). **Fig. 18:** Silicone wall for fixing the denture teeth in their defined positions in the maxillary denture base (CediTEC Adhesive).

Owing to the constant and rapid further development of the different components in the scope of the digital workflow over the course of recent years, the progress in the registration and processing of clinical parameters for the production as well as the design of dentures has been enormous.[9, 10] In the case presented here, the computer-assisted production of the denture bases was performed with an additive (rapid prototyping) procedure using a 3D printer and the denture teeth were produced with a subtractive procedure on a milling machine. Subtractive techniques are currently more popular than additive ones in dental laboratories,[11] but the two processes can be used in combination just as easily, as illustrated here using the CediTEC system. Compared with conventional denture production, the use of CAD/CAM technology offers the advantage of better accuracy of fit of the denture

Fig. 19: Individualisation of the occlusal surfaces of the mandibular denture with composite stains (FinalTouch). **Fig. 20:** Individualisation of the occlusal surfaces of the maxillary denture with composite stains (FinalTouch). **Fig. 21:** Individualised, digitally produced complete maxillary and mandibular dentures in their finished state (CediTEC).

Fig. 22: Individualised, digitally produced complete maxillary and mandibular dentures in their finished state on the 3D-printed master models in the articulator (CediTEC). **Fig. 23:** Individualised, digitally produced complete maxillary and mandibular dentures *in situ* (CediTEC). **Fig. 24:** Individualised, digitally produced complete maxillary and mandibular dentures *in situ*, en face view, habitual bite (CediTEC). **Fig. 25:** Individualised, digitally produced complete maxillary and mandibular dentures *in situ*, smiling (CediTEC).

bases. Using both additive and subtractive processes makes it possible to avoid dimensional changes resulting from polymerisation shrinkage. The reproducibility of the dentures for future replacements as mentioned is another advantage, as the digital data sets are available at all times and any location. The CediTEC system presented here represents a consistent process for both dental practice and dental laboratory. CediTEC stands for CAD/CAM-enabled denture individual TEChnique. In this case, CediTEC DT ("DT" stands for "denture teeth") was used in the scope of the milling technique for the computer-assisted production of the denture teeth. CediTEC DT is a special composite developed specifically for CAD/CAM technology and available in four shades. In the case described here, the denture bases were produced using additive process technology with the aid of a 3D printer and the printing resin V-Print dentbase. The denture bases could alternatively have been manufactured subtractively, in which case they would have been milled from a PMMA disc (CediTEC DB). CediTEC DB is available in three different shades. Both CediTEC DB and CediTEC DT can be subsequently further customised in the scope of aesthetic dentistry with composite stains.

Conclusion

The patient was very satisfied with both the aesthetic and the functional results. In addition, she was surprised that dentures so perfect in every way were possible in so few and such short appointments at that.

In our opinion, nothing has changed in terms of the fundamental principles of the production of complete dentures, even when new and state-of-the-art CAD/CAM systems are utilised. Corresponding expertise in dentistry and dental technology remains the basis for time- and cost-effective treatment with digitally produced dentures. Even in the future, handy software and hardware components will not be able to completely replace the expertise of dentists and dental technicians. Nevertheless, applications in dental practices and dental laboratories will be joined by further new working steps in the interest of the digitalisation of clinical, patient-specific data and virtual planning of dentures.

Editorial note: A list of references is available from the editor.

contact

Drs Francesco Zingari & Eleonora Carozzi
Clinica Briantea Odontostomatologica
Via Trento 41
20847 Albiate MB
Italy

https://clinicabriantea.it/lo-studio

US military utilising 3D printing to deliver dental care on and off battlefield

The US military is already using 3D printing to provide medical services to its soldiers and veterans around the world.

By Anisha Hall Hoppe, Dental Tribune International

3D printing is a powerful technology that the military has begun to apply across the board. Military physicians are now utilising the technology in the hopes of making specialised dental care accessible for soldiers anywhere in the world.

The US Department of Veterans Affairs has established the Veterans Health Administration (VHA) 3D Printing Network in order to coordinate 3D printing initiatives for medical care for the more than 30 Veterans Health Administration facilities across America. This means that any dentist or doctor in the system has access to files for printing medical models, custom prostheses and dental tools.

Military physicians made headlines last year when they used 3D-printed teeth in the newly reconstructed jaw of Marine Corps Lance Corporal Jaden Murry at the Naval Medical Center San Diego (NMCSD). The team who performed the surgery removed a tumour and the affected portion of the jaw, then used part of Murry's fibula to replace the missing bone. The procedure and the use of the 3D-printed teeth have enabled Murry to make a quick recovery, and he has regained the ability to speak and eat normally.

In a Department of Defense press release, Navy Lieutenant Commander Dr Daniel Hammer said, "To see him swallowing, speaking, walking and not using a tracheostomy tube one week post-surgery was a huge victory."

3D printing also means increased patient safety. Dr Hammer said: "We are able to obtain 3D imaging of the facial skeleton with increased accuracy and decreased radiation dose. These [digital] impressions are more accurate and do not require additional laboratory work. If a physical model is needed, we're able to print the scan on our 3D printers."

The increase in efficiency provides better options for treatment, according to Navy Commander Dr Mike Anderson, a maxillofacial prosthodontist also based at NMCSD. "We're able to combine numerous surgical procedures that were once split up over years of treatment," he said in a further press release.

"The ability to immediately transfer that data to our imaging software to discuss and plan cases with our team is unbelievably more accurate, consistent and predictable than traditional methods," he continued.

Dr Anderson explained how that same imaging empowered his patients to ask more questions and better understand the nature of their individual procedures, thus improving their postoperative experience. Dr Hammer agreed. He explained: "Whether our patients have cancer, trauma, or benign tumours, our goal is for patients to awaken from surgery with not only the pathology removed and a new craniofacial reconstruction, but to also have a full complement of implant-retained prosthetic teeth for immediate improvement of speech, swallowing, function, and overall quality of life."

Dr Beth Ripley, director of the VHA 3D Printing Network, explained in a video how, through the network's partnership with Dr James Hoying, partner and chief scientist at Advanced Solutions Life Sciences, advances have been made with the BioAssemblyBot. "It's a printer that can print anything that can come through a syringe. And that could be cells or collagen—the patient's own cells," said Dr Ripley. Dr Hoying clarified the process, saying: "We essentially take the basic components of bone. These are ground down into a powder and then reconstituted with other elements in order to create what is almost like a bone paste."

In a VHA Talks series video, Dr Ripley referred to a type of surgery similar to the one performed on Murry and further outlined the goals for 3D printing within the military. She explained that in the future there would be faster surgeries without the need to harvest bone from other parts of the patient's body, as is presently done in jaw reconstruction cases. "Well, now we have a bio-printer. We can take some [fat cells], we can take some bone cells, and remember we have the blueprint for your mandible. So, we know what the shape is, and we can start working on taking those cells, mixing them together and getting them to grow, with the idea that eventually we will be able to replace that piece of mandible with a living, growing bone that will be incorporated into your body and become part of you."

The main goal is for the military to be able to provide bio-tailored 3D-printed body parts for soldiers and veterans around the world, slashing development and build times and ensuring that the body parts are exactly what the patient needs, down to the cellular level.

A statement from the VHA Innovation Ecosystem confirmed this plan, highlighting the objective of using advanced manufacturing technologies, including 3D printing, injection moulding, vacuum forming and laser machining, to help improve the supply and specialised use of medical devices. The organisation has three U.S. Food and Drug Administration-registered Advanced Manufacturing Hubs at present that are capable of printing products to match the needs of individual veterans.

Marine Corps Lance Corporal Jaden Murry was the recipient of a new lower jaw and 3D printed teeth after having a dangerous tumour removed by surgeons with the Veterans Health Administration. *(Image: © Mass Communication Specialist 3rd Class Jake Greenberg)*

Making aligners digitally, the K and B way using 3D printing

Kristen Benitez, USA

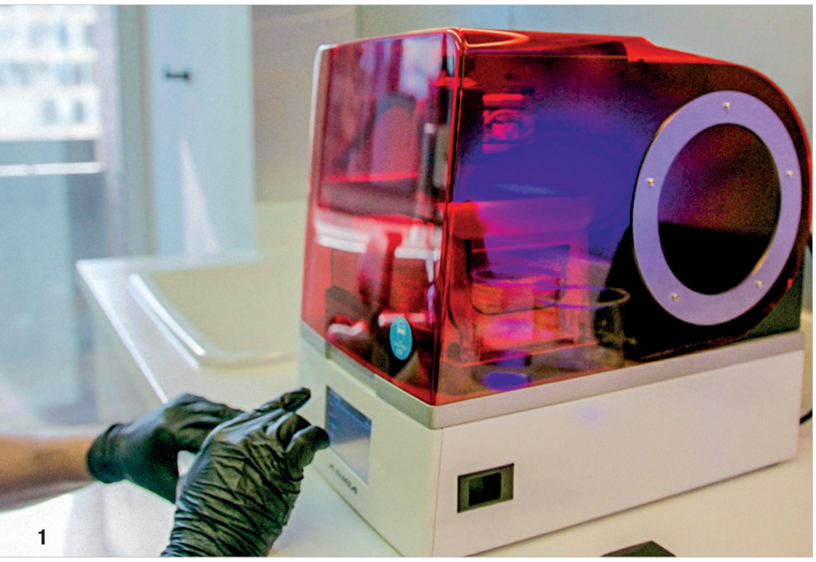


Fig. 1: Asiga MAX UV 3D printer.

K and B Orthodontics is a small orthodontic laboratory located in Norwalk in Connecticut in the US. I co-own the laboratory with my mother, Jane Hyatt, who opened it in December 1997. In December 2017, the dental field was rapidly moving towards a digital approach and the laboratory's analogue techniques were starting to lose ground. Around the same time, I was looking to move into something new, so we decided to work together and transition the laboratory to digital with me as the new digital dental technician. To do that, we would need to identify and invest in software and digital equipment, specifically a 3D printer.

Fig. 2: 3D-printed models in the optiprint model resin in light ivory.

After much research, we narrowed the selection down and saw the software and equipment up close at LMT LAB DAY Chicago in the US prior to making our final decision. We had a clear list of requirements for our purchase. There was little point in investing in equipment purely based on what was the cheapest. If the output was inaccurate, inconsistent or unstable, it would have a direct impact on our day-to-day production, which even in the analogue world is essential to maintain. If our models were not accurate, then our work would not be either, and if the printer was unstable, then we would quickly lose clients. The printer also needed to be capable of producing a certain number of models per day and be priced within our budget. With all these considerations, we chose the Asiga MAX UV (Fig. 1).

Only six months after purchasing our first 3D printer, work started to pick up, so a second printer was needed. There was no hesitation in selecting a second MAX UV. The demand for our digital services continued to grow, and in June 2020, we purchased our third Asiga MAX UV. Our digital growth did not end there. Once dental offices started to open again after the COVID-19 lockdowns, they no longer had time to manufacture Essix retainers inhouse and turned to us for support. We needed more 3D-printing capacity and purchased two of the PRO 4K80 UV, Asiga's larger, higher throughput 3D printer.

For our laboratory, the demand for clear aligners has exploded. Around 98% of our clients have scanners and the rest send us aligner cases via stone models. In order for us to be able to work on stone models, we scan them ourselves using an E1 desktop scanner (3Shape). We take the scan data, base the model and trim it to create a horseshoe model, which saves both time and material when 3D-printing. We then set the models up for tooth movement using the Ortho Analyzer software (3Shape). During the segmentation process, in which the planned tooth movement is entered into the software, it is extremely important that the anatomy of the tooth is as precise as possible. This precision will give me the most accurate reading when I need to consider interproximal contact points, occlusion and the anatomy of the tooth to be moved. The last step that needs to be considered before I can even start moving teeth is each root placement. This will allow for the software to know how each tooth needs to move in relation to its root direction. Straightening of the patient's teeth can then begin.

Much of the knowledge I have gathered over the years regarding aligners has been from hands-on training by our orthodontists. They have taught me what the constraints are per aligner, how to take into account contact points that are too great, when it is appropriate to have spaces to allow for better movement, and when and how you should place attachments.

Whenever I am aligning a patient's teeth, I always aim to overcorrect the problem area. What I have found over the years of working with aligners is that when you think it is perfect the final result will not be that way. Therefore, an overcorrection will help ensure that ideal alignment will be achieved. The first thing I check are the contact points. There is no point in moving teeth if it will poorly affect the patient's bite or if there is no room for the teeth to move. The interproximal contacts should be no greater than 0.5 mm. If the contacts are greater, interproximal reduction (IPR) will typically be done or the mouth will be expanded to reduce pressure from movement, allowing realignment. Virtually, I will go ahead and perform IPR if needed. When performing IPR, the most that should be removed is 0.15 mm per surface, so the most reduction done between two teeth should equate to 0.3 mm in total. You do not want to remove too much, as this will impair the integrity of the tooth. The same careful consideration needs to be given to the opposing teeth as well.

> "Our workflow benefits from printing as many models as possible, as this saves time and costs."

I check the bite using the same feature I use to check the interproximal contact points. It is important to make sure that the movements done do not impact the opposing teeth too much. Personally, when working with the incisors, I do not want too much contact, so the most I allow is 0.1 mm. To avoid too much contact, I retract or intrude the teeth, or talk with the dentist regarding preparation of the teeth accordingly. When working with molars, the contact points are obviously higher. As I have become more comfortable with aligners, I have started moving premolars and molars.

Fig. 3: The MINISTAR S for vacuum forming.

Regarding attachments and when and where to place them, what I have been taught is that if the tooth you are trying to align reaches a value greater than 10 mm, it is best to add an attachment. In most of the cases I have worked on, many issues that I was trying to resolve involved de-rotation. It is important to consider where the attachment needs to be placed based on what is needed. It is important that pressure is applied by the attachment to aid movement in the desired direction.

Once I have realigned the teeth, I then specify the number of aligners required. The amount of movement allowed per aligner is 0.3–0.4 mm. It is at this stage that I send my ClinCheck treatment plan (Invisalign, Align Technology) to the dentist for approval before I can start the production of aligners. Once the treatment has been approved, we set up the 3D-printing process. This starts with loading the final models into the 3D-printing software, which provides automatic placement and positioning. Once all the models are in place, we transfer this data to the PRO 4K80 UV. Our workflow benefits from printing as many models as possible, as this saves time and costs.

Fig. 4: Polishing the aligner edges with a fine Scotch-Brite disc.

Fig. 5: Aligner ready to be sent off.

For the past two years, our laboratory has been using the optiprint model resin in light ivory (dentona) for 3D printing (Fig. 2). We prefer the ivory colour because the detail visibility is greater than with a white resin, for example. This colour is also closer to that of stone models, which are still part of our workflow for some clients. The 3D printing time is reduced by printing the models at a layer thickness of 0.1 mm. This resolution provides a nice balance of detail definition, accuracy and print speed. After all the models have been printed, they are cleaned and processed. We process all parts through a pre-wash and then a post-wash of isopropanol, and once dry we polymerise them in a photopolymerising chamber for 6 minutes per batch.

For all our aligner material, we use Zendura FLX, which is 0.3 gauge. This material is very flexible and truly works wonderfully for moving teeth. All of our clients are happy with the tracking of each case, and patients say that the trays are very comfortable. Zendura makes a specific attachment template that we use when the patient needs attachments placed.

If a patient has undercuts, it is important to block out those areas. We have had many offices ask us what we use to prevent the aligner from breaking when removing it from the model. Compound 101 (Great Lakes Dental Technologies) has worked well. While there are other materials to use, Compound 101 does the trick and does it fast. The putty fits into the undercuts, but comes off

“Always keep an eye on new technologies and pending developments in the dental field.”

the models nicely, leaving them pristine for delivery. I apply the needed block-out prior to vacuum forming. The piece of equipment I use for vacuum forming is the MINISTAR S (SCHEU-DENTAL; Fig. 3). The pressurised vacuum allows for a more accurate fit. Each aligner is cut out using a saw and handpiece. In order to scallop each aligner, I use a composite bur from Komet. Lastly, I use a fine Scotch-Brite disc to polish the aligner edges (Fig. 4). Once all the aligners have been fabricated, polished, and cleaned, it is time for packaging (Fig. 5).

The great thing about being local and having 3D printers that can handle the volume of our work is that we are able to provide a much quicker service than any of our competitor laboratories. Additionally, offices like to use us because we can provide quality work in a quick time frame without the large laboratory fees. This allows for our clients to provide more affordable treatment to their patients.

In summary, the advice I would give to any laboratory trying to build its business is to take your time growing. Do not try to bite off more than you can chew. We made the decision to buy all our equipment slowly and when we could afford it. Always keep an eye on new technologies and pending developments in the dental field. The industry is continuously changing. It is important to know what those changes are and how to stay ahead of them. That also means that you should work with the best-quality equipment and materials. If you take shortcuts, your work will reflect that. Lastly, make sure you love what you do, because at the end of the day, it makes it all worth it.

Editorial note: This article was first published in aligners—international magazine of aligner orthodontics*, Vol. 1, Issue 1/2022.*

contact

Kristen Benitez
K and B Orthodontics
161 East Ave., Ste. 11
Norwalk, CT 06851
USA

www.kandborthodonticlab.com

4D-printed clear aligners found to show promise

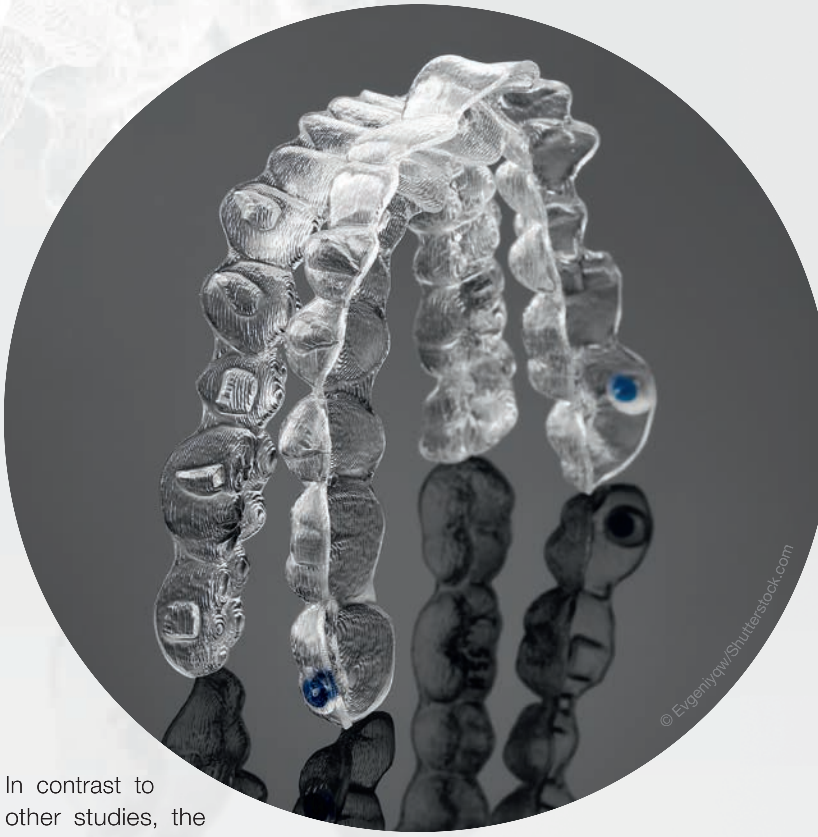
By Jeremy Booth, Dental Tribune International

A study led by researchers at the University Hospital Bonn has found that 4D-printed orthodontic clear aligners can apply biocompatible orthodontic forces in order to move teeth. The technology of 4D printing is based on the 3D printing of shape memory materials. The 4D aligners are clear aligner trays that are 3D-printed using shape memory polymers (SMPs), and the implications of this novel material in clear alig-ner therapy could include reducing the cost of treatment and its burden on the environment. Clear aligner trays are made of various types of polymers and are typically designed to move a tooth within the range of 0.2 to 0.3 mm—or to rotate it by 1 to 3°—before being replaced by successor trays. As the authors of the study point out, this stepwise treatment model requires more time and a higher cost for materials than treatment using fewer trays would. Naturally, for both patients and manufacturers, the use of successive plastic clear aligner trays also carries with it ethical concerns related to the environment.

Various studies have examined applications for SMPs in medical materials, including for orthodontic applications. The researchers, however, sought to add to what they perceived was a lack of data in the literature concerning SMPs and tooth movement by measuring the forces generated by the 4D aligners and thereby their suitability in the treatment of malocclusion.

The researchers, from dental faculties in Germany, Egypt and the UAE, used a biomechanical system in order to use forces to correct the malposition of a maxillary central incisor (tooth 21) in a custom-made typodont model using 4D-printed aligners. The generated forces were measured at different temperatures, and the clear aligner trays were made of ClearX v.1.1 material in the two thicknesses 0.8 mm and 1.0 mm. The forces delivered were quantified using an orthodontic measurement and simulation system (OMSS).

They found that the 4D-printed aligners were capable of achieving significant tooth movement within the range of 2.5 mm ± 0.5 mm, with little variation between the two thicknesses. In the OMSS simulations, it was found that the range of maximum forces delivered varied according to the different temperatures tested (37 °C, 45 °C, 55 °C) but that they were all within the range of acceptable physiological orthodontic forces, as reported by the literature.



In contrast to other studies, the researchers found that using a thicker aligner had no effect on the generated force except at the higher temperature of 55 °C.

The authors highlighted a number of limitations to the study, such as its focus on the isolated movement of a single tooth and not on a complex clinical case and the fact that it did not account for intra-oral conditions and factors such as humidity and salivation. They concluded, however, that the 4D aligner was capable of moving teeth using biocompatible orthodontic forces.

They wrote: "Although orthodontic aligners have been studied in several aspects and great progress was done in orthodontic treatment by aligners, practitioners still report some drawbacks to aligner use." They explained that these drawbacks included the limited movement achieved by single aligner trays, which necessitated changing regimes. They concluded: "Therefore, we believe that if a method could be applied to decrease the number of the aligners per treatment, together with a method to accelerate the biological movement of the teeth, that would be a quantum leap in the field of orthodontics."

The study, titled "Potential application of 4D technology in fabrication of orthodontic aligners", was published online on 28 January 2022 in *Frontiers in Materials*.

Invisible orthodontics market: North American market remains solid, Chinese market grows rapidly

By Rical Lee, China

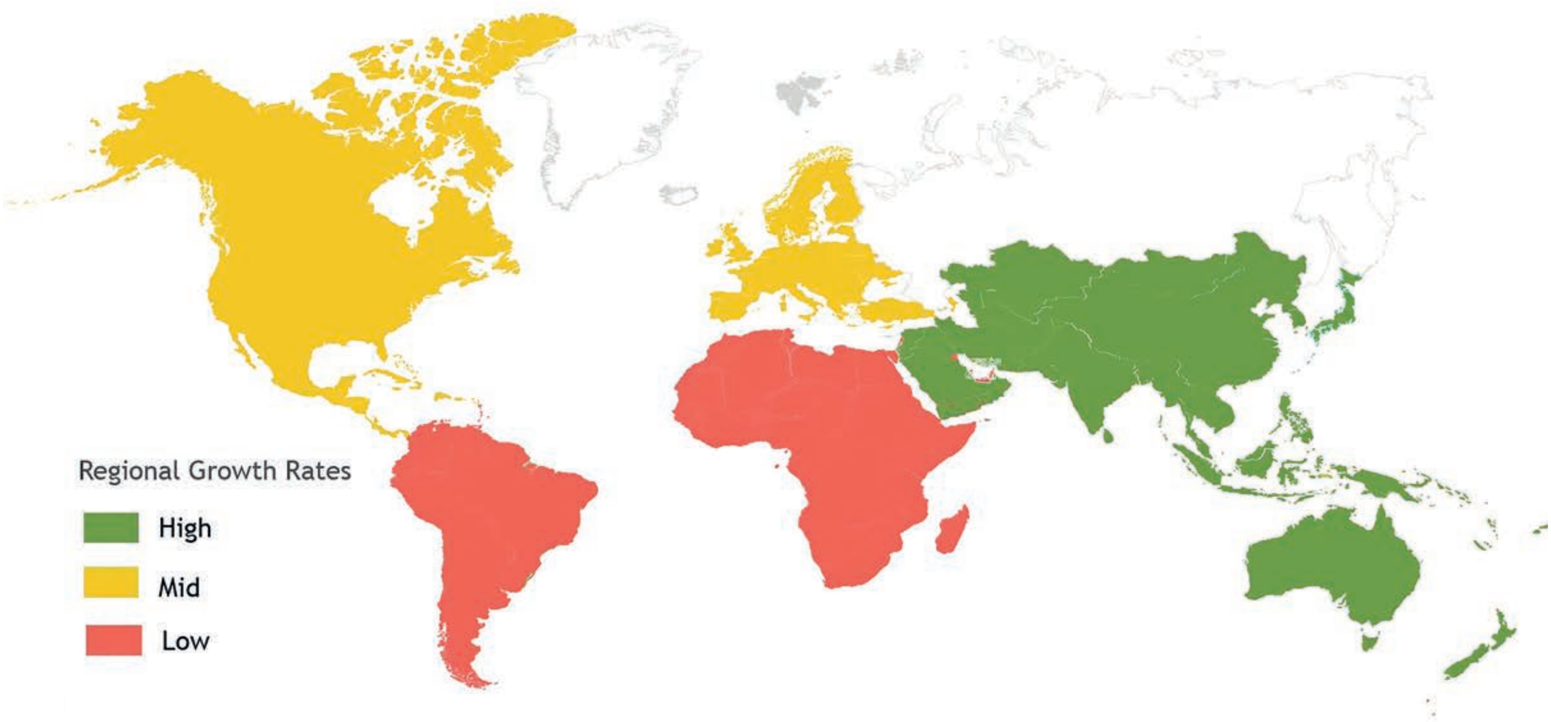
Overview

The global invisible orthodontics market size was valued at US$2.9 billion (€2.7 billion) in 2020. It is expected to reach US$11.6 billion in 2027, growing at a compound annual growth rate (CAGR) of 13% from 2021 to 2027. North America is expected to keep dominating the invisible orthodontics market, and substantial growth is predicted for some developing countries, such as China.

Increasing demand for invisible orthodontics is one of the major trends in dentistry worldwide. Owing to its convenience and flexibility, it is considered a favourable treatment option for patients of all ages compared with conventional orthodontic treatment with fixed metal appliances. Clear aligners, for example, are more comfortable to wear and more aesthetically appealing. Overall, invisible orthodontics has been one of most revolutionary advancements in the industry in the past decades.

Regional insights

North America dominated the market with a share of more than 55.0% in 2021, making it the largest market for invisible orthodontics at present. It is expected to reach US$840 million at a CAGR of more than 12.2% by 2024. A survey conducted by the American Dental Association reported that 85% of individuals in the US value dental health and consider it an essential aspect of overall well-being. The advent of clear aligners has attracted the attention of many patients wanting to improve their smiles, but who would prefer something more aesthetic than fixed metal appliances. Rising awareness of dental hygiene and convenience of orthodontic treatment



Invisible orthodontics market—Growth rate by region *(Source: © Modor Intelligence)*

options are driving the invisible orthodontics market in North America.

The Chinese invisible orthodontics market became the second largest market in the world in 2019 owing to the increasing demand for aesthetic dental treatments with clear aligners in developing economies. The market size increased from US$90 million in 2015 to US$300 million in 2020 and is expected to reach US$10 billion in 2030 at a CAGR of 390%.

Key companies and market share insights

The global market has been characterised by intense competition. One of the key factors driving competitiveness among market players is the rapid adoption of advanced digital technology such as intra-oral scanners, 3D printers and CAD software. At the same time, these players are rapidly opting for strategic expansion and collaboration in order to expand their geographical presence and sales volume.

In 1998, Align Technology's Invisalign clear aligner system was approved by the U.S. Food and Drug Administration and became the pioneer of invisible correction technology. In 2001, Align's successful initial public offering ushered in rapid development. By 2011, Invisalign had become the most important system in the global invisible orthodontics market.

In August 2017, Straumann officially entered the field of digital orthodontics. The company wholly acquired ClearCorrect, the world's second largest invisible orthodontics brand, invested in a 38% stake in Spanish invisible orthodontics brand Geniova Technologies and increased its stake in dental digital solutions provider Dental Wings to full ownership.

In the early 2000s, invisible orthodontics technology was introduced into China. After 20 years of development, the invisible orthodontics market in China includes Angelalign Technology, Align Technology and Shanghai Smartee Dental Technology. According to data from China Insights Consultancy, Angelalign and Align occupied 41.0% and 41.4%, respectively, of the market share in China in 2021, having obvious advantages over other brands.

In Wuxi in the Jiangsu province in China, Angelalign has built the largest dental 3D-printing base in the country and deployed fourth-generation 3D printers which are among the most advanced in dental applications, according to a China Insights Consultancy report.

With custom built-in parameters, Angelalign's 3D printer can meet the needs of mass production, and the production speed is 25–50% faster than the industry average. Compared with Invisalign, Angelalign has a price advantage. The completion of the Wuxi base will continue to increase its production capacity and is expected to further expand its market share.

Angelalign supplier Prismlab was founded in 2005 in Shanghai in China. Specialising in the research and development, manufacture, sales and service of 3D printers, the company is a high-tech enterprise that provides a complete set of invisible orthodontics solutions. Its sales volume has been growing steadily during the COVID-19 pandemic, attracting investment by global industrial giant BASF.

Summary

North America and China are the top two invisible orthodontics markets in the world. While advancements in and rapid adoption of dental technologies, including 3D printing, drive market growth in North America, China is still developing and has a huge population. Both have amazing market potential. The Chinese market is expected to surpass that of European and American countries in the near future. However, its medical resources are lacking compared with North America.

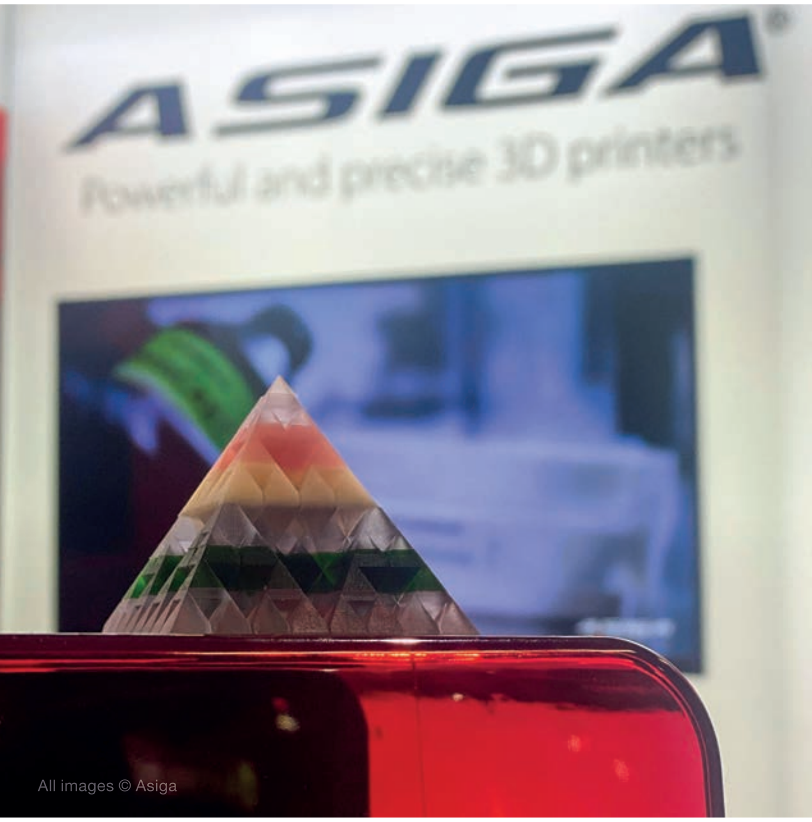
Overall, income level and awareness of oral hygiene and the acceptance of invisible orthodontics among Chinese people have gradually increased over the past decades. In addition, the pursuit of beauty and the development of digital invisible orthodontics are expected to boost the penetration rate of invisible orthodontics and to further intensify market competition in the future.

about

Rical Lee graduated from the Binzhou University in the Shandong province in China in 2014. He has a special interest in the 3D-printing industry and is engaged in market-related research.

Multi-range, multi-material printing: A unique technology found only in Asiga 3D printers

Minh Tran, Canada



All images © Asiga

As the demand for versatile direct printing applications is increasing, 3D printer manufacturers will need to find ways to differentiate themselves from the ever-increasing ubiquity of 3D-printing platforms and convergent technologies that are leading to little variation in companies in the field. In dentistry, additive technologies cover a wide range of indications across nearly every discipline and niche found within the profession. For these and various other reasons, dependence on additive manufacturing processes such as 3D printing will only continue to rise.

Many companies in the 3D-printing and dental realms focus on user experience, simplicity and a highly limited selection of resins to help streamline their processes and workflows. This is desirable in certain scenarios, such as in small clinics and for limited chairside use. However, it is not ideal for the majority of dental applications. The constant pace of innovation and the introduction of new resins could quickly make a closed system of choice obsolete.

When approaching resin compatibility, it is important to find a company that not only subscribes to a truly open philosophy but also has managed to dial in nearly every advanced setting down to a granular level. In today's ever-changing resin landscape, it is critical to find a platform that is nearly guaranteed to work with any resin released on the market. That is one of the reasons that my 3D printer brand of choice is Asiga.

Asiga, which is based in Sydney in Australia, has been in the 3D-printing industry since 2011. The company has produced numerous award-winning printers and pioneered many innovations that have changed digital manufacturing. In dentistry, Asiga is known for its high quality, reliability and repeatability. The company boasts a library of over 500 validated resins from all of the world's leading material manufacturers, something that helps to future-proof their users' investments in an open material system.

Nearly all leading dental resin manufacturers will first validate their resins on Asiga printers before validating or testing their resins on any other printer. I have spoken with many engineers, chemists and other team members who develop resins, and their preferred printing platform for testing and validating their resins is always Asiga. This speaks to the engineering and accuracy of the company and positions it as a market leader.

Despite its considerable success, the company does not cease to innovate to improve the performance of its hardware and software. At LMT LAB DAY Chicago in the US in February, I had the great pleasure of presenting one of these innovations: multi-material printing using Asiga's multi-range capabilities. Asiga's highly advanced Composer software offers an unmatched level of control and allows the user to dial in, adjust and perfect nearly every setting. This granular level of control allows the end user considerable creative freedom when working with resins. Additionally, multi-range printing adds an extra layer of

complexity and depth for the user to explore. Both multi-range and multi-material printing are only possible in Asiga printers.

What is multi-range printing?

A range is defined as a set of values in a data set. In 3D printing, a range refers to the starting and end point of a build. Essentially, every 3D-printing build is a ranged print. For example, a single-range, single-material print employs a material such as Asiga DentaMODEL and has only a single range, defined from 0 to 100% of the build volume. Conversely, a single-material, multi-range print could also employ Asiga DentaMODEL, but have 100 µm layers from 0 to 60% of the build and the remaining 40% could be printed in 50 µm layers. This feature was first implemented in Asiga's PRO 4K to overcome speed challenges.

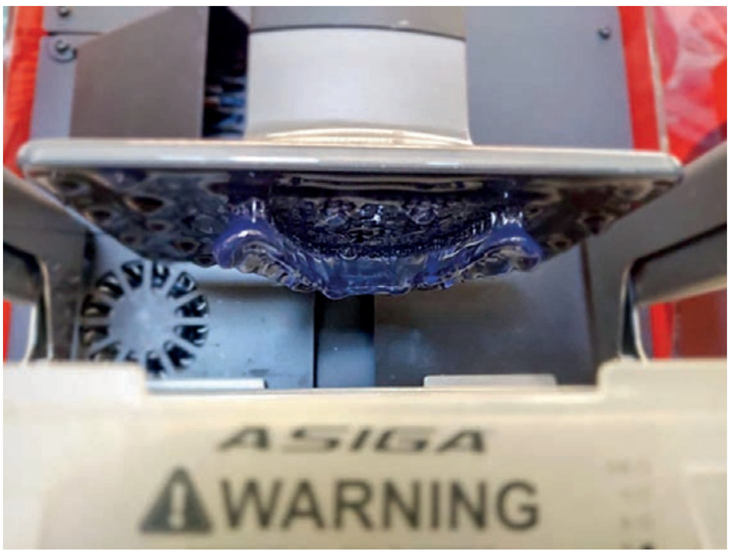
Most printing jobs of dental models consist primarily of low-detail areas that can be quickly printed in 100 µm layers, such as the base of a model. The highest margin quality and detail are found in the remaining top portion of the dental model and should be printed much slower and in more detailed 50 µm layers. Users quickly adapted this innovation and found new and creative ways to implement multi-range printing. Multi-material printing was the next logical step.

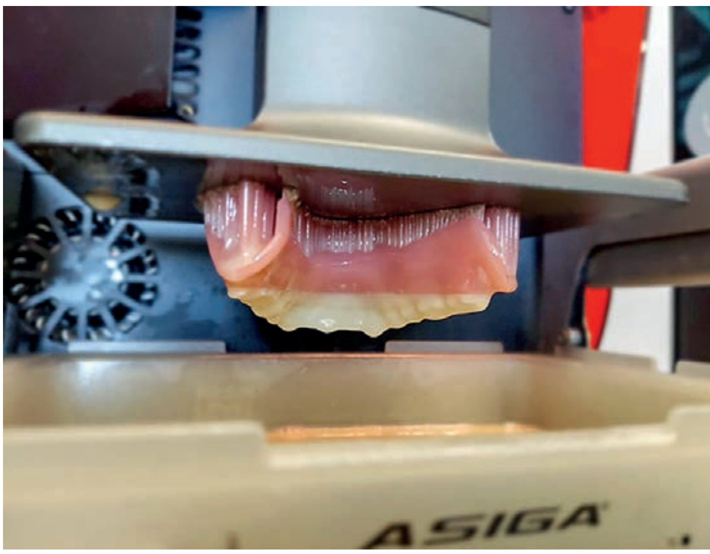
Instead of changing layer thickness from one range to another, multi-material printing switches the entire range's exposure, lift and speed to match a completely different material configuration file. After loading a new material configuration INI file on the fly and defining a separate range, the user can create multi-material prints of a single object.

The uses and benefits of this innovation are immediately obvious and include complete dentures that do not rely on bonding teeth to denture base sockets, dual hard and soft splints that offer patient comfort and increased wear resistance, and multi-material presentation and demonstration models for patient education or the showcasing of work. The options are limitless. As new and exciting resins are constantly entering the market, it is crucial to select a printer brand with an open material system that guarantees compatibility and offers an open system that actively pairs these multi-materials in an innovative way.

about

Minh Tran is the founder and creative director of DentalTechTips, an online independent publication and blog that provides unbiased product reviews, offers tips, tricks and tutorials, and covers the latest and greatest in the dental laboratory industry. He is a second-generation dental technician from Windsor in Ontario in Canada and has been working in the dental industry since 2006.





3D printing in dentistry: Developing the market

By Dr George Freedman, Canada

3D printing is the leading technology in the dental market today. It is a game-changer. It represents an identifiable threat to some currently established technologies and techniques, yet is creating enormous new opportunities for the profession and its supporting industries.

The digital transformation of dentistry has been expanding dramatically for more than a decade. Tools that were only recently revolutionary and impossibly expensive, such as CBCT, intra-oral and extra-oral scanning, and robotic implant placement, are now mainstream and relatively affordable. Materials science has kept pace with these developments, offering the highest quality restorative, provisional and laboratory products that can be milled and now printed. Even beyond the scope of laboratories offering numerous wide-ranging printing services, the most recent desktop printers have a much smaller footprint (encouraging chairside deployment), are readily affordable for the single practitioner, communicate with most or all existing software platforms, and offer high levels of precision with a comprehensive range of restorative materials. The most significant practice enhancement is that 3D printing promises to bring the functional and artistic control of the restorative process into the clinical chairside setting.

3D printing is a new field. It is evolving rapidly and growing exponentially. The key requirement is to keep the entire dental industry—professional, manufacturing and distribution—throughout the world on the fast track by sharing knowledge and innovations, overcoming obstacles, comparing outcomes and encouraging ongoing progress. The best mechanism for achieving this is to publicise all the most recent developments in an accessible forum.

The 3D printing magazine introduces the "3D-printing buyer's guide", the go-to platform through which interested clinicians, researchers and manufacturers can interact rapidly and openly to exchange and evaluate new ideas, technologies and techniques. The main role of the platform is to encourage and support communication and discussion. In order to establish a truly open-source environment, researchers are encouraged to submit updates on their current efforts, at both the theoretical and the pragmatic levels. Manufacturers are requested to post current information on their latest innovative products. Dental clinicians are invited to contribute their experiences and data that will guide both researchers and manufacturers in fine-tuning the printing process.

Industry-wide, there has been a growing acceptance of this transformative technology that contributes to managing the great demand for temporary, transitional and definitive restorations and appliances, all the while achieving the clinical excellence required by the dental profession. There are many 3D-printing applications in dentistry, and these will continue to expand.

For the clinical dentist, the world of 3D printing is a marvellous addition to existing clinical options. It promises to transform the practice and delivery of dentistry within the next few years. However, it is new, unfamiliar and uncharted territory. The "3D-printing buyer's guide" offers a platform where multi-sourced communication and feedback are enabled and encouraged.

The 3D-printing revolution will generate an increased demand for temporary, transitional and definitive restorations and appliances and will provide the tools and materials to manage these needs effectively. It will decrease delivery costs for these enhanced services, increasing patient accessibility and improving dental practice profitability. The "3D-printing buyer's guide" starting on the following pages, will inform, educate and speed general practitioner acceptance worldwide.

about

Dr George Freedman is adjunct professor of dental medicine at Western University of Health Sciences in Pomona in California in the US and a visiting professor and director of the MClinDent programme in restorative and cosmetic dentistry at BPP University in London in the UK. He is the author or co-author of 14 textbooks and of more than 900 dental articles and has presented numerous webinars. He serves on the editorial team of *REALITY* and is the editor-in-chief of *3D printing*.

MEDIFIVE

Masterpiece of 3D Printingwasher

Twin Tornado

Torando

Twin 3D Clenaer
Non flammable Cleanser

Twin Cure
Post Curing Unit

Dental Model & Castable
3D PrintingReins

www.medifive.com scho@medifive.com Made in Korea

3D printers

	3D Systems: NextDent 5100	Asiga: MAX UV	Asiga: PRO 4K80 UV
DEVICE/PRINTER DIMENSIONS in cm	42.6 cm (W) × 48.9 cm (D) × 97.1 cm (H)	26 cm (W) × 38.5 cm (D) × 37 cm (H)	46.5 cm (W) × 54 cm (D) × 134.5 cm (H)
SIZE OF BUILD PLATE in cm	12.48 cm (W) × 7.02 cm (D) × 19.6 cm (H)	11.9 cm (W) × 6.7 cm (D) × 7.6 cm (H)	21.7 cm (W) × 12.2 cm (D) × 20 cm (H)
TECHNOLOGY/PRINTING TECHNIQUE	○ SLA ○ LFS ○ PolyJet ◉ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	◉ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	◉ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD
ACCURACY/MAXIMUM RESOLUTION (µm)	65 µm	62 µm	56 µm
DENTAL APPLICATION **(which context or speciality field would benefit from this printer)**	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ○ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ○ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)
PRINTING INDICATIONS **Laboratory**	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns
Restorative dentistry	◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models	◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models	◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models
Orthodontics	◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays	◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ◉ Directly printed orthodontic aligners ◉ Indirect bonding trays	◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ◉ Directly printed orthodontic aligners ◉ Indirect bonding trays
Implantology	◉ Implant surgical guides	◉ Implant surgical guides	◉ Implant surgical guides
Endodontics	◉ Endodontic surgical guides	◉ Endodontic surgical guides	◉ Endodontic surgical guides
Dentures	◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims	◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims	◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims
Other indications	○ Maxillofacial models ◉ Other .... Try-in devices, splints	◉ Maxillofacial models ○ Other	◉ Maxillofacial models ○ Other
MATERIALS	○ Compatible with 3rd party resins ○ Compatible with manufacturer's materials ◉ Compatible with manufacturer's materials and some selected 3rd party resins	◉ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ◉ Compatible with manufacturer's materials and some selected 3rd party resins	◉ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ◉ Compatible with manufacturer's materials and some selected 3rd party resins
PRINTING MATERIAL/S	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ◉ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ◉ Ceramic ○ Metal ○ Powder ○ Other
PRINTING CAPACITY (units/printing cycle)	Models: .... 2 (full arch)/6 (quadrant) Orthodontic models (horizontal): .... 6 Orthodontic models (vertical): .... 30 Surgical guides: .... 6 Permanent restorations: .... 50 (crowns) Dentures: 4	Models: .... 3 Orthodontic models (horizontal): .... 3 Orthodontic models (vertical): .... 8 Surgical guides: .... 6 Permanent restorations: .... 12 Dentures: 8	Models: .... 11 Orthodontic models (horizontal): .... 11 Orthodontic models (vertical): .... 26 Surgical guides: .... 12 Permanent restorations: .... 32 Dentures: 18
PRINTING SPEED (mm/h or ml/h or g/h)	Models: .... 50 mm/h Single arch model at 100 microns (directly on build platform): .... n.a. Orthodontic single arch model at 50 microns (vertical): .... 96 mm/h Two articulated quadrant restorative model at 100 microns: .... n.a. Surgical guide at 50 microns: .... 60 mm/h	Models: .... 60 mm/h Single arch model at 100 microns (directly on build platform): .... 60 mm/h Orthodontic single arch model at 100 microns (vertical): .... 60 mm/h Two articulated quadrant restorative model at 100 microns: .... 60 mm/h Surgical guide at 100 microns: .... 60 mm/h	Models: .... 60 mm/h Single arch model at 100 microns (directly on build platform): .... 60 mm/h Orthodontic single arch model at 100 microns (vertical): .... 60 mm/h Two articulated quadrant restorative model at 100 microns: .... 60 mm/h Surgical guide at 100 microns: .... 60 mm/h
POST-POLYMERISATION PROCESS **Necessary?**	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
FILE TYPE/SOFTWARE **What kinds of files are accepted?**	◉ STL ◉ OBJ ◉ Other	◉ STL ○ OBJ ◉ Other .... (PLY, SLC, STM)	◉ STL ○ OBJ ◉ Other .... (PLY, SLC, STM)
USER SERVICE and SUPPORT	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None
USER SERVICE and SUPPORT (fees)	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee
PRINTING NESTING SOFTWARE	○ Paid ◉ Free	○ Paid ◉ Free	○ Paid ◉ Free
REMOTE PRINTING	○ Yes ◉ No	◉ Yes ○ No	◉ Yes ○ No
AUTOMATIC DISPENSE OF RESIN	○ Yes ◉ No	○ Yes ◉ No	○ Yes ◉ No
CONNECTION WITH PRINTER	○ Wi-Fi ◉ Ethernet ○ Both ◉ Other .... USB	○ Wi-Fi ○ Ethernet ◉ Both ◉ Other .... Wireless Direct	○ Wi-Fi ○ Ethernet ◉ Both ◉ Other .... Wireless Direct
WARRANTY (years)	12 months, extended warranty options available	1 year (Unlimited lifetime technical support)	1 year (Unlimited lifetime technical support)
PRICE RANGE	€10,999	€10,150	€23,300

The market overview does not claim to be complete. Status: May 2022.

 **Formlabs: Form 3B+**	 **Formlabs: Form 3BL**	 **Prismlab: Rapid-400**	 **Prismlab: Rapid-600**
40.5 cm (W) × 37.5 cm (D) × 53 cm (H)	77 cm (W) × 52 cm (D) × 74 cm (H)	840 cm (W) × 840 cm (D) × 1,750 cm (H)	930 cm (W) × 805 cm (D) × 2,300 cm (H)
14.5 cm (W) × 14.5 cm (D) × 18.5 cm (H)	33.5 cm (W) × 20 cm (D) × 30 cm (H)	384 cm (W) × 216 cm (D) × 340 cm (H)	576 cm (W) × 324 cm (D) × 100 cm (H)
◉ SLA ◉ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	◉ SLA ◉ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	◉ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	◉ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD
25 µm	25 µm	25 µm	38 µm
◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ○ Endodontics ○ Bone replacement ○ Dentures (complete and/or partial) ◉ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ◉ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ◉ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)
◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ◉ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ◉ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ○ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ◉ Endodontic surgical guides ○ Definitive complete dentures ○ Definitive partial dentures ○ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ◉ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ○ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ○ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ○ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ○ Other
○ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ◉ Compatible with manufacturer's materials and some selected 3rd party resins	○ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	○ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	○ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins
◉ Resin ◉ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other
Models: ... 8 Orthodontic models (horizontal): ... 8 Orthodontic models (vertical): ... 18 Surgical guides: ... 9 Permanent restorations: ... 90 Dentures: ... 8	Models: ... 24 Orthodontic models (horizontal): ... 24 Orthodontic models (vertical): ... 52 Surgical guides: ... 32 Permanent restorations: ... n.a. Dentures: ... n.a.	Models: ... 30 Orthodontic models (horizontal): ... 30 Orthodontic models (vertical): ... n.a. Surgical guides: ... 65 Permanent restorations: ... n.a. Dentures: ... 60	Models: ... 45 Orthodontic models (horizontal): ... 30 Orthodontic models (vertical): ... n.a. Surgical guides: ... 65 Permanent restorations: ... n.a. Dentures: ... 80
Models: ... 11.8 ml/h Single arch model at 100 microns (directly on build platform): ... 11.8 ml/h Orthodontic single arch model at 100 microns (vertical): ... 8.04 ml/h Two articulated quadrant restorative model at 100 microns: ... 19.6 ml/h Surgical guide at 100 microns: ... 4.6 ml/h	Models: ... 11.8 ml/h Single arch model at 100 microns (directly on build platform): ... 11.8 ml/h Orthodontic single arch model at 100 microns (vertical): ... 7.3 ml/h Two articulated quadrant restorative model at 100 microns: ... 18.7 ml/h Surgical guide at 100 microns: ... 7.3 ml/h	Models: ... up to 1,000 g/h Single arch model at 100 microns (directly on build platform): ... n.a. Orthodontic single arch model at 100 microns (vertical): ... n.a. Two articulated quadrant restorative model at 100 microns: ... n.a. Surgical guide at 100 microns: ... n.a.	Models: ... up to 1,500 g/h Single arch model at 100 microns (directly on build platform): ... n.a. Orthodontic single arch model at 100 microns (vertical): ... n.a. Two articulated quadrant restorative model at 100 microns: ... n.a. Surgical guide at 100 microns: ... n.a.
◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
◉ STL ◉ OBJ ○ Other	◉ STL ◉ OBJ ○ Other	◉ STL ◉ OBJ ○ Other	◉ STL ◉ OBJ ○ Other
◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None
◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee
○ Paid ◉ Free	○ Paid ◉ Free	○ Paid ◉ Free	○ Paid ◉ Free
◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
○ Wi-Fi ○ Ethernet ◉ Both ◉ Other	○ Wi-Fi ○ Ethernet ◉ Both ◉ Other ... USB 2.0	○ Wi-Fi ○ Ethernet ◉ Both ○ Other	○ Wi-Fi ○ Ethernet ◉ Both ○ Other
1–3 years	1–3 years	2 years	2 years
€4,034–5,899	€12,999	€42,900	€71,500

The market overview does not claim to be complete. Status: May 2022.

3D printers

	 Rapid Shape: D20+	 Rapid Shape: D30+	 Rapid Shape: D50+
DEVICE/PRINTER DIMENSIONS in cm	33.5 cm (W) × 34.9 cm (D) × 54.1 cm (H)	48 cm (W) × 41 cm (D) × 69 cm (H)	60 cm (W) × 57 cm (D) × 166 cm (H)
SIZE OF BUILD PLATE in cm	13.3 cm (W) × 7.5 cm (D) × 11.5 cm (H)	13.3 cm (W) × 7.5 cm (D) × 15.5 cm (H)	23.1 cm (W) × 13 cm (D) × 30 cm (H)
TECHNOLOGY/PRINTING TECHNIQUE	○ SLA ○ LFS ○ PolyJet ● DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	○ SLA ○ LFS ○ PolyJet ● DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	○ SLA ○ LFS ○ PolyJet ● DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD
ACCURACY/MAXIMUM RESOLUTION (µm)	34 µm	34 µm	30 µm
DENTAL APPLICATION (which context or speciality field would benefit from this printer)	● Dental laboratory ● Restorative dentistry ● Orthodontics ● Implantology and maxillofacial surgery ● Endodontics ○ Bone replacement ● Dentures (complete and/or partial) ● Education (preclinical training models)	● Dental laboratory ● Restorative dentistry ● Orthodontics ● Implantology and maxillofacial surgery ● Endodontics ○ Bone replacement ● Dentures (complete and/or partial) ● Education (preclinical training models)	● Dental laboratory ● Restorative dentistry ● Orthodontics ● Implantology and maxillofacial surgery ● Endodontics ○ Bone replacement ● Dentures (complete and/or partial) ● Education (preclinical training models)
PRINTING INDICATIONS **Laboratory**	● Custom trays ● Study models ● Diagnostic wax-up models ● Models for finishing crowns and bridges ● Castable wax patterns	● Custom trays ● Study models ● Diagnostic wax-up models ● Models for finishing crowns and bridges ● Castable wax patterns	● Custom trays ● Study models ● Diagnostic wax-up models ● Models for finishing crowns and bridges ● Castable wax patterns
Restorative dentistry	● Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ● Permanent (crowns, inlays, onlays, veneers and/or bridges) ● Diagnostic wax-up models	● Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ● Permanent (crowns, inlays, onlays, veneers and/or bridges) ● Diagnostic wax-up models	● Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ● Permanent (crowns, inlays, onlays, veneers and/or bridges) ● Diagnostic wax-up models
Orthodontics	● Occlusal guards ● Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ● Indirect bonding trays	● Occlusal guards ● Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ● Indirect bonding trays	● Occlusal guards ● Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ● Indirect bonding trays
Implantology	● Implant surgical guides	● Implant surgical guides	● Implant surgical guides
Endodontics	● Endodontic surgical guides	● Endodontic surgical guides	● Endodontic surgical guides
Dentures	● Definitive complete dentures ● Definitive partial dentures ● Wax try-in of dentures, base plates and wax rims	● Definitive complete dentures ● Definitive partial dentures ● Wax try-in of dentures, base plates and wax rims	● Definitive complete dentures ● Definitive partial dentures ● Wax try-in of dentures, base plates and wax rims
Other indications	● Maxillofacial models ○ Other	● Maxillofacial models ○ Other	● Maxillofacial models ○ Other
MATERIALS	● Compatible with 3rd party resins ● Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	● Compatible with 3rd party resins ● Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	● Compatible with 3rd party resins ● Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins
PRINTING MATERIAL/S	● Resin ● Ceramic ○ Metal ○ Powder ○ Other	● Resin ● Ceramic ○ Metal ○ Powder ○ Other	● Resin ● Ceramic ○ Metal ○ Powder ○ Other
PRINTING CAPACITY (units/printing cycle)	Models: 3 Orthodontic models (horizontal): 3 Orthodontic models (vertical): 8 Surgical guides: 2 Permanent restorations: 20+ Dentures: 3	Models: 3 Orthodontic models (horizontal): 3 Orthodontic models (vertical): 8 Surgical guides: 2 Permanent restorations: 20+ Dentures: 3	Models: 14 Orthodontic models (horizontal): 14 Orthodontic models (vertical): 30 Surgical guides: 6 Permanent restorations: > 100 Dentures: 14
PRINTING SPEED (mm/h or ml/h or g/h)	Models: up to 80 mm/h Single arch model at 100 microns (directly on build platform): up to 80 mm/h Orthodontic single arch model at 100 microns (vertical): up to 80 mm/h Two articulated quadrant restorative model at 100 microns: up to 80 mm/h Surgical guide at 100 microns: up to 80 mm/h	Models: up to 80 mm/h Single arch model at 100 microns (directly on build platform): up to 80 mm/h Orthodontic single arch model at 100 microns (vertical): up to 80 mm/h Two articulated quadrant restorative model at 100 microns: up to 80 mm/h Surgical guide at 100 microns: up to 80 mm/h	Models: up to 80 mm/h Single arch model at 100 microns (directly on build platform): up to 80 mm/h Orthodontic single arch model at 100 microns (vertical): up to 80 mm/h Two articulated quadrant restorative model at 100 microns: up to 80 mm/h Surgical guide at 100 microns: up to 80 mm/h
POST-POLYMERISATION PROCESS Necessary?	● Yes with RS wash & RS cure ○ No	● Yes with RS wash & RS cure ○ No	● Yes with RS wash & RS cure ○ No
FILE TYPE/SOFTWARE What kinds of files are accepted?	● STL ● OBJ ● Other	● STL ● OBJ ● Other	● STL ● OBJ ● Other
USER SERVICE and SUPPORT	● Live ● Online ○ None	● Live ● Online ○ None	● Live ● Online ○ None
USER SERVICE and SUPPORT (fees)	● Included with purchase ○ At additional fee	● Included with purchase ○ At additional fee	● Included with purchase ○ At additional fee
PRINTING NESTING SOFTWARE	○ Paid ● Free	○ Paid ● Free	○ Paid ● Free
REMOTE PRINTING	● Yes ○ No	● Yes ○ No	● Yes ○ No
AUTOMATIC DISPENSE OF RESIN	○ Yes ● No	○ Yes ● No	● Yes ○ No
CONNECTION WITH PRINTER	○ Wi-Fi ○ Ethernet ● Both ● Other: USB	○ Wi-Fi ○ Ethernet ● Both ● Other: USB	○ Wi-Fi ○ Ethernet ● Both ● Other: USB
WARRANTY (years)	1–3 years	1–3 years	1–3 years
PRICE RANGE	Approx. €10,000	Price on request	Price on request

The market overview does not claim to be complete. Status: May 2022.


Rapid Shape: D100+	Shining 3D: AccuFab-D1s	Shining 3D: AccuFab-L4D	VOCO: SolFlex 170HD
65 cm (W) × 108.0 cm (D) × 161.5 cm (H)	39.4 cm (W) × 40.6 cm (D) × 75.5 cm (H)	36 cm (W) × 36 cm (D) × 53 cm (H)	29.6 cm (W) × 31.8 cm (D) × 46.8 cm (H)
33.8 cm (W) × 19 cm (D) × 8 cm (H)	14.4 cm (W) × 8.1 cm (D) × 16 cm (H)	19.2 cm (W) × 12 cm (D) × 18 cm (H)	6.8 cm (W) × 12.1 cm (D) × 18.0 cm (H)
○ SLA ○ LFS ○ PolyJet ◉ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD	○ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ◉ LCD	○ SLA ○ LFS ○ PolyJet ○ DLP/DLS ○ SLS ○ DMLS ○ FDM ◉ LCD	○ SLA ○ LFS ○ PolyJet ◉ DLP/DLS ○ SLS ○ DMLS ○ FDM ○ LCD
44 µm	35 µm	50 µm	63 µm
◉ Dental laboratory ○ Restorative dentistry ◉ Orthodontics ○ Implantology and maxillofacial surgery ○ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ○ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ○ Education (preclinical training models)	◉ Dental laboratory ◉ Restorative dentistry ◉ Orthodontics ◉ Implantology and maxillofacial surgery ◉ Endodontics ○ Bone replacement ◉ Dentures (complete and/or partial) ◉ Education (preclinical training models)
◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ○ Implant surgical guides ○ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ◉ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ○ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ◉ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ○ Maxillofacial models ○ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ○ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ○ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ◉ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ○ Maxillofacial models ○ Other	◉ Custom trays ◉ Study models ◉ Diagnostic wax-up models ◉ Models for finishing crowns and bridges ◉ Castable wax patterns ◉ Temporary prefabricated restorations (crowns, inlays, onlays, veneers and/or bridges) ◉ Permanent (crowns, inlays, onlays, veneers and/or bridges) ◉ Diagnostic wax-up models ◉ Occlusal guards ◉ Models for fabricating orthodontic aligners and retainers ◉ Directly printed orthodontic aligners ◉ Indirect bonding trays ◉ Implant surgical guides ◉ Endodontic surgical guides ◉ Definitive complete dentures ◉ Definitive partial dentures ◉ Wax try-in of dentures, base plates and wax rims ◉ Maxillofacial models ○ Other
◉ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ◉ Compatible with manufacturer's materials and some selected 3rd party resins	◉ Compatible with 3rd party resins ○ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	◉ Compatible with 3rd party resins ○ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins	○ Compatible with 3rd party resins ◉ Compatible with manufacturer's materials ○ Compatible with manufacturer's materials and some selected 3rd party resins
◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other	◉ Resin ○ Ceramic ○ Metal ○ Powder ○ Other
Models: 24 Orthodontic models (horizontal): 24 Orthodontic models (vertical): 52 Surgical guides: n.a. Permanent restorations: > 200 Dentures: 24	Models: 2 Orthodontic models (horizontal): 3 Orthodontic models (vertical): 10 Surgical guides: 2 Permanent restorations: 10 Dentures: 6	Models: 5 Orthodontic models (horizontal): 7 Orthodontic models (vertical): 16 Surgical guides: 4 Permanent restorations: 18 Dentures: 10	Models: 3–6 Orthodontic models (horizontal): 3–6 Orthodontic models (vertical): 4 Surgical guides: 6–12 Permanent restorations: Depends on size Dentures: 2
Models: up to 100 mm/h Single arch model at 100 microns (directly on build platform): up to 100 mm/h Orthodontic single arch model at 100 microns (vertical): up to 100 mm/h Two articulated quadrant restorative model at 100 microns: up to 100 mm/h Surgical guide at 100 microns: n.a.	Models: 60 mm/h Single arch model at 100 microns (directly on build platform): 60 mm/h Orthodontic single arch model at 100 microns (vertical): 60 mm/h Two articulated quadrant restorative model at 100 microns: 60 mm/h Surgical guide at 100 microns: 60 mm/h	Models: 35 mm/h Single arch model at 100 microns (directly on build platform): 35 mm/h Orthodontic single arch model at 100 microns (vertical): 35 mm/h Two articulated quadrant restorative model at 100 microns: 35 mm/h Surgical guide at 100 microns: 35 mm/h	Models: 120 mm/h (depending on material) Single arch model at 100 microns (directly on build platform): n.a. Orthodontic single arch model at 100 microns (vertical): n.a. Two articulated quadrant restorative model at 100 microns: n.a. Surgical guide at 100 microns: n.a.
◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
◉ STL ◉ OBJ ◉ Other	◉ STL ◉ OBJ ○ Other	◉ STL ◉ OBJ ○ Other	◉ STL ○ OBJ ○ Other
◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None	◉ Live ◉ Online ○ None
◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee	◉ Included with purchase ○ At additional fee
○ Paid ◉ Free	○ Paid ◉ Free	○ Paid ◉ Free	○ Paid ◉ Free
◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No	◉ Yes ○ No
◉ Yes ○ No	○ Yes ◉ No	○ Yes ◉ No	○ Yes ◉ No
○ Wi-Fi ○ Ethernet ◉ Both ◉ Other: USB	○ Wi-Fi ○ Ethernet ◉ Both ○ Other	○ Wi-Fi ○ Ethernet ◉ Both ○ Other	○ Wi-Fi ○ Ethernet ◉ Both ◉ Other: USB
1–5 years	1 year	1 year	1 year
Price on request	Price on request	Price on request	Price on request

The market overview does not claim to be complete. Status: May 2022.

Digital dentistry

It is all about improving patient care and efficiency

For Michael Nguyen and his brother Tony, dentistry was an important part of life already early on. Michael had the opportunity to work part-time at a laboratory while attending high school. After graduating, it was the logical choice to pursue a diploma of dental technology at what is now TAFE Queensland in Australia. In 2007, after completing his studies, Michael started to work full-time in the family business. In 2018, he gathered all his courage and savings and invested in his own laboratory, Everdent, supported by his wife and his mother. The first several years proved challenging but rewarding. Upon graduating in 2020 as a certified prosthetist, he expanded the laboratory with a clinical space. It became a true family business when Tony rejoined the team in early 2021.

Going digital had always been a long-term strategic goal for Michael, and his journey started in 2015. While looking for a digital dental workflow, he could not find a solution that made sense. The design software was complicated, scanners were very expensive, and the available 3D printers were either marketed as hobby printers or very costly. However, as the years progressed, Michael noticed that the digital dental workflow had become more practical and affordable. In 2020, digital dentistry clearly had matured to the extent of feasible application in a professional setting.

Things progressed rapidly when Michael was introduced to CAD/CAM specialist Matthew Searle of Henry Schein Australia. Owing to the COVID-19 pandemic, general training at the Henry Schein training centre in Brisbane was not available, so Matthew travelled to Everdent for a personal demonstration instead. Impressed with how practical and proven the digital workflow had become, Michael moved forward in making the transition from an analogue to a digital workflow. For Everdent, Henry Schein proved to be a reliable partner, having the ability to deliver, install and provide on-site support for the complete workflow.

Initially, Michael was overwhelmed with the choice of 3D printers and materials, but for him as a prosthetist, 3D Systems' NextDent

© All images: NextDent

5100 came out as a clear winner. The standardised workflow, the speed and accuracy, and most importantly the company's more than 80-year legacy of fabricating denture base materials made the decision relatively easy.

During this first step into digital dentistry with the 3Shape scanner and software, Michael did not see the need for a milling machine, and the laboratory focused mainly on removable work. The investment and overhead of a milling machine were thus avoided. In this regard, Michael said: "I predict that more and more resins will become available for 3D printing of definitive fixed restorations for patients."

The impact on Everdent going digital was huge. Traditional dentures require a great deal of hands-on work, and the patient has to visit the clinic up to six times. The transformation from an analogue to a complete digital workflow enabled reduction of patient visits to the clinic to three in total on average. This, in combination with faster and more efficient fabrication of dentures, doubled the number of cases per week within a year.

Patient feedback to Everdent has been very encouraging. Patients have been pleased with the design, fitting and most of all reduced chair time. To Michael's surprise, very few dentures have needed a reline or reprint. Thanks to this overwhelmingly positive feedback, Everdent has continued to receive increasingly more requests from clinics, and the nearby dental hospital has started to refer patients who need dentures urgently to the laboratory.

It is not about the money—it's about the time saved!

Going digital has worked wonders for Everdent. Michael is often asked how much he needed to invest and how much extra revenue he has made. He underlines that it is not about the money but about the time saved: "Yes, you must invest time and money to transform your workflow into a digital one, but when you have everything up and running, you will have so much more time to focus on your patients, the lab, the clinic, marketing. In short, going digital resulted in far more time to manage the lab and clinic. As a result, Everdent is growing in the number of patients, cases, staff and revenue."

https://everdentclinic.com.au/

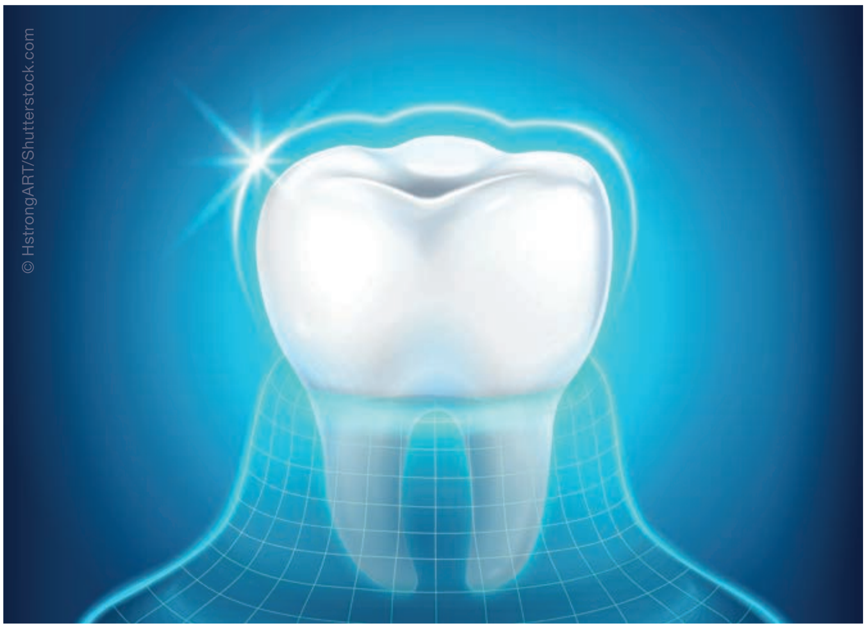
Printed with NextDent Ortho Flex

More than 30 high-performance 3D-printing resins

FREEPRINT crown

The DETAX FREEPRINT line offers more than 30 high-performance 3D-printing resins for all dental applications. The materials are currently validated for 30 qualified printers and post-curing devices, and the validation portfolio is growing rapidly (for the latest list, see the DETAX website). This ensures permanently reproducible printing results and the highest product quality.

The new FREEPRINT crown is a biocompatible resin for printing of permanent single crowns, denture teeth and long-term temporary bridges. The material offers a wide range of aesthetic shades (A1, A2, A3, B1, B3, C2, D3 and BL) thanks to perfectly matched transparency and opacity. High flexural strength and abrasion resistance guarantee optimum dimensional stability. High surface quality reduces post-processing time by more than a third.



All FREEPRINT medical devices are compliant with the EU medical device regulation (Regulation [EU] 2017/745) and feature an extended shelf life of 36 months. Certain products, for instance FREEPRINT denture and temp, have received U.S. Food and Drug Administration clearance.

Make the switch and benefit from an unlimited variety of applications and outstanding printing results!

www.DETAX.com

Designed and optimised for dental practices

HeyGears launches UltraCraft ChairSide and ChairSide Pro dental production solutions

HeyGears, a digital manufacturing company specialising in 3D printing, has recently launched two new products in its line of dental technology innovations: the UltraCraft ChairSide and UltraCraft ChairSide Pro 3D printers.

As the demand for digital workflows in dental practices grows, so does the need for streamlined, easy-to-use production. With ChairSide and ChairSide Pro, in-office 3D printing is no longer complicated. Users can easily complete the 3D-printing process for multiple dental applications with a minimal amount of training, providing dental practices and laboratories with the ability to fully optimise their 3D printing without requiring specialised staff or outsourcing of production.

UltraCraft ChairSide

UltraCraft ChairSide is an efficient, autonomous solution with plug-and-play operation and a small physical footprint. The combination of UltraCraft ChairSide, the UltraCraft AirWash cleaner and dryer, and the UltraCraft AirCure polymerisation machine is a lightweight desktop 3D-printing system that provides efficiency, speed and reliability. The solution has been specifically designed and optimised for dental practices and can go from scan to product within 30 minutes, depending on the application, providing efficient use of time and a positive patient experience.

After intra-oral data has been scanned and sent to HeyGears Cloud for design, the system begins printing operations. ChairSide handles the printing job using CapsulePrint, a 3D-printing solution that integrates the resin tank, resin liquid and material-adding mechanism in a single easy-to-use capsule. CapsulePrint is made from recycled plastic and is disposable, eliminating the hassle of resin tank cleaning and used resin storage. It makes shifting between applications fast and easy, having no need for calibration.

HeyGears UltraCraft C Series

UltraCraft AirWash completes the washing and drying process using the disposable platform as the base, preventing the need for contact with the liquid resin. There is also no need to clean the washing chamber when switching applications. AirWash can automatically detect the application in use and select the optimal washing solution for each output.

UltraCraft AirCure performs the final step in production, providing auto-calibrated fast polymerisation by identifying the application and the proper polymerisation strategy for each output.

UltraCraft ChairSide Pro

For increased output needs, UltraCraft ChairSide Pro incorporates the efficiencies of ChairSide, but is an industrial-grade desktop 3D printer designed for clinics or laboratories with multiple dental application needs. ChairSide Pro offers the same quality but at a faster speed, making it perfect for small-batch production.

ChairSide Pro utilises a matrix light source with an industrial-grade light engine for excellent resolution and a highly optimised separation strategy and offers a 40% increase in productivity compared with traditional digital light processing systems.

Artificial intelligence-enabled pixel-grade imaging technology reduces the risk of optical distortion, ensuring high uniformity across print jobs. The adaptive printing process can dynamically adjust the printing parameters, including exposure time, layer thickness and separation strategy, according to the specific requirements of the application, striking a balance between speed and quality.

Whether a dental practice or laboratory needs individual products or small-batch outputs, together these products provide the ability to increase production, fulfilling the needs of patients faster and more efficiently.

www.heygears.com

Winning combination of experience, expertise and passion

Meeting of dental industry at LMT LAB DAY Chicago

Rapid Shape, a manufacturer of professional 3D-printing systems, presented its innovative product range

The 37th LMT LAB DAY Chicago, the largest international gathering of dental laboratories in North America, took place in Chicago in the US from 24 to 26 February 2022. What began in 1985 as a small event has now grown to an event hosting more than 4,600 attendees and consisting of three days of seminars. Laboratory owners, technicians, dentists, managers and manufacturers from 47 states and 39 countries came to the halls of the Hyatt Regency Chicago for the industry's premier event in order to finally experience a sense of normality, meet face to face and exchange ideas. The excitement was palpable, and the energy generated by the reunion could be sensed everywhere.

Seminars and lectures by partners of Rapid Shape

Presented over three days, the programme consisted of seminars and lectures on technologies, processes, optimisations and innovations in the dental industry. The presentations were held by experienced and renowned industry experts from all over the world.

Attendees were delighted by technical and industry-specific seminars. Many of these were offered by Rapid Shape's partners 3Shape, DMG, exocad, Keystone and Straumann. "I have been coming to LAB DAY for 20 years, and today I attended literally the two best courses I have ever experienced," said one enthusiastic attendee.

At LMT LAB DAY, attendees had the opportunity to hear inspiring stories shared by dental technicians and dentists about how they make people smile. During the event, the visitors received tips and tricks for professional success and found out how to improve the efficiency of their own workflow in the laboratory. In total, around 200 exhibitors were present in the exhibition halls, showcasing their latest developments, products and services.

Rapid Shape in the middle of the action

In North America, 3D-printing technology used in modern dental laboratories plays a major role. It was, therefore, no surprise that Rapid Shape's high-quality 3D printers attracted a great deal of interest during LMT LAB DAY. Leading companies such as Keystone, Proto3000 and Straumann took part in the event alongside Rapid Shape. On-site, the company was represented by Andreas Schultheiss, CEO and founder of Rapid Shape, Karsten Müller, sales director at Rapid Shape, and Andreas Bott, who is a sales manager at the company.

They brought with them a selection of devices from the company's wide-ranging portfolio of 3D-printing systems, including the Rapid Shape models D20+, D50+ and D100+ ortho with cabinet. Visitors to the exhibition had an opportunity to have a closer look at these devices at Rapid Shape's state-of-the-art booth and to ask questions. To show dental laboratories the complete, safe workflow, the Rapid Shape team also demonstrated the RS wash and RS cure post-processing units. Rapid Shape, its experienced partners, interested laboratory owners, dental technicians and dentists were involved in lively professional exchanges and interesting discussions.

The D20+ from Rapid Shape for small laboratories
The D20+ 3D printer is perfectly suited for small laboratories and dental practices. The device saves time without sacrificing quality, and its simple, fast and safe application makes chairside production extremely uncomplicated. Visitors to LMT LAB DAY found the many benefits of this printer convincing.

Automation with the D50+
The D50+ 3D printer is the workhorse for dental laboratories, and Rapid Shape also had the opportunity to present this fast 3D printer for professional use in dental laboratories and practices at LMT LAB DAY. The printer can produce up to 11 models in one print cycle. As an all-rounder, the system, which has high 4K precision, is suitable for a wide range of dental applications and enables a professional, validated workflow.

All Rapid Shape 3D printers result from a winning combination of experience, expertise, ingenuity and passion for new technologies. The latest printer is the D50+, a modern and highly efficient 3D laboratory printer catering for high demands. Having validated processes, the printer offers safety and is a must for dental laboratories.

Series production in high volumes
The RS inline is a fully automated and scalable series production line. The line was on display at the Rapid Shape booth in the form of the D100+. The production concept can be individually expanded to include up to five machines in this model series. Additionally, if required, the RS inline can remain in operation around the clock. This means that it is possible to print 4,000 models per day.

The open material system of Rapid Shape 3D printers allows selection from over 200 resins. The material required for the parts to be printed is supplied by using an automatic refill unit. Combined with the possibility of uninterrupted production, this allows for very low part costs.

RS wash and RS cure
Immediately after printing, the parts are cleaned and cured using the RS wash and RS cure post-processing units. This ensures an optimal and validated end result. The RS wash automatic cleaning system boasts a simple operation and process-controlled connection to the 3D printer for professional and validated post-processing of the printed parts.

Thanks to the automatic selection of the appropriate cleaning program and cleaning medium, cleaning of the printed parts is not only process-safe and easy but also environmentally friendly. The process consists of two steps: pre-cleaning and final cleaning. Rapid Shape has applied for a patent for this intelligent system.

Using powerful LEDs, the RS cure automatic exposure system cures the printed parts homogeneously from all sides. Through the connection to the 3D printer, the device automatically selects the correct program. This ensures that the mechanical properties and the biocompatibility of the end product are always achieved. The presets are tested and validated in close cooperation with the material partners to ensure process reliability.

Rapid Shape's expert team was able to showcase the benefits and features of its 3D printers to the visitors to LMT LAB DAY. Next year, the company will certainly be back in Chicago and is already excited about the next developments.

More information about the products can be found at:

www.rapidshape.de/products/dental

EAS summer meeting to focus on 3D virtual planning of aligners

By Dental Tribune International

The European Aligner Society (EAS), in conjunction with the Sociedade Portuguesa de Alinhadores Dentários (Portuguese aligner society), will be holding its summer meeting in Oporto on 1 and 2 July at the Hilton Porto Gaia hotel. The event is expected to attract 350 participants and will offer a day of lectures and a day of hands-on courses.

The meeting will be held under the theme "ALIGNERS AND 3D PLANNING: FROM VIRTUAL TO REAL" as an in-person event. However, the lecture programme will be livestreamed for dental professionals who are neither EU nor UK residents.

The lecture programme will be presented by eight international experts, including Dr Victoria Martin from Germany, who will be sharing her routine on virtual planning, and Dr Bruno Filipe Almeida Gomes from Portugal, whose lecture will focus on movement predictability in treatment planning. In addition, Dr Pedro Costa Monteiro from Portugal will be presenting on Invisalign with mandibular advancement in Class II malocclusions and Dr Manuel Roman from Spain will be giving tips and tricks for virtual treatment planning for open bite and Class III malocclusions. After the lectures, attendees will have the opportunity to pose questions to all of the speakers in a discussion and Q & A session.

To allow attendees to apply the knowledge gained on the first day, the second day of the meeting is dedicated to practical workshops and in-depth courses, which will be delivered by two of the lecture presenters as well as by clinical and technological experts from some of the leading aligner and treatment planning companies.

For the welcome reception, attendees will be invited to a winery close to the venue to experience Oporto's famous port wine.

Participating in the summer meeting will provide 19 hours of continuing education.

Attendees are invited to submit research abstracts, which will be used for e-poster presentations during the event. More information on the programme, registration, the official conference app and how to submit abstracts is available at www.eas-aligners.com/2nd-summer-meeting-porto-2022.


Desktop Health
Permanent Printable Smiles
FDA cleared **Flexcera Smile Ultra+** offers the perfect blend of comfort, strength and flexibility to ensure best-in-class fit and finish.
More at DesktopHealth.com
Desktop Health
Flexcera
Smile Ultra+

International events

Dental Bern 2022

9–11 June 2022
Bern, Switzerland
https://dental2022.ch

EuroPerio10

15–18 June 2022
Copenhagen, Denmark
www.efp.org/europerio

European Aligner Society—EAS 2nd Summer Meeting

1–2 July 2022
Porto, Portugal
www.eas-aligners.com

British Orthodontic Society 2022—BOS Conference

15–17 September 2022
Birmingham, UK
www.bos.org.uk

German Society of Orthodontists—DGKFO Annual Meeting

21–24 September 2022
Berlin, Germany
www.dgkfo-vorstand.de

AAID Annual Conference 2022

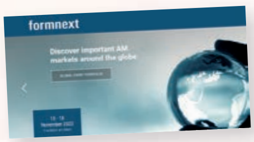
21–24 September 2022
Dallas, USA
www.aaid.com

Dental World Budapest 2022

13–15 October 2022
Budapest, Hungary
https://dentalworld.hu/dental-world-2022-en

19th ESCD Annual Meeting

13–15 October 2022
Rome, Italy
https://escdonline.eu



Formnext 2022

15–18 November 2022
Frankfurt am Main, Germany
https://formnext.mesago.com/events/en.html

IDS 2023

14–18 March 2023
Cologne, Germany
www.ids-cologne.de

How to send us your work

Please note that all the textual components of your submission must be combined into one MS Word document. Please do not submit multiple files for each of these items:

- the complete article;
- all the image (tables, charts, photographs, etc.) captions;
- the complete list of sources consulted and
- the author or contact information (biographical sketch, mailing address, e-mail address, etc.).

In addition, images must not be embedded into the MS Word document. All images must be submitted separately, and details about such submission follow below under image requirements.

Text length

Article lengths can vary greatly—from 1,500 to 5,500 words—depending on the subject matter. Our approach is that if you need more or fewer words to do the topic justice, then please make the article as long or as short as necessary.

We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

In short, we do not want to limit you in terms of article length, so please use the word count above as a general guideline and if you have specific questions, please do not hesitate to contact us.

Text formatting

We also ask that you forego any special formatting beyond the use of italics and boldface. If you would like to emphasise certain words within the text, please only use italics (do not use underlining or a larger font size). Boldface is reserved for article headers. Please do not use underlining.

Please use single spacing and make sure that the text is left justified. Please do not centre text on the page. Do not indent paragraphs, rather place a blank line between paragraphs. Please do not add tab stops.

Should you require a special layout, please let the word processing programme you are using help you do this formatting automatically. Similarly, should you need to make a list, or add footnotes or endnotes, please let the word processing programme do it for you automatically. There are menus in every programme that will enable you to do so. The fact is that no matter how carefully done, errors can creep in when you try to number footnotes yourself.

Any formatting contrary to stated above will require us to remove such formatting before layout, which is very time-consuming. Please consider this when formatting your document.

Image requirements

Please number images consecutively throughout the article by using a new number for each image. If it is imperative that certain images are grouped together, then use lowercase letters to designate these in a group (for example, 2a, 2b, 2c).

Please place image references in your article wherever they are appropriate, whether in the middle or at the end of a sentence. If you do not directly refer to the image, place the reference at the end of the sentence to which it relates enclosed within brackets and before the period.

In addition, please note:

- We require images in TIF or JPEG format.
- These images must be no smaller than 6 x 6 cm in size at 300 DPI.
- These image files must be no smaller than 80 KB in size (or they will print the size of a postage stamp!).

Larger image files are always better, and those approximately the size of 1 MB are best. Thus, do not size large image files down to meet our requirements but send us the largest files available. (The larger the starting image is in terms of bytes, the more leeway the designer has for resizing the image in order to fill up more space should there be room available.)

Also, please remember that images must not be embedded into the body of the article submitted. Images must be submitted separately to the textual submission.

You may submit images via e-mail or share the files in our cloud storage (please contact us for the link).

Please also send us a head shot of yourself that is in accordance with the requirements stated above so that it can be printed with your article.

Abstracts

An abstract of your article is not required.

Author or contact information

The author's contact information and a head shot of the author are included at the end of every article. Please note the exact information you would like to appear in this section and format it according to the requirements stated above. A short biographical sketch may precede the contact information if you provide us with the necessary information (60 words or less).

Questions?

Magda Wojtkiewicz
(Managing Editor)
m.wojtkiewicz@dental-tribune.com

3D printing

international magazine of dental printing technology

Imprint

Publisher and Chief Executive Officer
Torsten R. Oemus
t.oemus@dental-tribune.com

Editor-in-Chief
Dr George Freedman

Managing Editor
Magda Wojtkiewicz
m.wojtkiewicz@dental-tribune.com

Designer
Franziska Schmid

Copy Editors
Sabrina Raaff
Ann-Katrin Paulick

International Administration

Chief Financial Officer
Dan Wunderlich

Chief Content Officer
Claudia Duschek

Clinical Editors
Nathalie Schüller
Magda Wojtkiewicz

Editors
Franziska Beier
Jeremy Booth
Brendan Day
Anisha Hall Hoppe
Iveta Ramonaite

Executive Producer
Gernot Meyer

Advertising Disposition
Marius Mezger

Art Director
Alexander Jahn

International Headquarters

Dental Tribune International GmbH
Holbeinstr. 29, 04229 Leipzig, Germany
Tel.: +49 341 48474-302
Fax: +49 341 48474-173

General requests: info@dental-tribune.com
Sales requests: mediasales@dental-tribune.com
www.dental-tribune.com

Printed by
Silber Druck oHG
Otto-Hahn-Straße 25
34253 Lohfelden, Germany

Sign up for the free newsletter by scanning the QR code and receive the latest news on dental 3D printing, as well as the magazine editions digitally.

To receive printed copies & print subscriptions, please contact: *info@dental-tribune.com*


ASIGA