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digital

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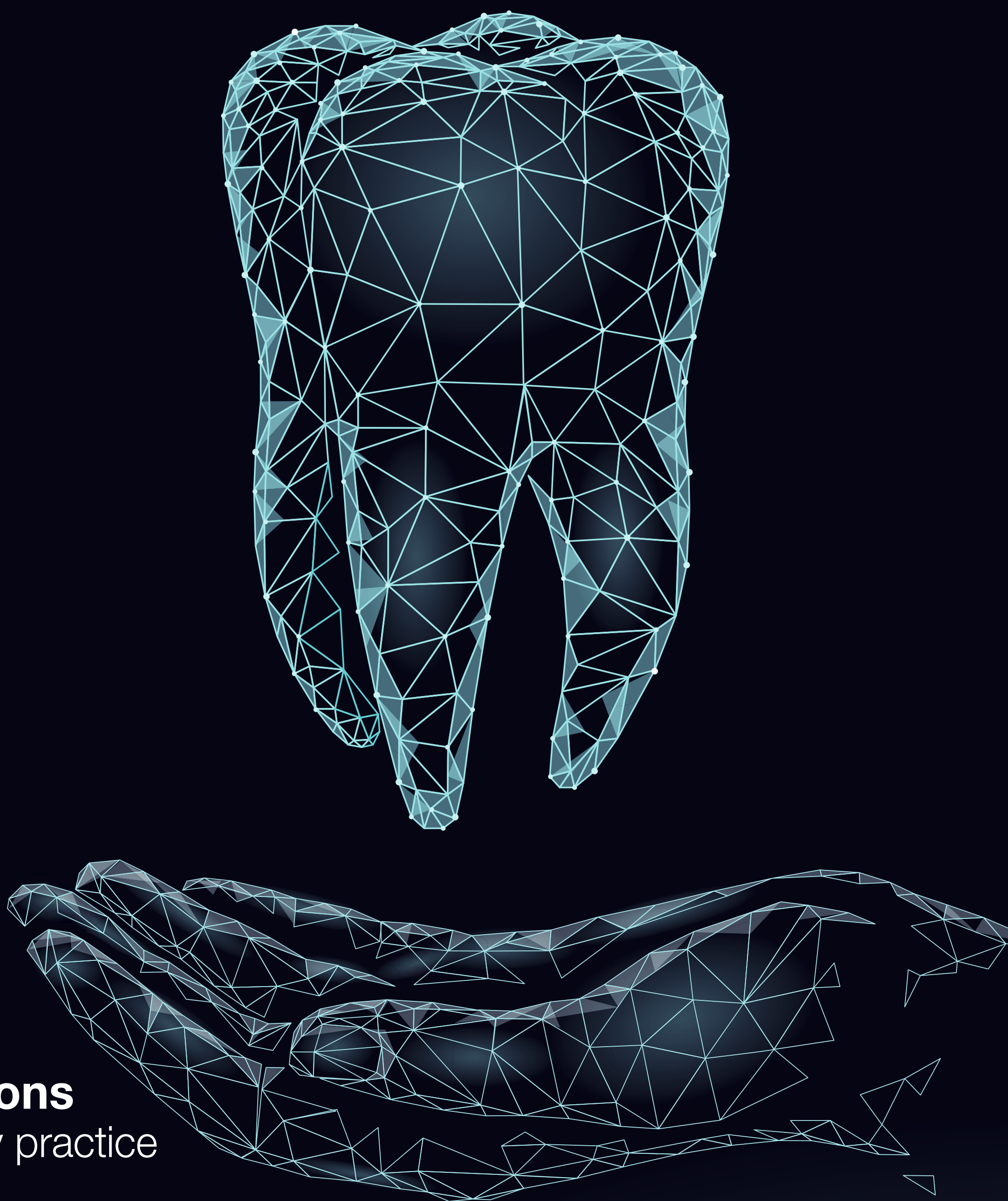

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feature
Dental startups are harnessing artificial intelligence

dti] Dental Tribune International

Dr Scott D. Ganz

Editor-in-Chief

digital is here!

What a great way to start off 2020! You might have noticed: our new name is digital! How great is that? It was a necessary change to encompass everything that we do today, to provide a platform for an exchange of ideas among the finest clinicians, researchers, educators, and much more, a platform that reflects the state-of-the-art in dentistry today. As I like to start many of my own presentations, there is a danger when we are bound by 2D concepts, when we truly live in a 3D world. Digital allows us all to communicate globally with a universal language that connects us all, the general practitioner, restorative dentist, surgical specialist, prosthodontist, paediatric dentist, orthodontist, oral and maxillofacial radiologist, dental laboratory technician, auxiliaries, and more.

Digital represents the evolution from the analogue modalities of Dr G.V. Black as incorporated in the curriculum of every dental school worldwide to perhaps unforeseen technological advances of today that have dramatically changed how we deliver care to our patients. Digital allows us to capture the intra-oral condition of a patient's occlusion without costly impression material, to visualise the result on a high-resolution LCD computer monitor and to utilise sophisticated software tools to diagnose, plan treatment and virtually simulate a smile design—to the amazement of our patients. Digital then allows us to virtually produce state-of-the-art CAD/CAM restorations with new and improved materials, a long way from the lost wax method of casting metal for metal–ceramic crown and bridgework. Digital allows a patient with malpositioned teeth to see a computer-driven simulation of how his or her teeth can be moved into the correct functional and aesthetic positions and then through rapid prototyping 3D printing modalities achieve these results with a series of wearable aligners.

Digital represents tremendous advances in the assessment of patients' individual and unique anatomy through cone beam computed tomography (CBCT) to diagnose potential pathology, to appreciate proximity of vital structures when planning for dental implants, to assess temporomandibular joint disorders, to plan for third molar extractions and bone grafting, and much more. The ability to then merge the data sets of a CBCT scan and an intra-oral scan enhances the clinician's diagnostic capability to fabricate static surgical guides, or as the foundation for dynamic navigation, greatly improving implant placement based upon a truly restoratively driven plan. Can we imagine placing implants without 3D imaging today? Digital finally allows for a seamless platform for the clinician to communicate and interact with the dental laboratory technician, who is crucial to changing the quality of life of our patients.

How can we be educated on our new universal language? Within the pages of this first issue of 2020, you will find articles by some of the best and brightest that illustrate these concepts, helping us to move from the constraints of two dimensions into the unlimited potential of the 3D world. Enjoy our first issue of digital in 2020!

Respectfully,
Dr Scott D. Ganz
Editor-in-Chief

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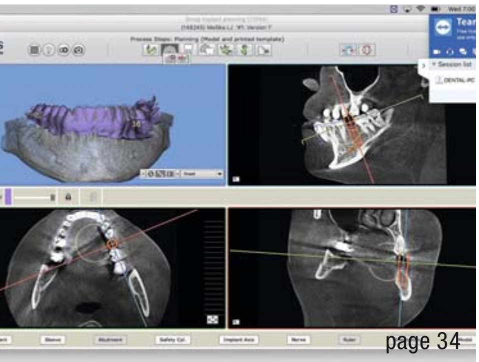

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Digital dentistry in daily practice

Dr Edouard Lanoiselée, France

How can a patient's treatment be optimised? How can both speed and efficiency be increased without sacrificing quality? These questions are constantly being asked in our practices. Our patients' demands are becoming increasingly advanced in terms of aesthetic and functional results, yet they have ever less time to dedicate to treatments. We now have a great deal of equipment at our disposal that enables this optimisation. Many of these tools are digital and as such allow us to digitise our patient files in order to transfer as much information as possible to the prosthetic laboratory. This information can thus be prioritised and streamlined to be processed in the laboratory by the appropriate people in the respective field (modelling, ceramic coating, etc.). In this effort to centralise information, colour is a complex area that requires extensive resources in terms of information. It is usually assessed in the chair by means of comparison of the patient's teeth to one or more shade guides. This reading is influenced by many factors, and results can be significantly affected by surrounding interference (brightness of the room, bright colour of lipstick, etc.), making it particularly subjective.[1, 2]

Dental photography is now considered an excellent way to convey colour information. It requires the prosthetist to use a shade guide as a reference to ensure that the information is as objective as possible. Working with dental photography, however, increases working time, as the prosthetist has to perform map-


Fig. 1


Fig. 2

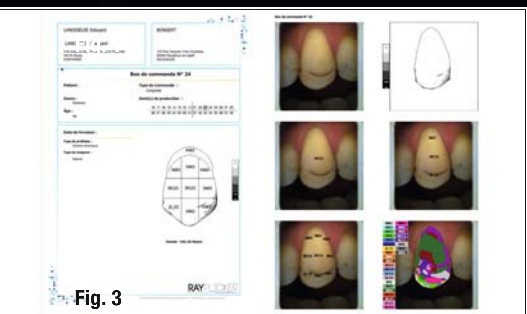


Fig. 3

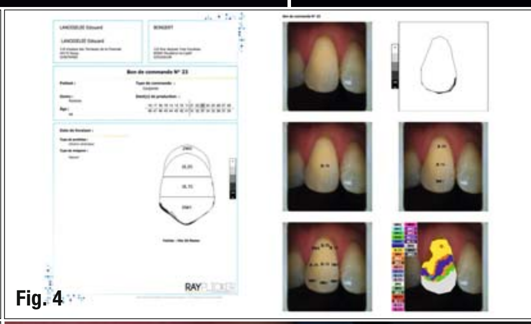


Fig. 4

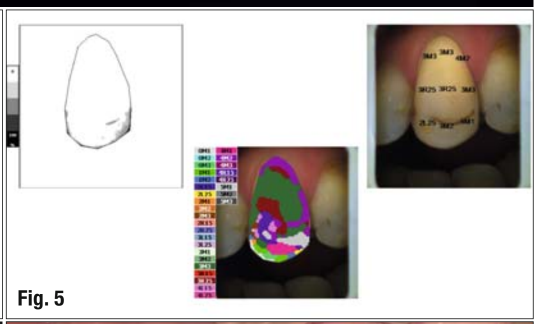


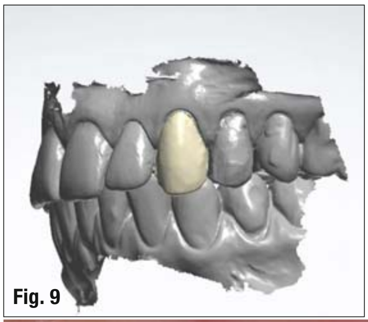
Fig. 5


Fig. 6


Fig. 7


Fig. 8

Figs. 1 & 2: Initial situation: teeth #22 and #23 required restoration. **Fig. 3:** Colour reading sheet on the tooth to be treated. **Fig. 4:** Colour reading sheet on the contralateral tooth. **Fig. 5:** Translucency, detailed (pixel by pixel) and 9 parts shade mappings. **Fig. 6:** Optical impression. **Fig. 7:** Reduction control. **Fig. 8:** Optical impression of the preparation (with TRIOS 4, 3Shape).



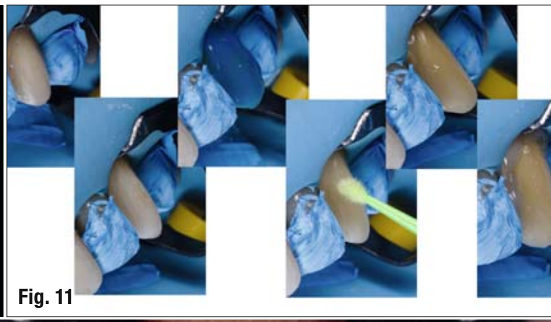


Fig. 9: Modelling of the restoration (with Dental System, 3Shape). **Fig. 10:** The veneer, ready to be seated in the patient's mouth. **Fig. 11:** Seating of the final restoration under dental dam isolation. **Fig. 12:** Final situation immediately after removal of the dental dam. **Fig. 13:** Check-up at four months.

ping based on the information obtained from the photographs. Moreover, cameras are sensitive to shade variations, depending on the colour temperatures predetermined by the camera, which can skew this reading.[3] To counter this problem, spectrophotometers are currently the best tools we have to objectify a result. They work by emitting calibrated light which, depending on the reflection registered, enables a colour reading to be taken. This reading is unaffected by environmental factors that could potentially skew its results (lipstick, colourful clothing, unsuitable lights, etc.).[4, 5]

Some models allow a photograph to be taken with mapping of the tooth, which enables the prosthetist to be guided more effectively in the process of creating the prosthesis. The sheet is then stored on the software and can be processed and archived in a patient file. The Rayplicker (Borea) is a device that allows the practitioner to record all the information collected and communicate it to the prosthetic laboratory. The laboratory sheet can be sent via a secure portal and reprocessed by the prosthetic laboratory. This flow enables the form to be marked as reviewed by the laboratory, in order to monitor the progress of the treatment from the practice. Most shade guides on the market are referenced, making the work easier for the laboratory.

Clinical case

The patient attended the practice for replacement of the restoration on tooth #23, which she found unsightly. The clinical examination revealed the presence of a composite restoration on the vestibular surface of tooth #23 with a stained joint, as well as the presence of early carious lesions on the neighbouring teeth (Figs. 1 & 2). After discussing treatment options with the patient, it was decided on composite restorations for the carious lesion and a veneer for tooth #23. However, there was a constraint that made this case more difficult: the patient had to go abroad for three months and needed the work to be done within ten days of accepting the treatment.

The first step in the treatment was registering the colour, performed using the Rayplicker. A reading was taken of the tooth to be restored and of the contralateral tooth (Figs. 3 & 4). This double reading would give the prosthetist information not only on the tooth to be restored but also on the overall integration of this tooth. The readings were sent to the laboratory via a secure server. The important information for creating the restoration is centralised on this sheet: translucency, detailed mass mapping and the shade guide values (Fig. 5).

As the treatment did not require any modification of shape, it was decided to use the initial situation as a reference for the laboratory, and an optical impression was taken, which would guide the laboratory in the design of the veneer (Fig. 6). A reduction guide was then made with silicone and the tooth was prepared (Fig. 7). The thickness would be checked at the end of preparation with this key, which enables the ceramic thickness, the homogeneity and the homothety of the preparation to be checked.

Fig. 14

Fig. 14: Spectrophotometer Rayplicker developed by BOREA.

The optical impression of the preparation was then performed (Fig. 8). To do this, tooth #23 was erased on the initial impression and then the area was registered. This would enable the impressions to be merged easily in the laboratory to control the modelling process. All the information was then sent to the laboratory (shade sheet and optical impression). In both cases, the files were sent via a secure portal with the option of verifying receipt by the dental surgeon. The veneer was then modelled in the Dental System software (3Shape; Fig. 9) and then printed in burnout resin on a 3D printer. It was then processed conventionally using the pressed ceramic technique, as the fineness of the veneer is not easily compatible with a machining technique (Fig. 10).

After curettage and sealing of the lesion on tooth #22, the veneer was placed with a try-in paste (Fig. 11). The patient confirmed the result, and then the veneer was glued on to the tooth. Only light-polymerised glue (G-CEM veneer, GC) is used for this—the advantage of this type of glue is the longer working time and therefore the management of excess glue, which is easier to remove. After thorough polishing, the dental dam was removed and a final polish was performed (Fig. 12).

The patient was seen again at four months, when she returned from abroad for a check-up. The teeth were rehydrated and the periodontal tissue that had been pushed in when the dam was put in place had resumed its original position (Fig. 13). It was evident that the restoration had integrated well.

The use of digital techniques means that it is now possible to create simple and reproducible protocols. If the practitioner or prosthetist encounters difficulties, these can be analysed and resolved quickly. While shape can now easily be checked by the practitioner, colour is one of the crucial points to master during procedures. Spectrophotometers such as the Rayplicker now offer a simple, fast and effective solution. The secure platform facilitates interaction between the practice and the prosthetic laboratory, as well as confirms receipt of documents, centralises information and provides the option of enhancing the content with photographs clarifying the surface qualities and characterisations required for the integration of the prosthesis. All these elements combined deliver qualitative and rapid results in line with patients' expectations.

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

about

Dr Edouard Lanoiselée graduated from the Faculty of Dentistry of the University of Nantes in France and later obtained a master's degree in medical sciences. He worked as a university hospital assistant at the teaching and research centre of the Nantes university hospital in the prosthetic department. He is the coordinator of the aesthetic dental restoration university degree at the University of Nantes and a consultant to the implantology department of Nantes university hospital. Dr Lanoiselée is a CAD/CAM specialist and a partner at a general dental practice in Nozay in France.

The integration of CAD/CAM into dental school curricula

By Brendan Day, DTI

By this point, the benefits of employing digital technologies in the dental practice and laboratory have been well documented. CAD/CAM was developed for commercial use in the 1980s at the University of Zurich in Switzerland by Prof. Werner H. Mörmann and Dr Marco Brandestini, and its usefulness for creating dental restorations and orthodontic appliances has grown in the decades since, as has its reputation. FDI World Dental Federation, the principal representative body for more than one million dentists worldwide, went so far as to issue a policy statement in 2017 declaring that it supports "the research and development of CAD/CAM dentistry to improve the quality of the final product and allow for cost reduction".

What has been less covered, however, is the role that CAD/CAM can play in tertiary dental education as both a teaching aid and a tool for future dentists to experience in a preclinical setting. In contrast to older dentists who may have had to learn how to use these technologies from scratch, today's dental students are frequently digital natives, already well versed in using computers by the time they reach university. As a result, they often have an increased affinity for the incorporation of CAD/CAM into their learning experiences.


Fig. 1

Fig. 1: Dr Mojdeh Dehghan, an associate professor and Chair of the Department of General Dentistry at the University of Tennessee College of Dentistry in the US.

A 2015 article in *Inside Dentistry* asserted that 76 per cent of American dental schools have at least one CEREC unit from Dentsply Sirona, perhaps the piece of CAD/CAM equipment most commonly found in dental practices. However, this level of access to such technology is nowhere near guaranteed, according to a survey that was the subject of a report by Dental Tribune International in 2017. Most British dentists stated that they did not use any CAD/CAM equipment in their practices, even though 89 per cent of them admitted that it had a major role to play in the future of dentistry.

So how has CAD/CAM been integrated into dental school curricula to this point?

The University of Tennessee College of Dentistry—a trendsetting school

One of the first dental schools to incorporate CAD/CAM into its undergraduate curriculum was the College of Dentistry at the University of Tennessee Health Science Center in the US. In 2001, the school invested in a CEREC 3 unit from Sirona—having tested five CEREC 2 units the summer before—and, slowly but surely, let its students experience at first hand the potential of this digital technology.

Dr Mojdeh Dehghan, an associate professor and Chair of the Department of General Dentistry, was one of the chief drivers of this technological shift. She outlined to Dental Tribune how the dental school's curriculum integrates CAD/CAM technology from the very first day of students' preclinical studies, which allows them to gain a better understanding of what their eventual clinical study will entail.

"Before the end of their first year, our undergraduate students have not only been introduced to CAD/CAM in their dental morphology course, they have also undertaken an 'Introduction to CAD/CAM Dentistry' course, where they get to work directly with mannequin teeth that are already prepared for an onlay and a crown, going through the whole process of scanning, designing and milling," Dehghan says.

"When they're exposed to technology like this early on in their education, especially for this tech-savvy generation, they not only often really enjoy being given the opportunity to see what they'll be doing later on but also are able to reinforce their knowledge of tooth morphology and anatomy that they've learned in prior courses," adds Dehghan. "It's the optimal way to integrate technology into the basic science courses and has been a really successful programme for us."

Maryland's father of digital dentistry

Dr Gary Hack is an associate professor at the University of Maryland School of Dentistry, where he teaches in the Department of Advanced Oral Sciences and Therapeutics. Having instructed dental students for more than three decades now, Hack might be forgiven for not having stayed up to date with all of the technological developments in dentistry. This, however, couldn't be further from the truth, since he was one of the first dental educators in the nation to integrate CAD/CAM devices into his teaching. At Maryland, Hack's enthusiasm for modern dental technology is such that many of his colleagues call him the university's father of digital dentistry.

"In the early 2000s, there were some representatives from Sirona who came to conduct a demonstration at our dental school," Hack explains. "At that time, they had the CEREC Red Cam. I had been teaching a crown and bridge course for many years at that point, but when I saw this technology at first hand, I was overwhelmed. I knew that this was the future of dentistry. I knew that this would introduce an incredible level of excitement for the dental students. And I knew about the students' passion for computers and technology."

By 2006, Hack had set up ten CEREC Red Cams in the school's so-called Dream Room and began integrating digital dentistry into his classes with immediate effect.

"I was teaching a freshman course on amalgams and composites, and the general thinking was that you couldn't gain any value from scanning amalgam and composite preparations because they have undercuts," he says.

"What I quickly learned, however, was that it was very easy to scan these. Instead of ten or 15 students gathered around me and a typodont, failing to really see anything while I tried to explain about the walls of an intracoronal preparation, a single scan allowed for me to show everybody all the different elements in a way that was much easier for them to understand," Hack adds.

Somewhat surprisingly, Hack asserts that the software available on certain CAD/CAM devices comes with an added benefit for students: the provision of unbiased

Fig. 2: Dr Gary Hack, an associate professor at the University of Maryland School of Dentistry in the US. **Fig. 3:** Dr Selim Pamuk, a retired professor who used to teach at Istanbul University's Department of Prosthodontics in Turkey.

feedback regarding site preparation. "After 35 years of teaching, I can tell you that it's almost impossible to get ten dentists to look at the same dental preparation and each come up with the same grade," he declares.

"Everyone has his or her own bias, his or her own way of looking at things. However, the computer has no such bias."

The era of digital natives

When it comes to understanding how to use dental CAD/CAM technologies, it is clear to educators like Dehghan and Dr Selim Pamuk that this current generation of students is much more capable than their predecessors. "Today, young generations are growing up using smartphones, game consoles and powerful computers from their childhood onwards," says Pamuk, a retired professor who used to teach at Istanbul University's Department of Prosthodontics in Turkey before opening up his own private practice in the same city.

"Teaching these students everything in a virtual environment is much easier than adapting ourselves to these changes. They understand how to use technology with ease, and do it instinctively," he admits.

Pamuk's assertions are echoed by Hack, who emphasises that "there really is no learning curve" for the dentists of tomorrow. "These students pick it up within minutes, to a point where they understand it better than I do!" he remarks. "They grew up with computers and are naturally drawn to this technology, are passionate about it and are excited to bring it into their future dental practices."

Are we moving too fast?

It can be somewhat easy to argue that, given CAD/CAM's increasing influence in the dental world, it should be

Fig. 4

Figs. 4–7: By 2006, Dr Gary Hack had set up ten CEREC Red Cams in the school's so-called Dream Room and began integrating digital dentistry into his classes.

readily and widely employed in dental schools. "More and more dentistry is surrounded by new digital 'toys' that can make our practices more efficient than ever before," claims Pamuk, who is a strong believer in the power of CAD/CAM.

"Digital dentistry is now a reality, and dental schools and practices should all be part of this. Dental schools should change and adapt their curricula accordingly," he adds.

However, the truth of the matter, according to Dehghan, is somewhat more complicated given the oral health inequalities that continue to exist between and within different communities.

"A lot of the time, we don't know exactly where our students are going to end up working," Dehghan says. "They may end up working in public health, in remote areas, in the military—any number of places that often have less access to CAD/CAM. This is why we're exposing them to these advanced technologies while also ensuring that they learn all of the traditional methods of impression taking, crown preparation, temporizing the patient, sending the information to the laboratory, and so on. CAD/CAM is wonderful, and while it should be integrated into dental education, it shouldn't be the sole method," she adds.

Dehghan affirms that the initial cost of investing in CAD/CAM devices and technologies is something that puts off not just private dental practices but certain schools as well.

It's a sentiment that Hack readily agrees with. "In my opinion, all dental schools are, to some degree, struggling with this decision," he says. "Clearly, they know that they have to do this, that it is incumbent on them that they teach their students this technology, since if they don't, they are not properly preparing them for their future practice. Yes, the financial cost can be a barrier, but this is clearly outweighed by the benefits that come with integrating CAD/CAM devices into current methods of teaching," Hack continues.

There is a way, however, that the financial burden of CAD/CAM investment can be lessened for dental schools: partnering with key players in the industry.

Fig. 5

Fig. 6

Fig. 7

Industry involvement in dental CAD/CAM education

The role that industry can play in promoting CAD/CAM use in dental schools has already been recognised. Henry Schein, for example, has partnered with the American College of Prosthodontists Education Foundation since 2018 to create its Digital Dentistry Curriculum Initiative, which aims to develop new curricula for American dental schools that incorporate CAD/CAM technologies into their curricula.

"We believe CAD/CAM technology enhances dentistry and we are pleased to support this initiative, which will offer dental students the education and training needed to effectively apply this exciting technology in their future work," said Stanley M. Bergman, chairman of the board and CEO of Henry Schein, in a press release announcing the company's initiative. "By rallying the industry to ensure that dental students are fully educated on the practice benefits and patient benefits of digital dentistry, we are helping the dentists of tomorrow succeed."

Hack sees the relationship between dental schools and CAD/CAM providers as one that, if executed correctly, can prove to be essentially symbiotic in nature. "As teachers, we can go back to the manufacturers and tell them what we would like to see in their evaluation software and they will work on it," he explains.

"There is a collaboration between dental school education and the manufacturers that becomes a win-win situation. The manufacturers know that, if the students are being taught digital dentistry, then chances are, when they get into private practice, they'll move in that direction," Hack adds.

For Pamuk, this association is something that can ultimately lead to reduced costs and greater access to CAD/CAM technology for dental schools.

"The industry has to collaborate with dental schools and research centres, even with private practitioners, in order to develop digital dentistry and reduce the cost of equipment," he says.

"Once the cost has been lowered, digital dentistry will be more democratic. But for this, close collaboration is needed, as teaching and learning skills will change completely with the adoption of digital tools in classrooms," Pamuk adds.

On the whole, it appears as though the integration of CAD/CAM into dental school curricula throughout the world is on the increase. Heidelberg University Hospital in Germany, Queen Mary University of London in England and RMIT University in Australia are just a few of the educational institutes that currently offer courses centred on dental CAD/CAM technologies. Though there are certain barriers to its widespread adoption, this number looks set to continue to grow.

Digital workflow versus conventional approach in aesthetic dentistry

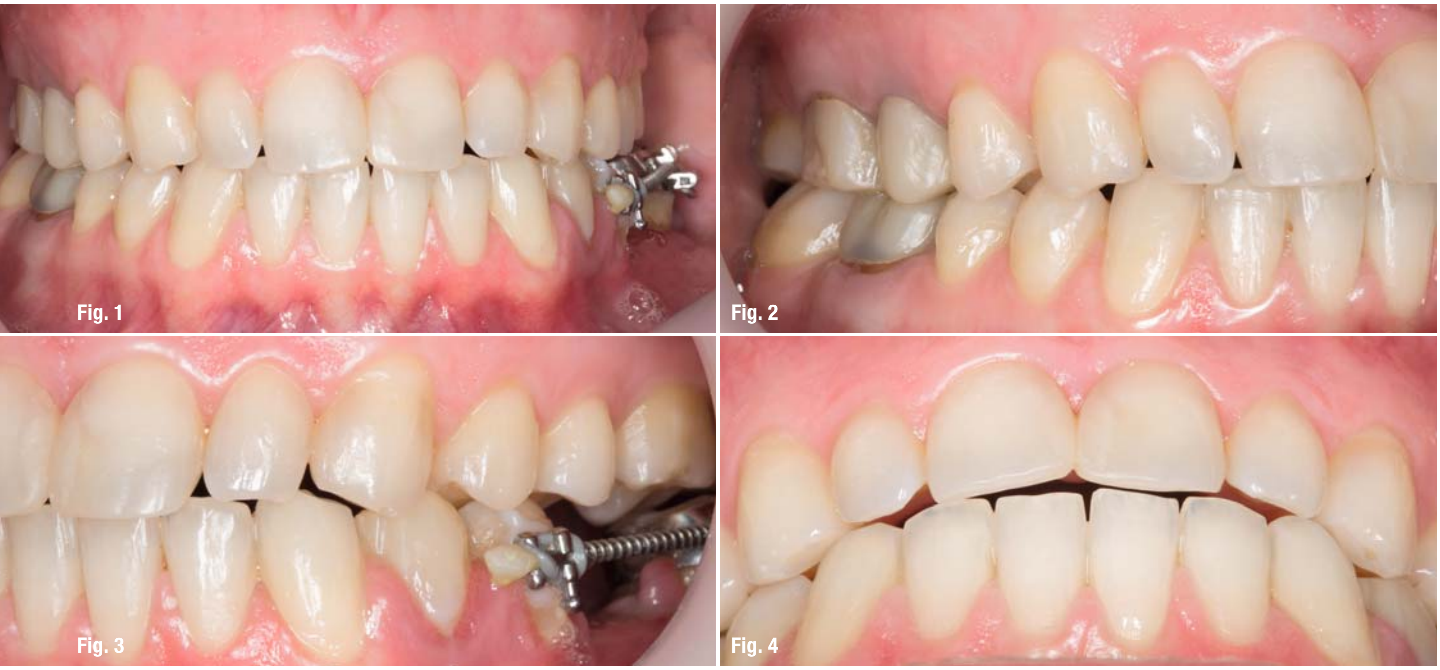
Dr Florin Lăzărescu, Romania

Digital technologies are becoming ever more present in the daily work of dental clinicians, even if sometimes the digital part of the work is done by the dental laboratory using CAD/CAM technology. Nowadays, as dental practitioners, we often ask ourselves which technique we should use—should we trust only new digital solutions or rather stick to conventional, analogue, techniques? In this article, I seek to answer this question by presenting the same case treated in a digital and an analogue way.

Every dental practitioner uses common impression materials; we are used to them, they have passed the test of time and they appear to be predictable. Therefore, many of us might ask whether digital scanning is reliable and if so which scanner to choose. My colleagues from the Iuliu Haţieganu University of Medicine and Pharmacy in Cluj-Napoca in Romania conducted research on the accuracy of different scanners and milling machines, considering them singularly and in combination (products both from single manufacturers in combination and from different manufacturers in combination; Tables 1–5).[1] Their research found a median precision of 78.40 µ for complete in-office systems, of 76.04 µ for additive CAD/CAM systems and of 60.46 µ for laboratory CAD/CAM systems. When scanners and milling machines from different producers were combined, a median precision of 49.85 µ was obtained for laboratory systems, while complete in-office systems had a precision of 78.32 µ and single brand laboratory systems 60.46 µ. The results of this research demonstrate that the precision is very good no matter which system one uses, that CAD/CAM technology is reliable and that we can count on it in everyday work.

Case report

A 32-year-old female patient came to our clinic for improvement of the aesthetics of her smile. After analysing the initial situation (Figs. 1–4), we recommended veneers on teeth #14 to 23 and ceramic crowns on teeth #15 and 16. To optimise the final outcome, it was decided with the patient to treat this case both ways, analogue and digital.



Figs. 1–4: Initial clinical situation.

Table 1: Precision for various CAD/CAM systems according to product.[1]

System kind	Scanner and milling machine (product and manufacturer)	Measurement	Precision (µ)	Median precision (µ)
Complete in-office systems	Lava C.O.S. (3M ESPE)	MVS	46.81	
	E4D (Planmeca)	MVS	85.98	
	CEREC 3 MC (Dentsply Sirona)	MVS	102.43	
				78.40
Additive CAD/CAM systems	PM100 Dental (Phenix Systems)	MVS	62.60	
	EOS 3D scanner + EOSINT M 270 (EOS)	MVS	72.60	
	laser sintering (BEGO Medical)	MVS	92.93	
				76.04
Laboratory CAD/CAM systems	Zenotec (Wieland)	MVS	13.78	
	Decim (Dentronic)	MVS	23.00	
	NobelProcera (Nobel Biocare)	MVS	30.78	
	KaVo Everest (KaVo Dental)	MVS	41.50	
	M5 (Zirkonzahn)	MVS	47.26	
	DECSY SCAN (Digital Process)	MVS	49.00	
	CORiTEC 250i (imes-icore)	MVS	53.00	
	Lava Is (3M ESPE)	MVS	55.68	
	CEREC inLab (Dentsply Sirona)	MVS	56.10	
	Gn-I	MVS	66.80	
	Cercon eye (Dentsply DeguDent)	MVS	66.85	
	Ceramill Motion 2 (Amann Girrbach)	MVS	71.31	
	DigiDent (DigiDent Labs)	MVS	75.00	
	Cynovad Pro 50 (Cybernetic Innovations)	MVS	79.50	
	E4D (Planmeca)	MVS	90.47	
	iTero (Align Technology)	MVS	93.13	
	Compartis (Complete Milling Lab)	MVS	114.70	
				60.46

MVS = Medium vertical space

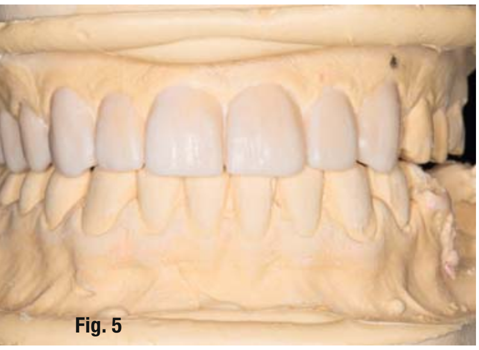


Fig. 5


Fig. 6


Fig. 7

Figs. 5–7: Functional analysis wax-up.

Analogue approach

We started with dental impressions taken with common materials. Next, the facebow registration was taken and sent to the dental laboratory together with the impressions. The dental technician then prepared the wax-up and analysed it in an articulator (regarding occlusion and functional movements; Figs. 5–7). The first important observation in this case was the overjet distance. In order to achieve a perfect bite, I would have recommended double veneers (buccal and palatal) from teeth #12 to 22. An analogue approach allows fabrication of double veneers, and it is a common procedure, but a digital approach using a CAD/CAM chairside system does not permit this solution, or makes it complicated (double scanning is necessary and is possible only after cementation of one of the parts of the veneers, palatal or buccal).

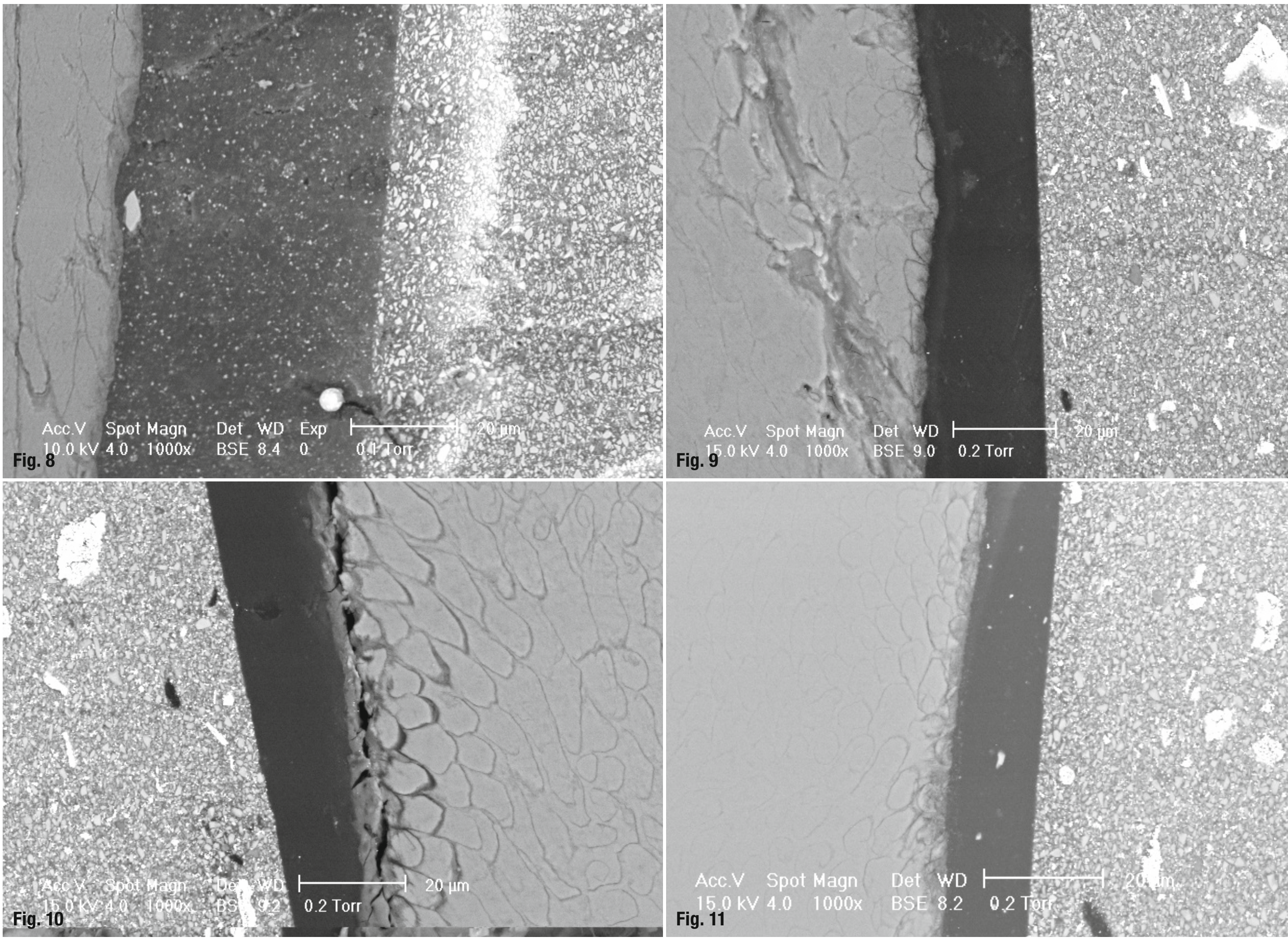
A mock-up was done, followed by guided tooth preparation through the mock-up in order to have a minimally invasive procedure. Next, we analysed the central incisor (CI) length and ratio, visibility of the anterior teeth in different lip positions (at rest, during smiling and during functional movements), levels of the fixed gingiva and zenith points. If necessary, based on this mock-up, we can perform gingival surgery in order to achieve a highly aesthetic final result.

According to many studies, resin–enamel bonds are reliable and durable. The presence of the enamel at the preparation margin offers a perfect seal against the ingression of oral fluids and bacteria. When the cavity margins are bonded to enamel, bonds to dentine are more durable (even a simplified, more hydrophilic adhesive may survive because of the protective effect of bonded enamel against the diffusion of water across the bonded interface).[2–4]

The greater the difference between acid solubility of enamel periphery and prism core, the stronger the

Table 2: Precision for laboratory CAD/CAM systems of different producers.[1]

Scanner and milling machine (product and manufacturer)	Measurement	Precision (µ)	Median precision (µ)
TRIOS (3Shape) D900 + RXD5 (Röders)	MVS	19.80	
Dental Wings DW-5-140 (Dental Wings) + D40 (Yenamak)	MVS	29.25	
Lava C.O.S. (3M ESPE) + Mori Seiki (DMG MORI)	MVS	48.00	
TRIOS (3Shape) D900 + DNM500 (SMT)	MVS	51.50	
TRIOS (3Shape) D900 + Zanotec (Wieland)	MVS	60.16	
iTero (Align Technology) + E4D milling machine (Planmeca)	MVS	68.50	
Dental Wings 3D (Dental Wings) + DC 40 (Yenadent)	MVS	71.80	
			49.85



Figs. 8–11: Microscopic views of acid etching of the enamel surface, prisms cut longitudinally and transversally, displaying the three acid etching patterns.[5]

bond is. Resin tags up to 25 µ in length and 6 µ in diameter are formed into microporosities of the conditioned enamel, providing a long-lasting bond by mechanical interlocking (the mean values of tensile and shear stress are 20–25 MPa, higher than the surface tension after polymerisation shrinkage of the composite resin [16–18 MPa]; Figs. 8–11).[5, 6–8]

While enamel is predominantly mineral, dentine is a vital tissue. Permeability of the dentine depends on the diameter of the dentinal tubules. The smear layer extends 1–10 µ into the initial part of the dentinal tubules. The smear layer is in direct proportion to the grain size of the bur. The smear layer has a weak bond to the underlying dentine. Micro- and nano-leakage phenomena still pose major theoretical and clinical challenges (Fig. 12).[5, 9–11]

Owing to minimal preparation, restricted to the enamel surface, local anaesthesia was not necessary in this case. Vitality of all teeth was maintained. Because of the necessity of closing the overjet, a slightly palatal preparation was performed (Figs. 13–15). The ceramic preparations were no thicker than 0.5 mm, and because of the minimal thickness of the ceramic restorations, a try-in paste was used in order to determine which cement to use (Figs. 16–19).

Digital approach

An intra-oral scan of the initial situation was performed (Primescan, Dentsply Sirona) and sent to the dental laboratory. Initially, we planned to scan the wax-up previously prepared in a conventional (analogue) way and to use these references for the final preparations. However, the software of the scanner could not match the teeth from the wax-up model and from the oral cavity, so we had to repeat the scanning and manually prepare the aesthetic modelling. The aesthetic modelling is time-consuming, and this has to be taken into consideration when choosing between a digital and conventional approach. In the digital chairside approach, all work is done in the dental office (Fig. 20).

Table 3: Median precision according to scanner type.[1]

Scanner type	Measurement	Median precision (µ)
Intra-oral	MVS	81.25
Model	MVS	75.32

Table 4: Median precision according to system type.[1]

Scanner type	Measurement	Median precision (µ)
In-office	MVS	78.40
Laboratory single brand	MVS	60.46
Laboratory composed	MVS	49.85

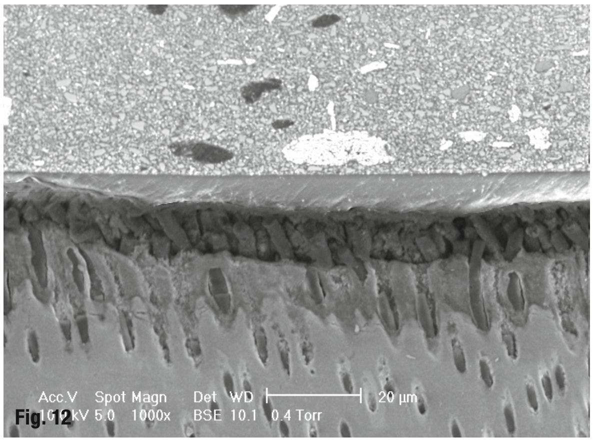


Fig. 12

Fig. 12: Microscopic view of demineralised dentine and penetration of the hybrid layer into dentinal tubules.[5]

If one wants to keep the workflow digital only, a virtual wax-up can be performed as well (3D-printed model), followed by a mock-up and the aforementioned aesthetic analysis. Guided enamel preparation is done through the mock-up in order to conserve as much tooth structure as possible.

Definitive ceramic restorations with a thickness of 0.3 mm were milled. They were sent to the dental laboratory for staining in order to achieve better aesthetics. For a highly aesthetic result, staining or the cut-back technique in the dental laboratory is mandatory. A try-in paste was used in order to observe the transparency of the tooth structure (Figs. 21–24).

Patient’s choice

The patient was asked to choose one of the sets of ceramic restorations (Figs. 25–31). From a clinical and technical point of view, both sets of restorations were perfect, both were adapted, functional movements were present for both and both were highly aesthetic. The patient chose veneers and crowns prepared using conventional techniques; her choice was totally subjective, since she did not know which set of restorations had been produced with the digital approach and which with the analogue procedures.

Conclusion

Are we able to follow a digital workflow for a major dental rehabilitation? In my opinion, yes; however, some learning is necessary, and in many cases, analogue and digital methods should be combined.

We can conclude the following:
- Both fully digital and fully analogue treatments are possible and give great aesthetic results, bearing in mind that staining and the cut-back technique is mandatory.
- Thickness of definitive restorations can vary between 0.3 and 0.5 mm for both approaches.
- Precision is perfect for both approaches.
- The double veneer technique is not possible when using the digital approach.

Table 5: Median precision and range according to system type.[1]

Scanner type	Measurement	Median precision and range (µ)
In-office	MVS	78.32 (39.60–161.40)
Laboratory single brand	MVS	60.46 (13.78–114.70)
Laboratory composed	MVS	49.85 (19.80–71.80)


Fig. 13


Fig. 14

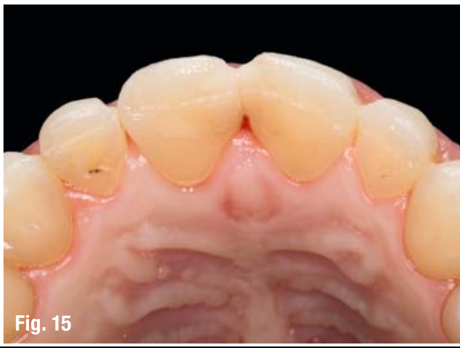


Fig. 15

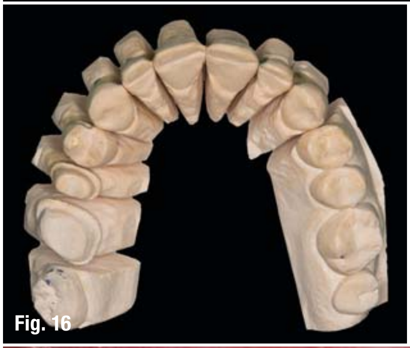


Fig. 16


Fig. 17


Fig. 18

Fig. 19


Fig. 20


Fig. 21


Fig. 22


Fig. 23


Fig. 24

Figs. 13–15: Minimally invasive preparation. **Figs. 16–19:** Final analogue ceramic restorations. **Fig. 20:** Digital modelling**. Figs. 21–24:** Final digital ceramic restorations.


Fig. 25


Fig. 26


Fig. 27


Fig. 28


Fig. 29


Fig. 30


Fig. 31

Figs. 25–31: Final results of the analogue and digital approach.

The future belongs to the digital approach certainly. My recommendation is to allow dental practitioners a period of learning in which to integrate digital and analogue methods, to start with minor cases and gradually progress towards fully digital and/or full-mouth rehabilitation.

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

about

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

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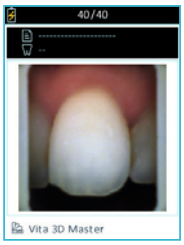

Polorized picture

Overall shade

3 parts mapping

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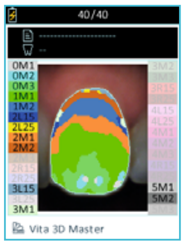
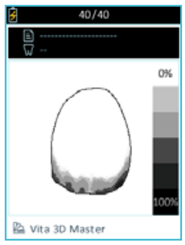


Detailed mapping



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A new smile in one day

Dr Gustavo Harfagar, Chile


Fig. 1


Fig. 2


Fig. 3


Fig. 4


Fig. 5

Introduction

Digital workflows can improve our treatment results. In this report, a multidisciplinary patient treatment is presented, focusing on the chairside workflow and the use of n!ce ceramic material (Straumann). Nine successful chairside restorations (six in the aesthetic zone) are described. The teeth and implants were prepared and scanned during the morning, and the final restorations were placed the same day. The patient received her new smile in a much shorter time than with traditional protocols, and this was a key driver in her decision to accept the treatment plan exclusively with Straumann digital solutions.

Initial situation

A generally healthy 51-year-old female patient visited our clinic requesting a new smile. On extra-oral and intra-oral examination, she was found to have a medium smile line with fixed restorations and multiple recessions in the aesthetic zone, carious lesions, inflammation, plaque and missing teeth at positions #16, 25, 26, 36 and 45 (Figs. 1–5).

Procedure

Treatment planning

After cause-related therapy (oral hygiene instructions, prophylaxis and dental fillings), the patient was ready for the surgical phase. This would include mucogingival surgery in the second sextant in order to improve the pink aesthetics and the placement of dental implants in the posterior region.

After the soft tissue had healed, the restorative phase would begin. In the second sextant, the old crowns


Fig. 6


Fig. 7


Fig. 8

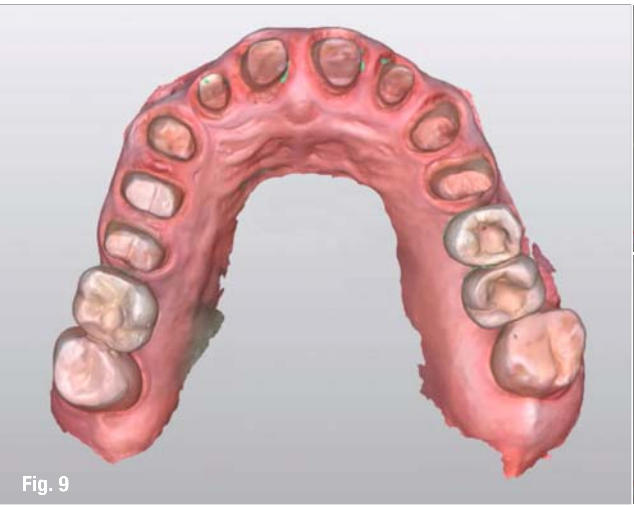


Fig. 9

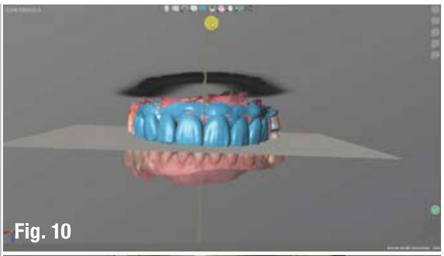


Fig. 10


Fig. 11

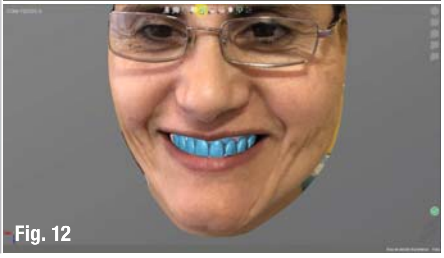


Fig. 12


Fig. 13

would be removed and the teeth prepared for the new n!ce crowns following the Straumann chairside workflow.

Surgical procedure

The five planned implants (Straumann Standard Plus; diameter: 4.1 mm, length: 8.0 mm, regular neck, Roxolid, SLActive) were placed in positions #16, 25, 26, 36 and 45 in one surgical phase. Provisional crowns were placed for all the implants.

The multiple recessions in the aesthetic zone were treated with a tunnel technique using a connective tissue graft taken from the palate. This surgery was performed by Dr Enrique Javer (Figs. 6–8).

Prosthetic procedure

When all the implants had osseointegrated, the posterior remaining teeth were prepared for crowns, and in the same session, a digital impression was taken with the new Straumann Virtuo Vivo intra-oral scanner.

Using the Straumann CARES Visual software, all the posterior crowns were designed and then milled with the Straumann CARES C series chairside milling machine. On the same day, after confirmation of fit, all crowns were placed and cemented. With the new vertical dimension, the mandibular premolars, canines and incisors were adjusted with IPS Empress Direct composite (Ivoclar Vivadent).

After a further intra-oral scan, a new smile was designed using Straumann CARES Visual. A 3D model printed with the Straumann P30 3D printer was used for the digital wax-up. Photographs were taken to register all the details needed for the final design of the restorations.

At the next appointment, the patient came to the clinic early in the morning. All the old crowns were removed, and teeth #24, 25 and 34 were prepared for crowns. Intra-oral data was acquired with Virtuo Vivo, and a photograph of the patient's face was taken.

STL files of the digital wax-up and prepared teeth and the patient's photograph were uploaded to Straumann CARES Visual, and the crowns were designed. After 25 minutes, all the crown designs were sent for milling with the C series milling machine. On completion of the milling process, all the crowns were placed for a final fit check (Figs. 9–13).


Fig. 14


Fig. 15


Fig. 16


Fig. 17


Fig. 18


Fig. 19


Fig. 20

The fit was confirmed, and only minor adjustments were needed at the contact points. The crowns were removed from the patient's mouth and polished by hand using OptraFine (Ivoclar Vivadent; Figs. 14 & 15). All the crowns were cemented using IPS Ceramic Etching Gel (Ivoclar Vivadent) according to the Ivoclar Multilink protocol (Figs. 16–21).


Fig. 21

Treatment outcome

The patient was very happy with the functional and aesthetic result, as well as the short treatment period. She finally received her new smile in a much shorter time than expected, and this was a key driver in her decision to accept our treatment plan.

about

Dr Gustavo Harfagar graduated with a BSc from the University of Chile in Santiago and then went to dental school at Universidad Mayor, also in Santiago. He completed his studies in implantology at the same university. For ten years, he was an assistant professor in the department of prosthodontics at the school of dental medicine of Universidad del Desarrollo in Santiago, Chile and a visiting professor at the postgraduate school at the same university. In 2016, he attended the ITI Education Week at Harvard School of Dental Medicine and Tufts University, both in Boston in the US. He returned to Harvard School of Dental Medicine for a continuing education course on digital restorative dentistry in 2017. In the same year, he was named director of the digital restorative dentistry programme at Universidad del Desarrollo. He gives lectures on digital dental technologies both nationally and internationally. Dr Harfagar has his own practice and twelve years of experience working in aesthetic and implant dentistry.

The copyCAD

Dr Yassine Harichane, France

Introduction

Nature has always captivated us with its beauty. Whether it is a landscape, a sunset or the intricate details of a leaf, one marvels at natural aesthetics. The goal of an artist is to copy nature in every medium: painting, sculpture, music, photography. It is easy to see parallels in dentistry. The teeth and soft tissue display details on the macroscopic and microscopic scale that make up all their beauty. Even the smile has characteristics that define what is beautiful and what is not. Like an artist, the dentist and the dental technician use all their combined talents to create lifelike restorations. The secret to imitating nature is in the details of daily practice and hard work.

Fortunately for dental practices and laboratories, technology has advanced considerably, making the ability to imitate nature much more achievable while paving the way for new practical methodologies. Performing a single restoration on a central maxillary incisor is a challenge, both technically and artistically. Whether it is a filling, a crown or an implant, all the skills of the artistic dentist must come into play because the patient naturally expects a result symmetrical to the contralateral tooth. Using the latest technology, it is as simple as the copy and paste function one is so accustomed to using on a computer. The dentist has gone from being an artist to a computer scientist with the same optics: copying nature in all its perfection.

On the basis of a clinical case without the utilisation of an intra-oral scan, I will demonstrate a workflow with CAD/CAM technology. This will show that the ability to copy nature has now become accessible to all practitioners.

Preparation

In this clinical case (Figs. 1 & 2), the patient wanted the aesthetic aspects of her smile to be improved without losing unique features she had come to consider as part of her look and personality. The maxillary anterior teeth showed caries and defective restorations, but their overall shape was satisfactory and they had a certain charm despite their defects. Although her premolars did not have an optimal aesthetic appearance, the patient's budget limited treatment to the incisors and canines.

The first step was to take an impression of the preoperative oral condition. Although the dimensions and appearance did not conform to all the rules of dental aesthetics, they would be preserved because they had characteristics specific to the patient and they respected the occlusal dynamics. The impression of the teeth can be taken with an intra-oral scanner. However, the number of dentists who own intra-oral scanners is relatively low. The current materials allow for a satisfactory physicochemical impression and remain accessible to all dentists. A polyvinylsiloxane impression was performed in one step and two viscosities (V-Posil Putty Fast and V-Posil X-Light Fast, VOCO) to record the initial clinical situation (Fig. 3).

Temporisation

The second step was to prepare the provisional crowns by copying and pasting the patient's teeth. After preparing the teeth, the impression is sent to the laboratory, which will scan and design the provisional crowns. Most CAD/CAM software possesses this copy and paste function (Fig. 4), so the scan and design processes take less


Fig. 1


Fig. 2

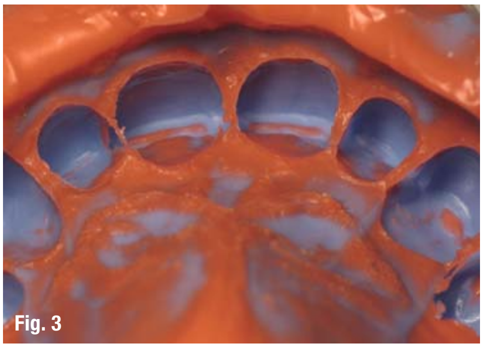
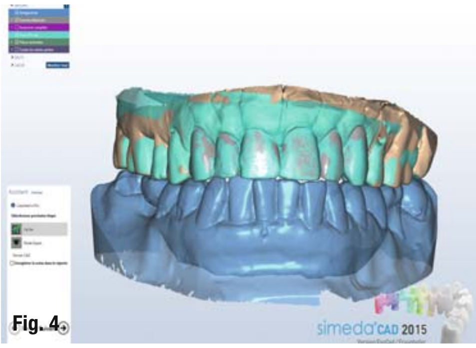


Fig. 3

Fig. 1: Initial situation, smiling. **Fig. 2:** Initial situation, frontal view with lips retracted. **Fig. 3:** V-Posil impression.



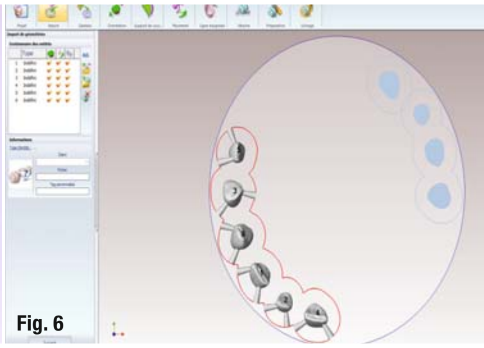


Fig. 4: Screenshot of the design software. **Fig. 5:** Structur CAD disc. **Fig. 6:** Screenshot of the nesting software.

than 1 hour. The six provisional crowns were then milled over the course of 1 hour and 30 minutes from a resin disc suitable for producing long-term provisional restorations (Structur CAD, VOCO; Figs. 5 & 6). Finishing the provisional crowns—checking the contact points, controlling the occlusion and polishing—required 30 minutes, allowing delivery of the crowns two days after taking the impression. The result obtained was strikingly natural (Fig. 7) thanks to the material's aesthetic properties: natural shade, easy polishing and improvable with characterisation. Concerning the form, the provisional crowns had an asymmetry that is found only in nature, being both spontaneous and pleasant. They were temporarily cemented in the mouth to validate the prosthetic project (Figs. 8 & 9). The material's biocompatibility clinically allows for a three-year maximum period in which the crowns can be worn, making it a material perfectly suited for complex cases, or those requiring periodontal rehabilitation. The material's composition provides not only excellent resistance to abrasion, but also the possibility of repair with a compatible composite. In this clinical case, the provisional crowns were kept in the mouth for one week—the time needed to prepare the definitive restorations. No defects were observed.

Finalisation

During the last stage, after the functional and aesthetic validation of the provisional crowns, definitive porcelain crowns (IPS e.max, Ivoclar Vivadent) were milled also by copying the preoperative situation from the original scan. The provisional crowns were then removed, and the underlying teeth were cleaned. After fitting and validation within the mouth, the definitive crowns were luted (Futurabond DC and Bifix QM, VOCO; Fig. 10). The final result was a harmonious smile that did not distort the features the patient considered to be an important part of her facial personality (Fig. 11).

Discussion

Therapeutic success is measured by dental and periodontal health, as well as by patient satisfaction and feedback from the healthcare team. The skills of a caregiver are not limited to making the right diagnosis or defining the ideal treatment plan; technical skills are essential and mimicking nature is a daily challenge.

Dentistry has come a long way with the introduction and implementation of digital technologies, becoming faster and more precise as a result. These tools are becoming increasingly popular, and many practitioners are quickly equipping their offices and operatories. Contrary to what one might think, the acquisition of an intra-oral scanner for the office is not an absolute obligation for one to take advantage of the digital dentistry revolution. Digital dentistry, above all, is a concept and we have just seen that it allows for an unsuspected and perhaps surprising function: copy and paste.

The advantages of copying and pasting are numerous and benefit everyone involved: dentist, dental technician and patient. For the dentist, the main advantage of copying and pasting is obtaining an intuitive result. On the one hand, the current materials (composite and porcelain), allow for a natural rendering. On the other hand, digital technology makes it possible to copy nature with all of her details. The use of computer-generated provisional restorations makes it possible to validate complex or demanding projects. In the end, restorations are both functional and aesthetic. They integrate perfectly with the occlusion because no major changes have been made. In addition, they integrate with the overall harmony of the face.

For the dental technician, the copy and paste function is part of his or her skill set. On the one hand, the laboratory scanner can capture every detail of the dental arch. On the other hand, milling machines can deliver strictly identical crowns over and over again as needed. The milling of a provisional disc or block will therefore validate the therapeutic project before moving to more expensive materials such as zirconia or lithium disilicate. In the same way, if returned to the laboratory, the cost will be lower by using a millable temporary resin. After provisional crowns are

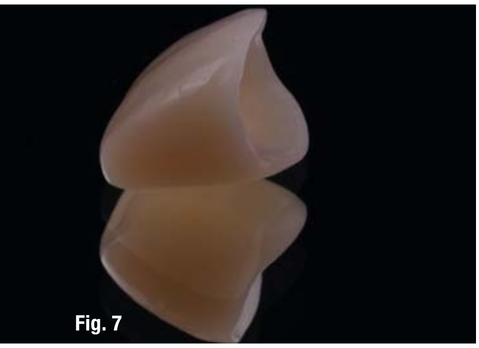


Fig. 7


Fig. 8


Fig. 9


Fig. 10


Fig. 11

Fig. 7: Structur CAD provisional crown. **Fig. 8:** Try-in of provisional crowns. **Fig. 9:** Smile with provisional crowns. **Fig. 10:** Porcelain crowns luted with Futurabond DC and Bifix QM (VOCO)**. Fig. 11:** Final result.

validated, the dental technician only needs to press a button to start producing the definitive crowns in the desired material.

For patients, digital dentistry is an education on just how far dentistry has evolved: technological advancements in clinical procedures are replacing many of those treatments of their bad childhood memories. It is now possible for the patient to reclaim the smile of his or her twenties. Better still, it is possible to copy the child's juvenile smile and place it in the deteriorated dental arch of the father. The smile will become a legacy that will be passed down through families.

Conclusion

Technology is making significant progress in dentistry, it is up to us to appropriate it. The emergence of new tools, such as intra-oral scanners, and unique new materials, like millable temporary resins, makes it possible to develop new therapeutic concepts and procedures. Copying and pasting is now a part of the dentist's, and dental technician's, therapeutic armamentarium. A copycat is an artist who tries to capture nature in all its glory through painting. Now, a copyCAD is an artist who can capture nature in all its perfection through CAD/CAM technology.

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about

Dr Yassine Harichane graduated from the Paris Descartes University and conducted several research there. He is an author of numerous publications and a member of the Cosmetic Dentistry Study Group (CDSG) at the Paris Descartes University in Paris, France.

Immediate post-extraction implants in the anterior maxilla

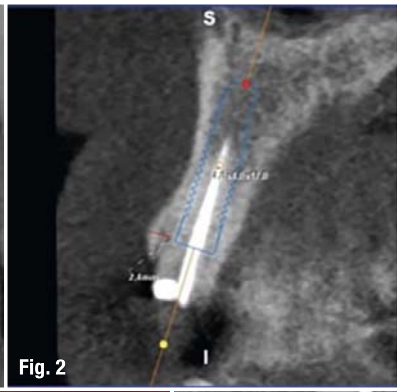
The importance of a high-resolution CBCT system in patient selection

Drs Gian Battista Greco & Danilo Alessio Di Stefano, Italy

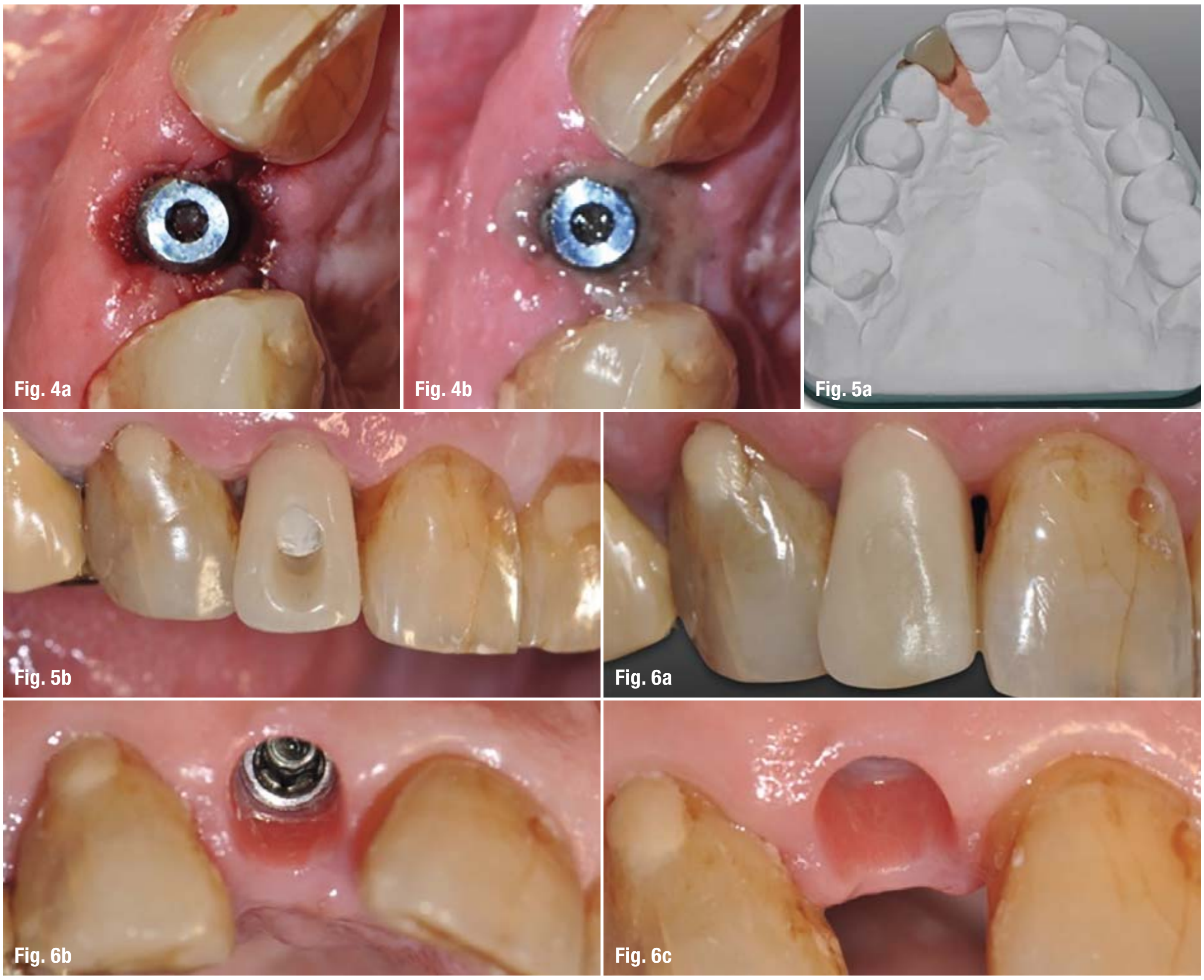
Introduction

Placement of an immediate post-extraction implant in the aesthetic zone is a sound and well-documented approach.[1–3] Yet the success of this procedure calls for careful selection of the candidate patient; if not performed following a precise decision tree, the risk of aesthetic and prosthetic failure is high.[4] Consequent to tooth extraction, the alveolar process undergoes a well-known sequence of events leading to progressive bone atrophy.[5–7] These 3D changes in the alveolar bone cannot be prevented by placing an implant immediately.

Immediate implant placement creates a condition that, conversely, may enhance bone resorption and accelerate the apical migration of soft tissue, mainly on the buccal side.[8, 9] These consequences may be prevented only by means of a careful preoperative diagnosis that involves assessment of the alveolar bone characteristics at the implant site and positioning the implant accordingly.[10, 11]



Figs. 1a & b: (a) The initial clinical situation and (b) the intra-oral radiograph taken when the patient presented. Tooth #12, which had been endodontically treated, had lost its crown because of a traumatic fracture. **Fig. 2:** The patient provided a CBCT scan obtained at another centre. On this scan, the buccal bone plate was measured with difficulty because of the background noise and therefore of the lack of sharpness of the scan images. It was found to be approximately 2.4 mm thick. **Figs. 3a–d:** Implant positioning. (a) The implant site underwent no flap elevation nor any bone or tissue regeneration. (b & c) The implant was placed according to the manufacturer's instructions and (d) at bone level.



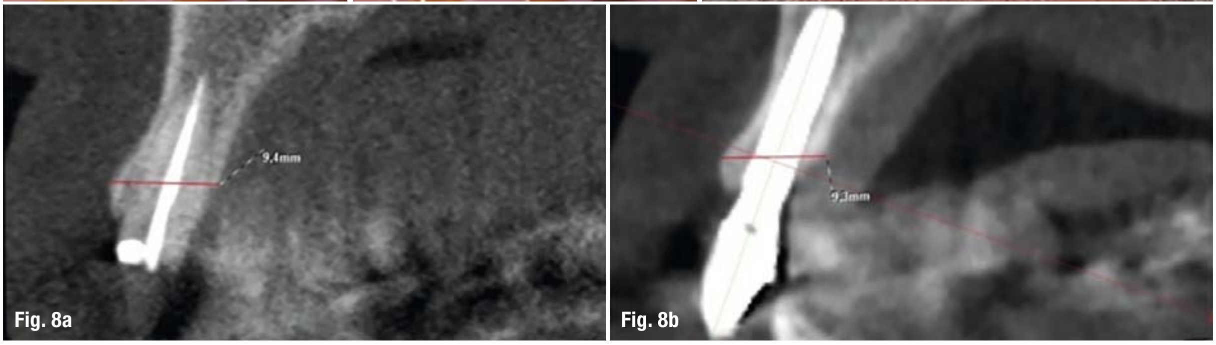
Figs. 4a & b: (a) The implant after placement, occlusal view. (b) Twenty-four hours later, the patient's own fibrin was visible around the implant. **Figs. 5a & b:** Provisional restoration. After taking an impression, a provisional crown was prepared (a) on the cast model and (b) delivered to the patient approximately 24 hours after the surgery. **Figs. 6a–c:** Five-month post-op control. (a) The provisional crown. (b & c) Soft-tissue conditioning was excellent. No buccal resorption was observed.

Some authors suggest routine regeneration of the hard and/or soft tissue using guided bone regeneration (GBR) and guided tissue regeneration (GTR) techniques to prevent resorption.[12, 13] Some even suggest abstaining from immediate post-extraction implant placement in the aesthetic area (such as Quirynen et al.: "When clinicians operate in the aesthetic zone it may be reasonable to allow soft- and hard-tissue healing before implant surgery to be able to compensate for the resorption at the buccal site."[14]). Yet both the periodontal biotype[15, 16] and the initial bone thickness[17, 18, 10] may strongly influence buccal bone remodelling after tooth extraction, and patients presenting with specific anatomical features, that is, a thick gingival biotype and a high-density and a coronal buccal bone plate that is more than 2 mm thick, show little or no tendency to alveolar bone resorption.

Additionally, the thickness of the periodontal ligament may be a predictor of the probability of fracture of the vestibular bone plate. Precise and reliable information about the gingival biotype, the cortical bone width and the periodontal ligament thickness are consequently of paramount importance when planning immediate post-extraction implant placement followed possibly by immediate implant loading. Beyond performing a careful clinical examination, the quality of the cone beam computed tomography (CBCT) scans recorded is crucial in collecting reliable information about the thickness of the periodontal ligament and of the buccal plate. Accordingly, the surgeon should use devices that provide high-quality, high-resolution scans, possibly measuring bone density in absolute Hounsfield units.[19] Given the small amount of radiation to which the patient is subjected when undergoing a CBCT examination, this may be safely applied even when planning the extraction and replacement of a single tooth.[20, 21, 22] The following case illustrates such an approach.

Case report

A 74-year-old male patient presented at the Dentalnarco dental centre in Trezzano Sul Naviglio in Milan in Italy with a coronal fracture of tooth #12 (Figs. 1a & b). He had already under-



Figs. 7a–c: The definitive crown was delivered to the patient, achieving a highly satisfactory aesthetic outcome. **Figs. 8a & b:** (a) The CBCT scan taken after 25 months using a high-quality, high-resolution CBCT device and (b) the initial CBCT scan. The buccopalatal thickness of the alveolar bone process was unchanged, showing complete preservation of the 3D bone features and confirming the correctness of the treatment plan. The high-resolution CBCT scan showed no metal artifacts and provided excellent details of the various anatomical parts, allowing accurate measurement.

gone a CBCT examination (using a 6 × 6 cm field of view) some days before at a different dental clinic (Fig. 2). Examination showed that the fractured tooth, previously devitalised, presented with a reduced ferrule because of the coronal fracture. The periodontal tissue was slightly inflamed because of marginal gingivitis. No significant pockets were detected with probing, and the gingival biotype appeared to be thick and flat. The CBCT scan provided by the patient showed a residual root of about 16 mm long, no bone defects and no endodontic lesions. The coronal buccal bone was a 2.0–2.5 mm thick dense cortical plate (Fig. 2).

The patient was first presented with a plan that would involve the orthodontic extrusion of the damaged tooth in order to allow for restoration with a prosthetic crown. The patient refused, however, and the alternative plan presented would involve extraction of the damaged tooth followed by immediate implant placement and possible delivery of an immediate screw-retained provisional prosthesis. Given the patient's apparently low risk of bone resorption, this plan did not call for any GBR or GTR procedures involving connective tissue grafting. The patient provided informed consent.

The patient underwent thorough professional cleaning four days before surgery. Antibiotic prophylaxis (amoxicillin and clavulanic acid, Augmentin, GlaxoSmithKline; 2 g 1 hour before surgery and then every 12 hours for eight to ten days) was initiated, and the patient was subjected to mouth rinsing with 0.2% chlorhexidine (Corsodyl, GlaxoSmithKline) and given instructions to continue this for two weeks after surgery. Nimesulide (100 mg; Aulin, Roche) was also administered 1 hour before surgery. The surgical area was anesthaetised using 40 mg/ml articaine hydrochloride with 1:100,000 epinephrine. No flap was elevated. The root was extracted atraumatically (Fig. 3a).

After probing the socket walls to check their integrity, a cylindrical 3.75 × 17.00 mm implant (Aries, IDI evolution) was placed (Figs. 3b–d, 4a & b). The maximum torque at insertion was 55 Ncm. After connecting a pick-up impression coping to the implant, an impression was taken with elastomeric impression material. The dental technician used this to prepare a cast and manufacture a screw-retained provisional crown (Fig. 5a). A screw-retained healing abutment was then connected to the implant, and the patient was dismissed.

Approximately 24 hours later, the provisional crown was connected (Fig. 5b). After checking all the interproximal contacts and unloading all the static and dynamic occlusal contacts, the retaining screw was tightened at 15 Ncm. The patient underwent no anaesthesia for this. He was advised to abstain from biting hard food with his incisors for eight weeks.

Five months later, the provisional prosthesis was removed and placed on the hard- and soft-tissue cast used for its manufacture. As no changes were observed involving either the soft tissue (Figs. 6a–c) or the interproximal contacts, a

definitive cement-retained prosthesis was manufactured using a commercial titanium abutment and a metal–ceramic crown. The abutment was connected to the implant by tightening the retaining screw to 25 Ncm, using a torque wrench, and the definitive prosthesis was connected using a temporary cement (Figs. 7a–c). Radiographs were taken and they confirmed a good fit of the prosthetic components and preservation of the peri-implant bone level.
Twenty-five months later, the patient presented asking to have his mandibular arch rehabilitated. Consequently, a new set of CBCT scans was obtained, and this enabled assessment of the peri-implant bone levels at position #12 (Fig. 8a). The CBCT examination was performed using a high-resolution CBCT device (X-Mind trium, ACTEON) with a 12 × 8 cm field of view. This system employs an acquisition and reconstruction algorithm that ensures a uniform and high-quality image on all visual axes, and the system employs 3D software with advanced functionalities. The high-quality CBCT scans made it possible to assess the peri-implant alveolar bone at position #12 with a very high degree of precision. They showed complete preservation of the alveolar bone, in both the buccopalatal dimension and the apicocoronal dimension when compared with the initial CBCT scan (Fig. 8b). This result confirmed the suitability of the preoperative treatment plan proposed to the patient.

Discussion

Patients like the one described here represent the ideal candidates for immediate implant placement without elevation of a flap or performance of any tissue regeneration procedures. Such patients (i.e. those with both a thick, flat periodontal biotype and more than 2 mm of thick cortical bone plate) are seldom encountered, as the association between gingival thickness and type and bone thickness is low.[23, 24] Identifying such relatively rare cases spares the patients longer, more expensive surgical procedures that do not offer any additional benefits but do increase morbidity.

In the presented case, a careful preoperative diagnosis made it possible to develop an adequate treatment plan. This spared the patient additional surgeries, possible infective complications, worse postoperative progress and additional costs. A misdiagnosis that called for additional procedures, such as bone grafting, to preserve the alveolar bone from resorption could have increased the risk of bone resorption as a result of disconnecting the periosteum[25] and, according to the outcome actually observed, would have meant overtreating the patient.

This case thus underscores the importance of a correct preoperative diagnosis. As this must be based on objective and precise data, using high-quality, high-resolution CBCT devices such as the X-Mind trium system to acquire high-definition scans can make a significant difference; the higher the quality of the scans, the greater the diagnostic power of the surgeon will be.

The difference between scans with high and low background noise, and thus different sharpness, may be easily appreciated by comparing the initial CBCT scan provided by the patient in the present case, which allowed assessment of the thickness of the buccal bone plate only with great difficulty, to that taken after 25 months. In the latter, virtually no metal artifacts can be observed and all the anatomical elements surrounding the implant, that is, the alveolar cancellous and cortical bone layer, the soft tissue and the empty spaces, could easily be distinguished and their dimensional parameters carefully measured. This confirms that high-quality, high-resolution CBCT devices are a necessary tool for gaining reliable information and identifying sound, proper therapeutic alternatives.

Conclusion

When planning immediate post-extraction implant placement in the aesthetic zone, a proper preoperative diagnosis is essential. Thick and flat gingival biotype patients who have more than 2 mm of buccal bone may be safely rehabilitated without elevating flaps or performing other procedures aimed at preserving the alveolar bone. Under certain conditions, it may be possible to immediately load the implant. Conversely, misdiagnosis may expose the patient to additional discomfort, expense and overtreatment. Using only high-quality, high-resolution CBCT devices can help to prevent such misdiagnosis.

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

about

Dr Gian Battista Greco graduated from the University of Trieste in Italy in 2000. In 2007–2008, he completed a biennial master's degree in prosthetics and implantology at the University of Milan in Italy under the direction of Dr Stefano Gracis. He is in private practice in Trezzano Sul Naviglio at the Dentalnarco dental centre, of which he is co-owner, and concentrates his activity mainly in the field of prosthetics and implant prosthetics. He is the author of scientific publications and has lectured at national and international courses and conferences.

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Digital workflow with a metal-free surgical guide and zirconia implant

Dr Saurabh Gupta, India

In recent years, ceramic implants have become an attractive and reliable alternative to titanium implants. With the advancement of digital implant dentistry and increasing use of metal-free surgical guides, there should be reliable guided surgery options available to place such implants.[1–3] There are different kinds of surgical guide designs available in the current market. The ideal guide should be produced defect-free; should offer precision, a perfect fit and high primary stability; and should aid exact reproduction of the planning.[4] Furthermore, the surgical guide should be robust and thus not be affected by transport, storage and sterilisation. In addition, the guide design should allow clear visual inspection and easy irrigation. Finally, the use of this guided system should not lead to an increase in the cost of the operation.[5–8] Companies manufacturing guided systems for dental implant placement offer surgical guides of almost similar design: they are tooth-, mucosa- or bone-supported, and mostly made out of resin, and drilling and implant holes are placed within the body of the guide itself. These drilling holes usually receive metal sleeves of various diameters to guide successive drills.[9, 10] In this case report, we used a metal-free fully guided system (2ingis) for the placement


Fig. 1a
Fig. 1b

Figs. 1a & b: Missing tooth #36. **Figs. 2a–d:** Digital planning with SMOP software.

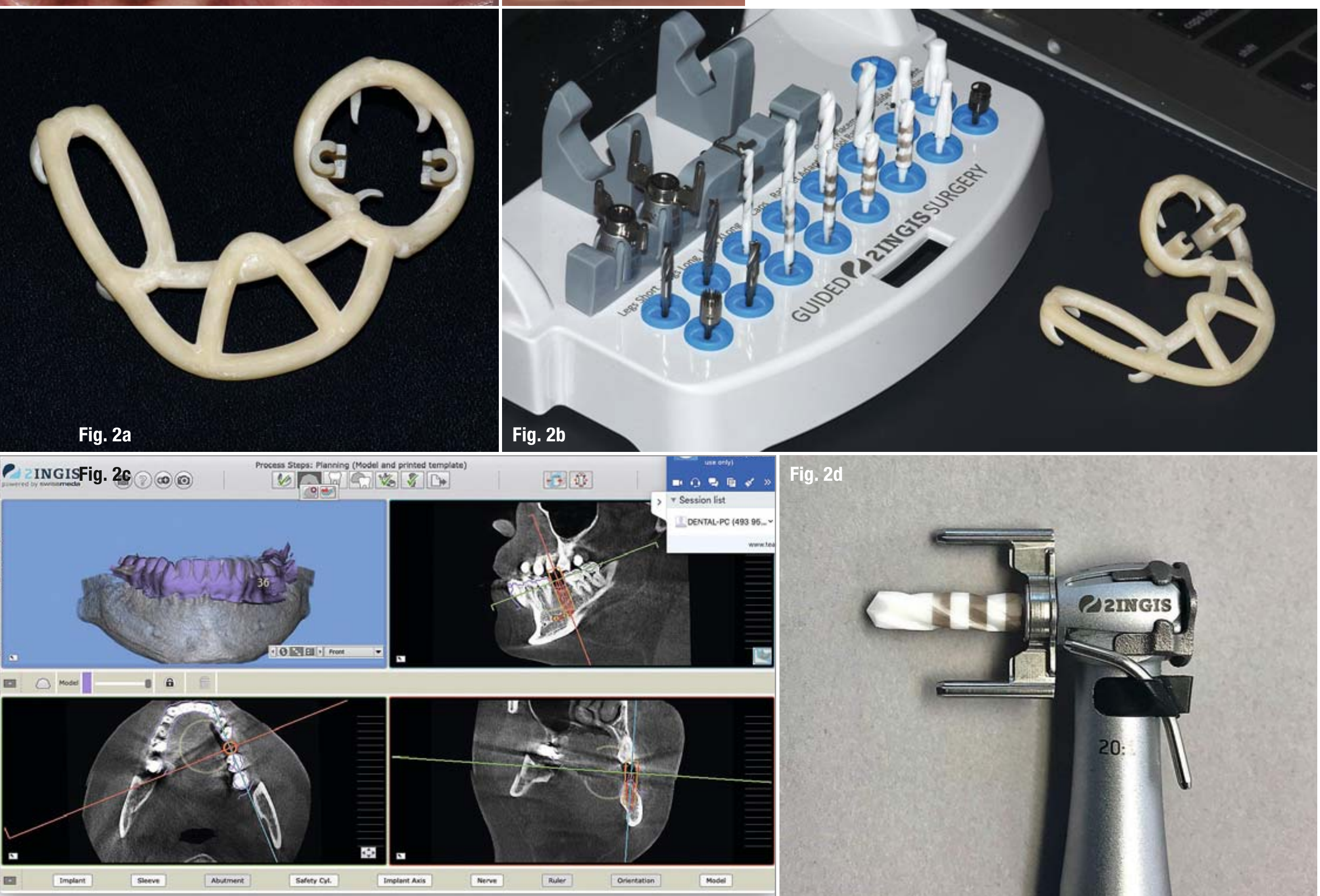

Fig. 2a
Fig. 2b
Fig. 2c
Fig. 2d

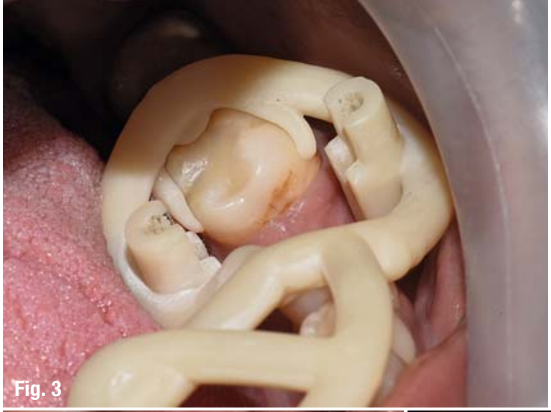
Fig. 3

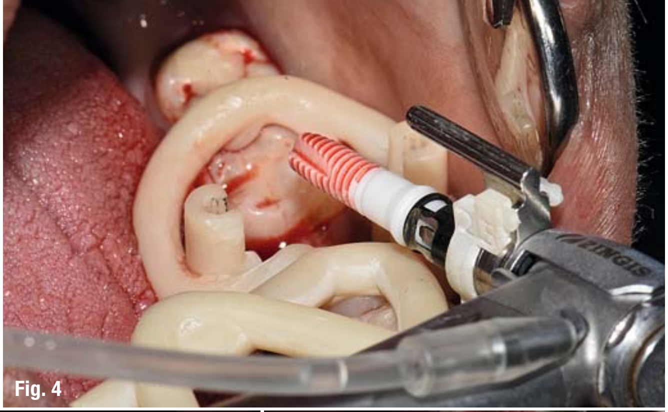
Fig. 4


Fig. 5


Fig. 6a


Fig. 6b


Fig. 7a

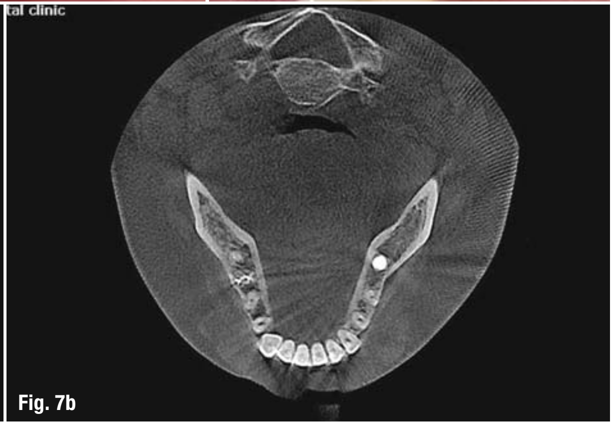

Fig. 7b

Fig. 3: Stabilisation of guide. **Fig. 4:** Implant placement. **Fig. 5:** Ideal position of implant. **Figs. 6a & b:** Immediately post-op **(a)**; seven days post-op **(b)**. **Figs. 7a & b:** CBCT scan.

of a ZiBone zirconia dental implant (COHO Biomedical Technology) for missing tooth #36 (Figs. 1a & b).

Planning phase

The manufacturing of the surgical guide was done using CAD/CAM technology. The design of the guide was first worked out on a computer with CAD software (SMOP, Swissmeda) after the DICOM and STL files had been uploaded (Figs. 2a–d). Guide stability by dental supports was sought preferentially. Finally, the surgical guide was printed in try-in resin using a NextDent 3D printer (3D Systems).

Surgical phase

During the surgical phase, flapless surgery was performed and the specific surgical kit (2ingis) was used along with the instruction manual provided. It included a contra-angle handpiece (W&H) with guide forks of different lengths (depending on the patient's mouth opening, the edentulous span and the depth of drilling). It also has depth wedges, a ring with two arms (to be inserted into the guide tubes in the same way as for the drilling guide fork) to guide the implant holder during manual placement of the implant, a metal trephine to cut the gingival tissue, and zirconia drills which allow flattening of the bone crest and performing of the initial drilling (pilot drill), respectively. Zirconia drills were then used for the rest of the drilling sequence, using depth wedges when necessary. The instruction manual was followed, which listed the drills needed throughout the surgery phase. With the surgical guide remaining in place, the implant was placed with the contra-angle handpiece in the planned site with good primary stability, and the desired torque of 35 Ncm was achieved (Figs. 4–6b).

Prosthetic phase

The provisional restoration was prepared and fixed soon after intra-oral scanning (TRIOS, 3Shape) of the abutment part of the zirconia implant (Fig. 8). The crown was

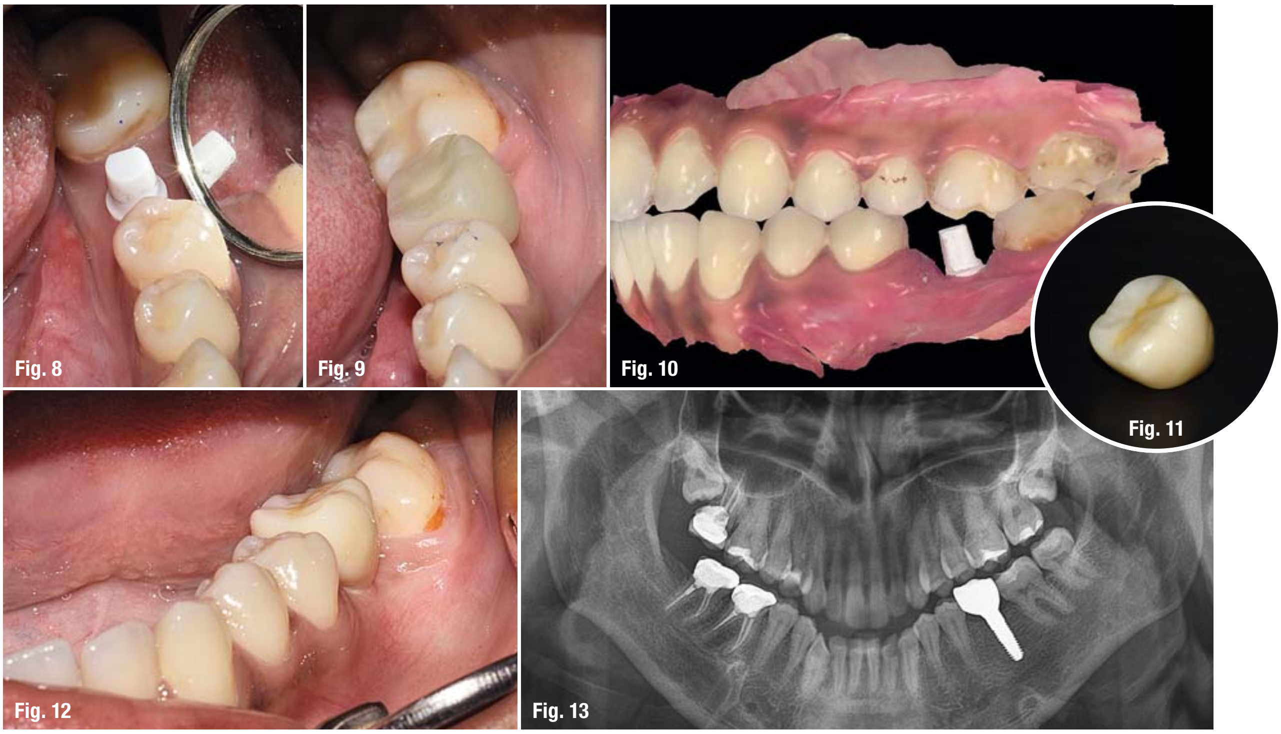

Fig. 8: Provisional restoration. **Fig. 9:** Twelve weeks post-op. **Fig. 10:** Intra-oral scan. **Fig. 11:** Monolithic crown. **Fig. 12:** Final crown *in situ*. **Fig. 13:** Final radiograph.

kept out of occlusion, and strict instructions were given to the patient. The osseointegration process was successful, and the implant was planned for restoration using a permanent monolithic zirconia crown (3M) after 12 weeks (Fig. 9). The TRIOS intra-oral optical scan was retaken with the provisional restoration seated (Fig. 10). The final monolithic crown was then designed, milled and prepared according to a completely digital workflow (Fig. 11). The crown's intaglio surface and the implant's abutment surface were cleaned and primed with a coating of Z-Prime Plus (BISCO) and was later cemented with a self-adhesive resin cement (3M ESPE). Extra cement was carefully removed using dental floss soon after the final crown had been cemented. The occlusion of the crown was checked with articulating paper. The patient was well satisfied with the treatment procedure with respect to both form and function (Figs. 12 & 13).

Conclusion

In conclusion, the metal-free surgical guide stands out from other guided systems and appears to be a significant advancement in the field of guided implant surgery. In this case report, the wide-open design of this guide allowed unrestricted irrigation and visual control under conditions comparable to those of surgeries performed without surgical guides. There was no friction of the zirconia drills on the surgical guide, which would have damaged it or contaminated the drilling hole with sleeve particles torn from the guide. This metal-free guided system seems to be ideal for placement of zirconia dental implants.

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

about

Dr Saurabh Gupta is an oral and maxillofacial surgeon from India. He is a private practitioner working as Clinical Director at the Digital Dental Design Clinic & DVG's lab (3M authorized) in India. He is Education Director/Board Member of the International Academy of Ceramic Implantology (IAOCI) and part of the Zirconia Implant Research Group (ZIRG) in the US. In addition, he is a fellow and an ambassador for the Clean Implant Foundation in Germany. At present, he is involved in many research studies on zirconia implant materials and digital dentistry.

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Treatment of an edentulous space with a digital workflow

Two-piece ceramic implants in the aesthetic zone

Prof. Heinz Kniha, Thomas Lassen & Dr Kristian Kniha, Germany

More and more dentistry students, individuals working in dental care, dental science and dental technology, as well as university lecturers, are now encountering modern zirconia implants. The subject of zirconia implants not only polarises patients, but is also hotly debated at international congresses and in respected scientific publications. Irrespective of this, the amount of evidence-based *in vivo* data concerning zirconia implants continues to grow. On the one hand, the ceramic surface allows a very pleasing aesthetic result to be achieved, especially in the soft-tissue region. Studies with a follow-up period of three years have shown that hard tissue remains stable and that there is even a statistically significant enlargement of the interdental papillae.[1–3] On the other hand, an experimentally induced mucositis study has shown that titanium implants prompt a greater inflammatory immune response to plaque accumulation with regard to specific inflammatory markers (interleukin-1 beta values, total bacterial count and sample volumes of *Tannerella forsythia* and *Prevotella intermedia*).[4,5] These clinical insights into zirconia implants lead us to hope that the risk of peri-implantitis too can be minimised with the lower incidence of mucositis. Initially, single-piece zirconia implants were restored with cement-retained prostheses.


Fig. 1


Fig. 8


Fig. 2


Fig. 3

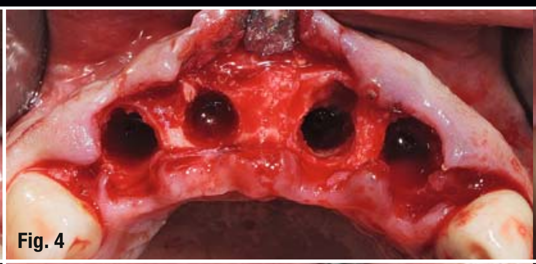


Fig. 4


Fig. 5

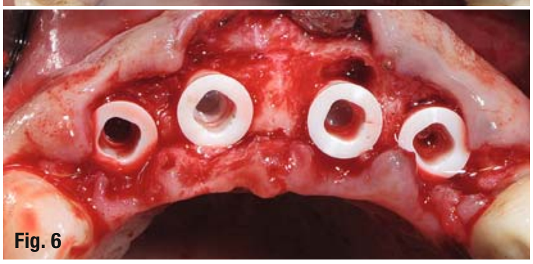


Fig. 6


Fig. 7

Fig. 1: Radiographs showing root fillings and post-and-cores in teeth #12, 21 and 22. **Fig. 2:** Visible scarring after apicectomy and dark-coloured gingiva in region #11. **Fig. 3:** Secondary caries in the hopeless abutment teeth. **Figs. 4–6:** Immediate implantation of two-piece zirconia implants in regions #12, 11, 21 and 22. **Figs. 7 & 8:** An intra-op digital impression of the two-piece implants was taken.

Now, two-piece implants allow screwed connections between the prosthesis and implants. The following case describes the clinical application of two-piece zirconia implants in an extensive anterior reconstruction in combination with digital procedures.

Patient case

Baseline

This is a clinical case of a 34-year-old healthy woman. The baseline showed a splinted bridge extending from tooth #12 to tooth #22, where tooth #11 had been replaced with a bridge unit. Radiographs showed root fillings and post-and-cores in teeth #12, 21 and 22 (Fig. 1). Scarring after apicectomy and dark-coloured gingiva in region #11 were noted (Fig. 2). Clinically, there was a loosened bridge with secondary caries in the hopeless abutment teeth (Fig. 3). The procedure was explored with the patient and the various treatment options were discussed. The patient wanted a permanently fixed restoration for which the healthy adjacent teeth in positions #14 and 13 should not be ground down. With this in mind, to close the gap, four zirconia implants restored with screw-retained crowns with palatal screw access holes was agreed with the patient. The patient exhibited excellent oral hygiene. All conditions for immediate implantation with immediate treatment (without immediate loading) were met.

Surgical procedure

A pickup impression was taken so that chairside temporary restorations could be produced after the implantation. First, teeth #12, 21 and 22 were extracted atraumatically. After tooth extraction, the situation was not inflamed and there was sufficient bone available to allow immediate implantation of two-piece zirconia implants (PURE implants, with the ZLA surface, Straumann) in regions #12, 11, 21 and 22 while maintaining primary stability (Figs. 4–6). This was achieved with a minimally invasive approach via a marginal incision without vestibular release. Scan bodies allowed an intraoperative digital impression of the two-piece implants to be taken (TRIOS 3, 3Shape; Figs. 7 & 8). The digital data set was then sent via the Internet to the laboratory to produce temporary crowns.

Prosthetic restoration

Wound closure was performed with single interrupted sutures. All scan bodies were shortened and transformed into provisional telescopic solutions. The temporary crowns were made with Luxatemp (DMG Chemisch-Pharmazeutische Fabrik) based on the existing pickup


Fig. 9


Fig. 10

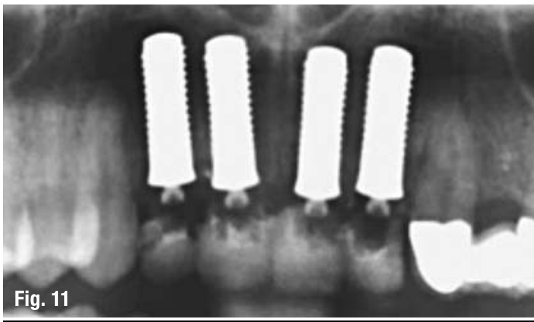


Fig. 11


Fig. 12


Fig. 13

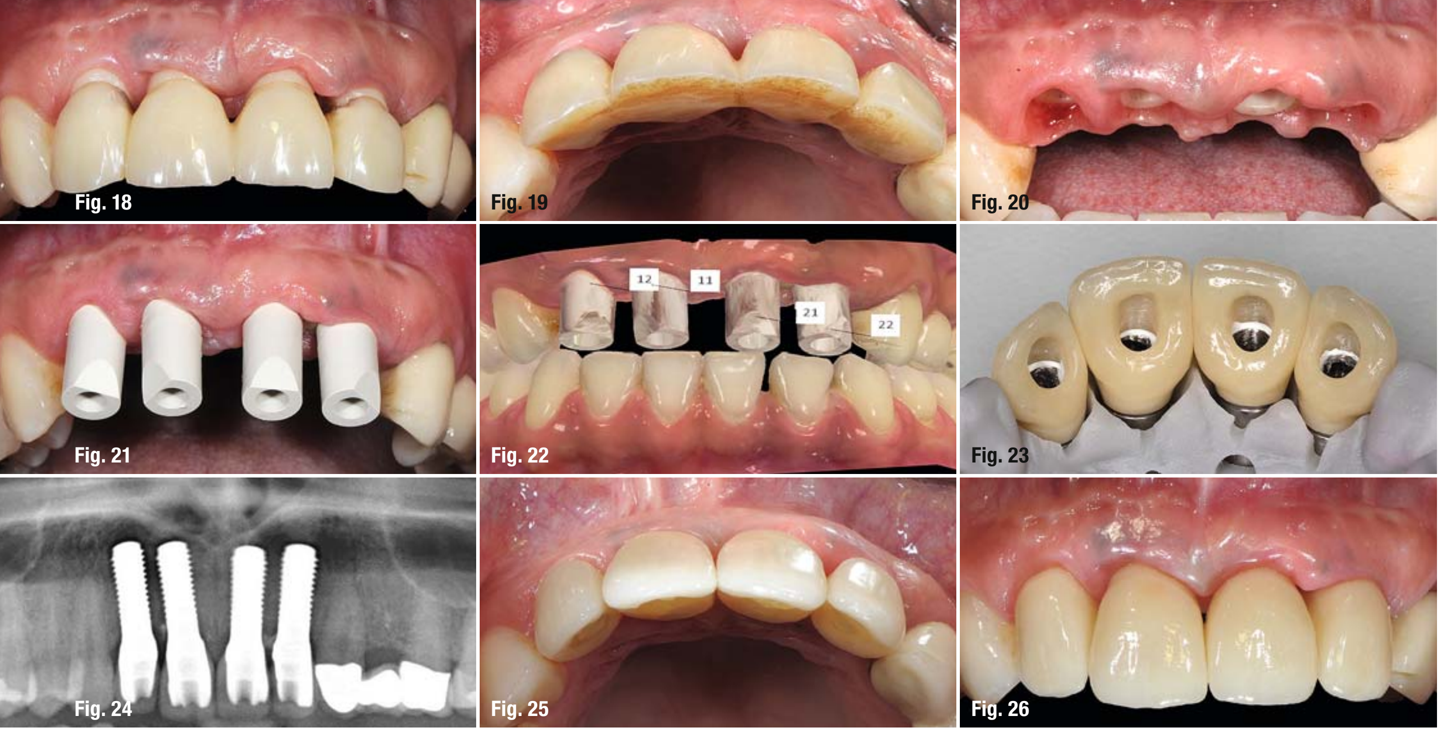

Fig. 14


Fig. 15


Fig. 16


Fig. 17

Figs. 9–12: The temporary crowns, which were made based on the existing pickup impression, were provisionally cemented to the anchoring elements. **Figs. 13–17:** Clinical situation at the second appointment seven days after the implant surgery. The dental restorations were produced by the Thomas Lassen dental laboratory.



Figs. 18–22: Another digital impression of the intra-oral situation was taken. **Fig. 23:** The definitive implant prostheses. **Figs. 24–26:** The radiographic and clinical situation six weeks post-op.

impression. These were then provisionally cemented to the anchoring elements with Temp-Bond (Kerr Dental, Figs. 9–12). During the cementing process, it was essential that no material was pressed into the periodontal gap. Postoperative radiographic follow-up was performed in line with the cementation protocol (Fig. 11). The temporary restorations were taken out of occlusion, and the patient was instructed not to bite off food with her incisors in the next three months, but rather to spread the masticatory force to the posterior region.

All the dental restorations were produced by the Thomas Lassen dental laboratory (Figs. 13–17). The sutures were removed as standard on the seventh day postoperatively. In the same appointment, the chairside temporary restorations were replaced with aesthetically high-quality temporary restorations made of composite in the form of a crown block. Provisional bonding was achieved with Temp-Bond on the screw-retained zirconia mesostructures. After a total healing phase of three months, there was a significant harmonisation of the soft-tissue situation. Another digital impression of the intra-oral situation was taken so that the final crowns could be produced (Figs. 18–22). The CAD/CAM-supported workflow allows simple and time-saving procedures using modern materials. The definitive implant prostheses consisted of screw-retained customised CAD/CAM-milled zirconia frameworks which were bonded with the angled Variobase abutments in the laboratory and then veneered (Fig. 23). The radiographic and clinical situation six weeks after implantation showed stable bone progression and irritation-free, pale membranes (Figs. 24–26).

Conclusion

Two-piece zirconia implants allow reliable anterior reconstruction with predictable outcomes. The individual soft-tissue conditioning can start directly after implantation. The digital workflow in particular supports the optimum shaping of the peri-implant soft tissue with ceramic materials and accelerates interdisciplinary processes. It is evident that there is an increase in the size of the interdental papillae in the first three years. For this reason, the interdental spaces should be physiologically designed from the outset as part of the prosthetic treatment.

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

about

Prof. Heinz Kniha is a Munich-based oral surgeon working in a joint practice together with Dr Karl Andreas Schlegel. He is highly specialised in implant dentistry and is an internationally prominent figure in research on zirconia implants. He studied dentistry and human medicine at the Friedrich-Alexander-University Erlangen-Nürnberg and University Hamburg, and completed his education as a specialist in maxillofacial surgery under the supervision of Prof. Dieter Schlegel at the Medical Center of the University of Munich. Today, being the author of many scientific articles, he is frequently invited to lecture at dental conferences on an international level.

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Digitally fabricated bulb obturator using virtual data and 3D printing

Dr Tariq Saadi, UAE

Introduction

Computer-assisted digital planning has become an important diagnostic and therapeutic tool in modern dentistry. Digital technologies related to imaging and manufacturing provide the clinician with a wide variety of treatment options. Additive manufacturing (3D printing) technology offers a simple and predictable means of fabricating dental prostheses.[1]

This case report presents the rehabilitation of a patient who had undergone a hemi-maxillectomy. This clinical case describes the digital workflow using an intra-oral digital impression, 3D facial scanning, and cone beam computed tomography (CBCT) volumetric data to create a digital (3D) virtual model of the dentition, defect area, and soft and hard tissue for this patient. 3D printing technology was used to manufacture a resin obturator prosthesis (a hollow bulb with a removable partial denture).[2]


Fig. 1


Fig. 2a


Fig. 2b

Clinical case

Clinical history

A 65-year-old patient with squamous cell carcinoma of the maxillary left alveolar process presented to our clinic two months post-surgery. According to her medical report, she had undergone left hemi-maxillectomy, left neck dissection and a split-skin graft harvested from her left thigh for the lining of the maxillary defect (Fig. 1).

Clinical examination

There was a significant limitation in her mouth opening, owing to radiation and surgical scar contracture, a stiff oral aperture and difficulty in stretching of the lips. Intra-oral examination revealed the surgical removal of the entire upper left jaw, including the premaxilla, maxilla, and hard and soft palate. The dissection extended to the nasal septum, and there was communication between the oral cavity and nasal cavity (Fig. 2a). For two months after the surgery, the patient had worn a medicated gauze pack covering a flat acrylic plate retained by metal clasps (Fig. 2b).[3]

Chief complaint

The post-surgical maxillary defect had resulted in hyper-nasal speech, leakage of fluid into the nasal cavity and impaired masticatory function.[4] Trismus, xerostomia, mucositis, tissue ulceration and gingival bleeding were

Fig. 1: Initial situation with missing maxillary left dentition. **Fig. 2a:** Mirrored intra-oral view revealing a surgically removed left maxilla, extending up to the nasal septum. **Fig. 2b:** Used medicated gauze and flat acrylic plate with metal clasps.

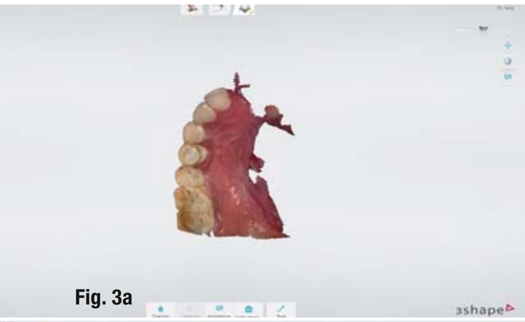


Fig. 3a

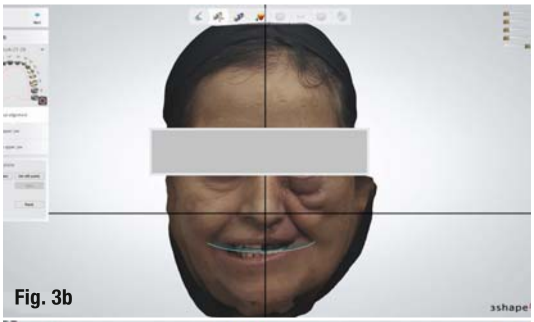


Fig. 3b


Fig. 3c

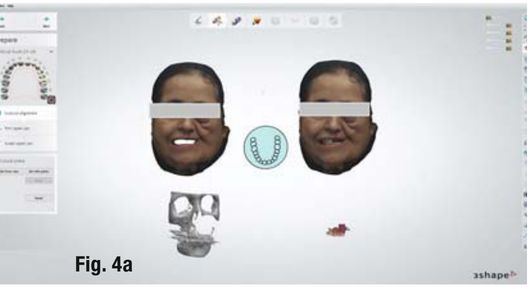


Fig. 4a


Fig. 4b

Fig. 3a: Intra-oral digital impression of the right maxilla. **Fig. 3b:** 3D facial scan. **Fig. 3c:** CBCT image. **Fig. 4a:** Acquired 3D data placed into one software program: facial, CBCT and intra-oral scan data. **Fig. 4b:** Merged digital data using the Dental System software.

side effects of the patient's postoperative chemoradiotherapy (adjunctive treatment).

Dental assessment

The absence of a dental prosthesis had resulted in both functional disability and cosmetic disfigurement.[2, 4] The fabrication of a dental prosthesis like a bulb obturator and denture is essential for oral functions such as speech, swallowing and mastication, and for esthetics.[5]

Limited mouth opening (microstomia)[3] commonly leads to difficulties in taking conventional impressions even when using custom-fabricated trays. The reduced mouth opening hinders conventional dental treatment, and so alternative procedures have to be considered in order to overcome these challenges when managing the case.

Digital technology creates opportunities for enhancing the fabrication and delivery of a maxillofacial prosthesis.[5] Digitised data of any object can be obtained from various sources, such as CBCT, 3D facial and 3D intra-oral scans (digital impressions).

Data collection phase

Digitising this patient was initiated with an intra-oral digital impression (TRIOS 3, 3Shape). Utilising the intra-oral scanner allowed for successful capture of the right maxilla and remaining dentition, even with the limited mouth opening (Fig. 3a).[6, 7] A facial scanner (Bellus3D) was then utilised to digitise the patient's face (Fig. 3b).[8] A CBCT unit (GiANO HR, NewTom) was capable of producing high-quality 3D diagnostic images in submillimetre resolution with a short scanning time, low radiation exposure, and minimal distortion, capturing the maxillofacial hard and soft tissue accurately (Fig. 3c).[9, 10]

Data integration phase

The representation of a 3D virtual patient requires the successful superimposition of the data collected on the 3D structures: (1) the DICOM format derived from the CBCT scan; (2) the STL and PLY formats derived from the intra-oral scan; and (3) the OBJ format derived from the facial scan. showing colour and texture information.[11] The key to linking the different files was to identify common reference points as constant landmarks within the same software in all three data acquisitions, to allow for predictable superimposition, in order to create a 3D virtual patient (Fig. 4a).[11] In this case, all the data was integrated using the Dental System software (3Shape; Fig. 4b). The superimposition of data from the CBCT, intra-oral and facial scans and the creation of the virtual patient allow for better diagnosis, treatment planning and communication with the patient, the laboratory and other professionals involved in the treatment.[11]

Treatment plan

The goal of treatment for this patient was to restore a barrier between the oral cavity and the structures above it.[12] Owing to the complexity of this case and the difficulty in inserting and removing the obturator, the decision was made to fabricate[13] a detachable obturator to overcome this problem.[14] The plan

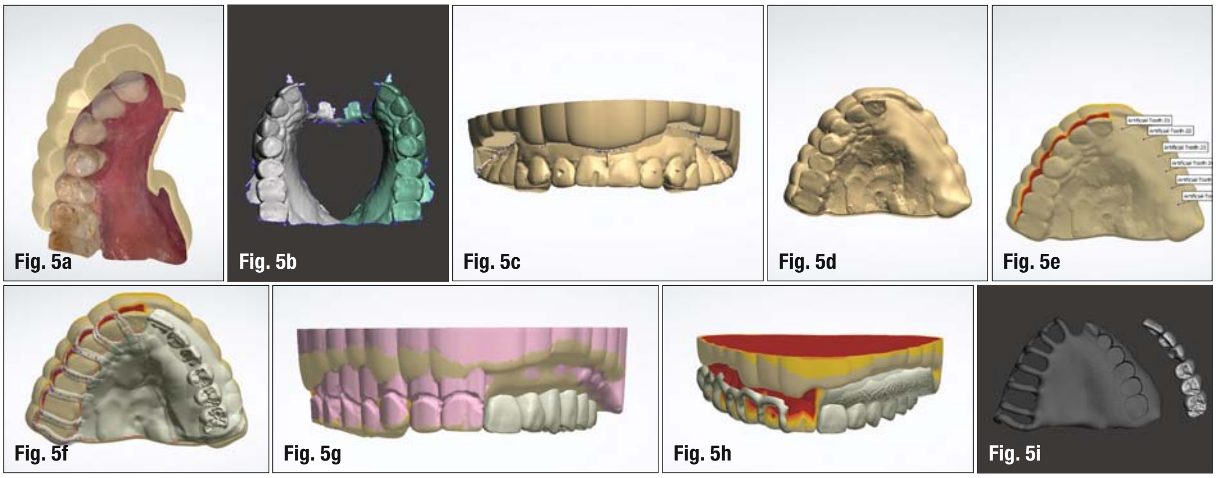


Fig. 5a: First step in fabrication of the removable partial denture. **Fig. 5b:** Digital maxillary left dentition acquired by mirroring the data gathered from the right maxilla. **Fig. 5c:** Complete digital maxillary dentition. **Fig. 5d:** Digital maxillary left teeth virtually extracted. **Fig. 5e:** Digital maxillary dentition with artificial left alveolar ridge. **Fig. 5f:** Digital maxillary dentition with denture borders. **Fig. 5g:** Digital maxillary dentition with designed maxillary left teeth. **Fig. 5h:** Digital maxillary dentition with an artificial left alveolar ridge and left teeth. **Fig. 5i:** Final removable partial denture design for printing.

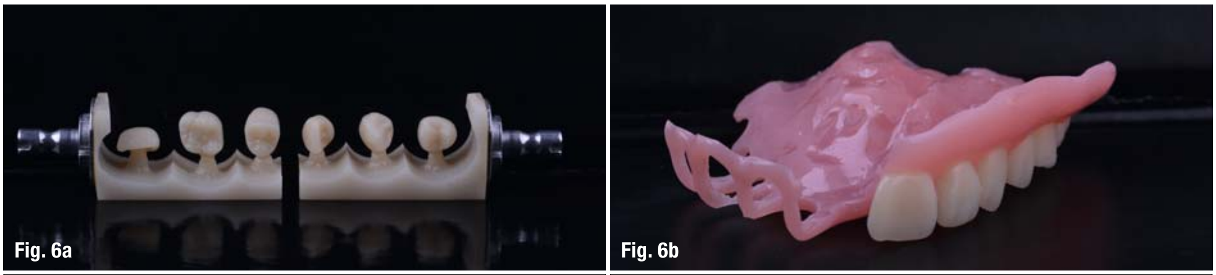
was to fabricate a hollow bulb and a removable partial denture as a transitional solution for this patient, until the surgical site had healed completely and patient was prepared, physically and emotionally, for any further surgical and restorative care that might be necessary.[15]

Prosthetic phase

Digital denture fabrication

Digitalisation of intra-oral data enables design and fabricate of dentures without trays or conventional impressions.[16] A digital workflow using design software and a 3D printer was simplified to produce a partial denture quickly, easily and cost-effectively:

1. Denture fabrication began by importing the patient's digital data (CBCT, intra-oral and facial scan data) into Dental System to create a 3D virtual patient (Figs. 4a & b).
2. A digital artificial substructure for the left maxilla was required to allow for setting up of the virtual teeth (Fig. 5a). The upper right jaw intra-oral scan data was inserted into Meshmixer software (Autodesk), and the copy and mirror tools were used to create a digital upper left jaw in the mirror image of the acquired data of the right side of the jaw (Fig. 5b).[17]



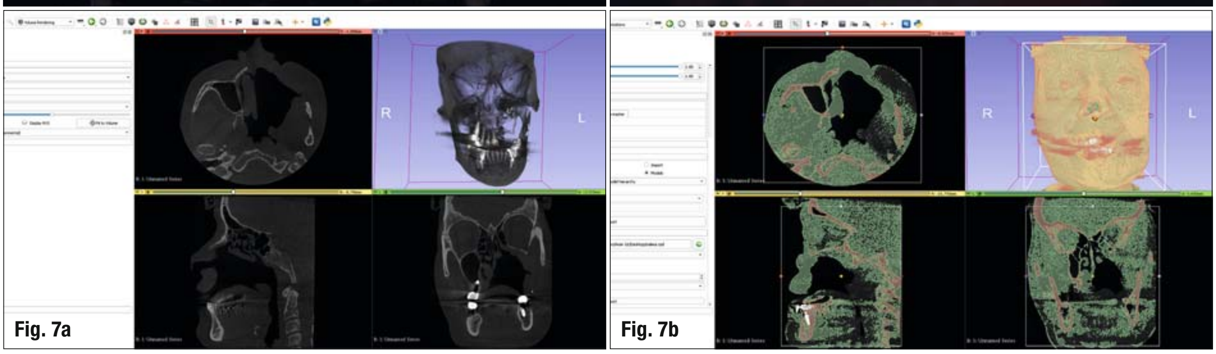


Fig. 6a: Milled teeth (milled using the CORiTEC 140i, imes-icore). **Fig. 6b:** Printed denture. **Fig. 7a:** 3D image from CBCT data. **Fig. 7b:** Segmented hard and soft tissue using 3D Slicer software.

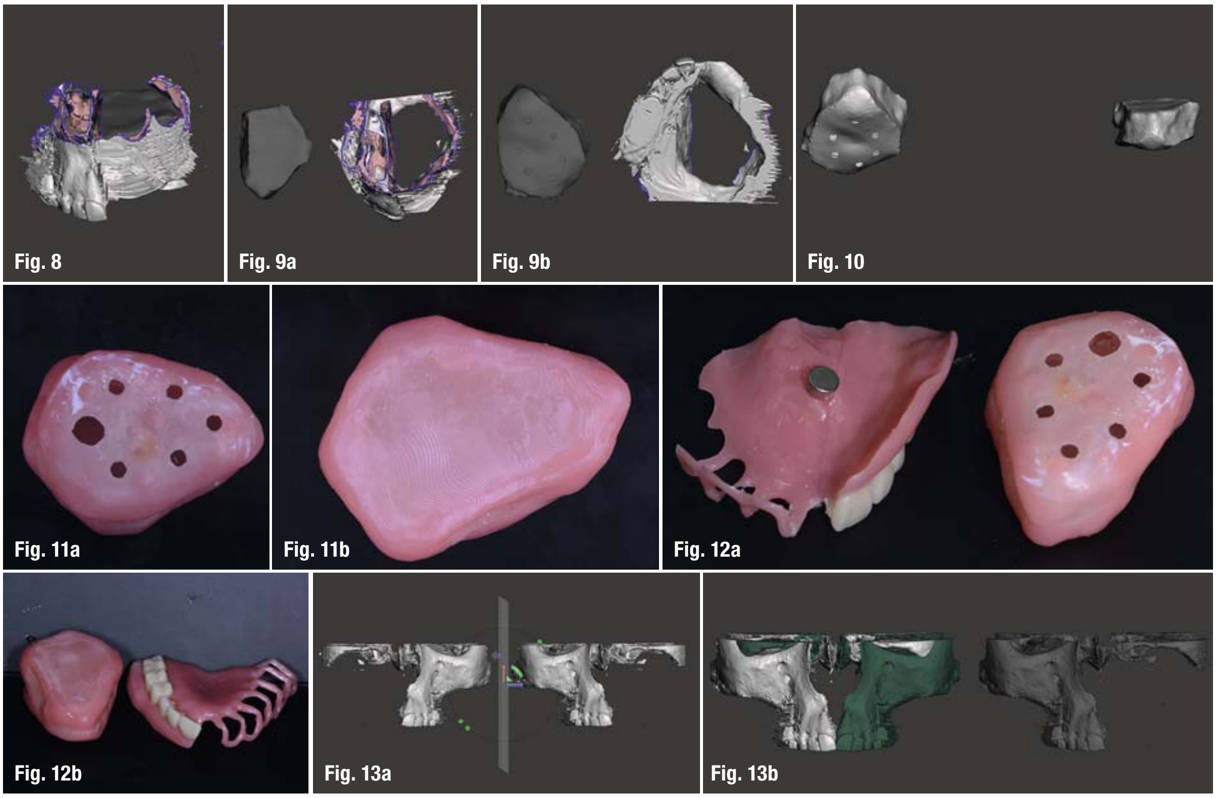


Fig. 8: Digital maxillary dentition and the segmented CBCT data uploaded to Meshmixer software. **Fig. 9a:** Obturator fabricated using the Meshmixer software. **Fig. 9b:** Hollow obturator. **Fig. 10:** Initial obturator design. **Fig. 11a:** Printed hollow bulb obturator. **Fig. 11b:** Top side of the obturator. **Figs. 12a & b:** Definitive prosthesis. **Fig. 13a:** Mirrored digital maxillary left dentition using CBCT data. **Fig. 13b:** Complete digital maxillary dentition using CBCT data.

3. A complete maxillary digital arch was obtained by joining both sides together.
4. The new data was imported into Dental System (Fig. 5c), and virtual teeth extractions were done to remove the teeth from the mirrored left side (Fig. 5d).
5. An artificial alveolar ridge was created to allow for setting of the new virtual teeth (Fig. 5e).
6. The design process continued by creating a denture border, denture base and retentive clasps (Figs. 5f–i).
7. The final design was printed on a 3D printer (NextDent 5100, 3D Systems) using a denture resin material, and the acrylic teeth were milled (CORiTEC 140i, imes-icore; Figs. 6a & b).

Digital hollow bulb fabrication

The conventional fabrication of an obturator is a complex task that requires multiple scheduled appointments and involves a maxillofacial surgeon, prosthodontist and dental laboratory technician.[5, 18, 19, 20] Modern digital technology, including CBCT and 3D printing, opens up the possibility of manufacturing maxillofacial prostheses more efficiently and cost-effectively:[21, 22]

1. A 3D image of the maxillary defect and the remaining maxilla was compiled from the CBCT scan (Fig. 7a).[23]
2. The images were imported into 3D Slicer software for 3D processing of the DICOM images and building of an anatomical virtual model.
3. 3D Slicer software was utilised for hard and soft tissue segmentation and preparation of an STL file (Fig. 7b).
4. The data obtained from 3D Slicer was processed and then uploaded to Meshmixer (Fig. 8). Meshmixer was utilised to design the digital obturator to fit within the defect borders and extensions (Figs. 9a & b).[24] The weight of the obturator was minimised by reducing the thickness of the walls and hollowing its internal aspect (Fig. 10).
5. The digital bulb obturator was 3D-printed (NextDent 5100 and NextDent Denture 3D+ resin material, 3D Systems; Figs. 11a & b).

Prosthesis delivery

The two-piece maxillary detachable obturator required a retentive element to facilitate the easy insertion and removal of the prosthesis (Figs. 12a & b).[13] Magnets were added to retain the prosthesis and assist in easy orientation and placement of the denture.[14] The obturator bulb housed one part of the magnet using autopolymerising acrylic resin. The other magnet was embedded into the inner surface of maxillary denture in the proper position to the opposite magnetic pole in the bulb during the try-in session.[14] A soft denture relining material (Bisico Softbase, Bisico Bielefelder Dentalsilicone) was used on both components to achieve a more intimate fit to the soft tissue and to ensure the magnets would remain completely isolated from the oral environment when the bulb and denture of the obturator were in place.

The patient was educated on how to insert and remove the prosthesis and instructed on oral hygiene and self-maintenance. Follow-up visits every two weeks for further assessment and a new reline were indicated owing to rapid soft tissue changes that occur during the wound healing process.[15, 25]

Future steps

Based on 3D digital data, patient-specific reconstructions (custom-made implants) can be produced as a definitive solution.[26] In close collaboration with the maxillofacial surgeon and prosthodontist, the design can be modified, customised and fabricated utilising 3D printing material to achieve better aesthetics and function to enhance patient satisfaction (Figs. 13a & b).[27]

Conclusion

Dentistry has entered a new era where 3D virtual treatment planning, design and fabrication are common and affordable. The thought process on how to treat our patients has changed. We can now predictably have a prosthesis fabricated using CAD/CAM technology without the need for conventional impressions and fabrication techniques.

The digital revolution is changing dentistry, and the impact of new 3D image acquisition devices such as CBCT devices, intra-oral scanners and facial scanners is already influencing the dental field.[28] At the same time, CAD/CAM software and innovative fabrication procedures, including 3D printing and milling, are transforming the way we treat our patients, making those previously difficult manual tasks easier, faster, cheaper and more predictable.[11] Nowadays, digital design, including 3D virtual planning, and fabrication of a provisional or definitive prosthesis can be accomplished with a concise workflow with predictable aesthetic and functional outcomes.[1, 29]

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

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The author certified that all appropriate patient consent forms were obtained.

Conflicts of interest
There are no conflicts of interest. There was no financial support or sponsorship.

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about

Dr Tariq Saadi is a medical director and general dental practitioner in a dental facility in the UAE. Dr Saadi focuses on the digital workflow in cosmetic and implant dentistry. His vision is that digital technologies will dramatically change the world of dentistry; therefore, he decided in 2015 to transform his work completely from analogue to digital. He invested in digital intra-oral scanners, 3D facial scanners, 3D printing, CAD/CAM software, milling machines and CBCT. He believes that digitally driven dentistry is what we need today to fulfil patients' expectations of dental treatments.

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New grinding and milling unit

CEREC Primemill makes excellence easy

Fig. 1: CEREC Primemill: fast fabrication speed, excellent quality and easy to handle.

CEREC has taken another big step forward with the introduction of CEREC Primemill, a brand-new grinding and milling unit from Dentsply Sirona. Fabricating chairside restorations is about to get easier and significantly faster. Thanks to state-of-the-art technology, a wide range of restorations can now be manufactured with greater speed and outstanding results. Together with CEREC Primescan and CEREC Software, CEREC Primemill forms a modern set-up for achieving predictable results with a completely new chairside experience—for both the user and patient.

CEREC Primemill, Dentsply Sirona's new grinding and milling machine, ensures the production of impressive restorations with precise margins and a very smooth surface, thanks to the high-speed set-up with two spindles and four motors. CEREC Primemill features a powerful 7 in. touch interface, an integrated camera for scanning material blocks with compatible data matrix codes and a radio-frequency identification (RFID) scanner for reading tool information. It also works with a wide range of materials. The new design offers significantly smoother operation.

"CEREC Primemill is a real game changer in the whole workflow," said Dr Gertrud Fabel, a dental practitioner in Munich in Germany and key opinion leader for Dentsply Sirona. "Everything works significantly faster than before, the quality of the restorations is convincing owing to the very fine margins and smooth surfaces, and handling is more than simple: the team can provide perfect support and thus accelerate the entire workflow to make it even more pleasant for the patient."

Guided operation for maximum convenience

When developing the new CEREC Primemill, special attention was paid to its user-friendliness: the large touch interface guides the user through all workflow processes. Each workflow step is displayed in order and shows, for example, which tools are used for the selected material and machining option. The tools are outfitted with colour codes according to the material to be processed and are therefore easy to distinguish. Each tool also contains a small RFID tag that can be read by an integrated scanner in the CEREC Primemill. The machine informs the user about the tool's status and when it should be replaced. The new user guidance makes it even easier to delegate the operation of the machine.

For additional convenience, material blocks with compatible data matrix codes can be scanned with the integrated camera. With this, the block information, including type, size, colour and zirconia enlargement factor, are recorded. The unit's LED light strip also informs the user about the unit's status, including a moving blue progress bar, which changes to green when the manufacturing process is finished. In addition, the interface guides the user through routine maintenance procedures and thus facilitates the easy upkeep of CEREC Primemill.

More aesthetic, faster and simply excellent

With CEREC Primemill, restorations, especially those made of zirconia, can be milled even faster thanks to new tools and improved technology. The time required to fabricate a zirconia crown has been reduced by more than half: it can be cut from around 10–12 minutes to as little as 5 minutes using the new super-fast mode.

The results speak for themselves. Using newly developed, very fine tools (0.5 mm) in the extra-fine milling mode, the unit achieves a high level of detail for occlusal fissures as well as interdental areas on bridges, enabling users to achieve predictable, first-class results.

Superior chairside experience

The entire CEREC system takes on a new dimension with CEREC Primemill. For those customers who now want to step into the chairside CAD/CAM world and want to use CAD/CAM technology in their practice, the all-new CEREC gives them a full system with great flexibility for reliable results. Users who are already suc-

Fig. 2: Familiar usage of the touch interface. Easy and guided processes speed up the workflow.

cessfully using CEREC in their practices will appreciate the new level of speed and high level of quality and convenience provided by CEREC Primemill.

“It was important for us to create real added value with CEREC Primemill, both for the CEREC newcomer and for those who have been passionate CEREC users for years,” explained Dr Alexander Völcker, group vice president of CAD/CAM and orthodontics at Dentsply Sirona. “We have noticeably increased the process speed while delivering outstanding restoration results. The variety of applicable materials leaves nothing to be desired and operation the unit has never been easier. The complete system does not require any data imports or exports. All processes are coordinated with one another and fully validated for an excellent and seamless chairside experience.”

Owing to various certification and registration periods, not all products are immediately available in all countries.

Dentsply Sirona
www.dentsplysirona.com

Fig. 3: The renewed CEREC system. CEREC Primemill has proved to be a real game changer.

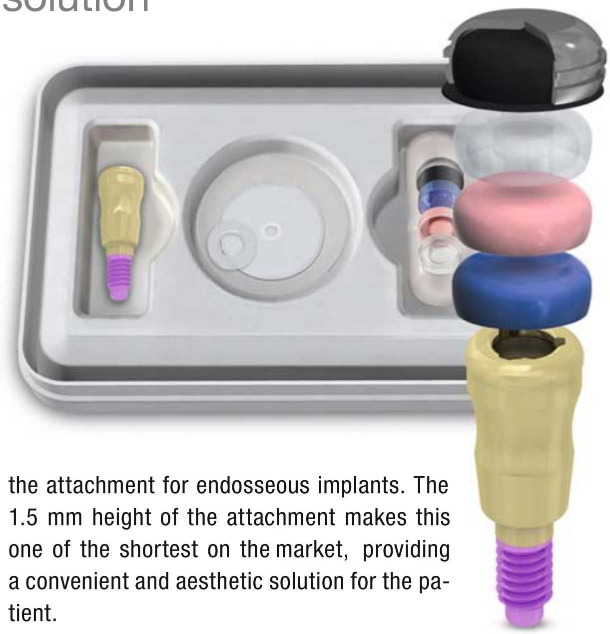
implant solutions for edentulism

MIS introduces the LOCKiT, an affordable, long-term, quality solution

MIS Implants Technologies has released its new LOCKiT advanced anchoring system for implant-supported overdentures. With life expectancy on the rise and an ever-growing ageing population effected by edentulism, there is a significant need for simple and affordable long-term solutions. The system was developed to answer these needs, while maintaining an uncompromising level of quality and patient comfort.

The LOCKiT system was designed with customisable levels of retention, features a concave emergence profile and anodised colour-coding for easy identification during the workflow, and is available for MIS internal hexagon and conical connections in all platforms, narrow, standard and wide. The abutment is coated with anti-wear material and is strengthened above the threads, which enables maximum durability. The plastic caps exhibit excellent resistance to abrasion over time and have a predictable and consistent retention level.

Tali Jacoby, implants product manager, explains: “We are attentive to the needs of our customers and looked for a solution that would include everything in a single package—a compact and convenient kit.” In order to get it right, “we considered the doctors who currently use a parallel product and made sure to incorporate full compatibility for the components. This way, they can use our solution with their own existing tools and accessories.” In order to provide an advantage when it comes to aesthetics, the LOCKiT was designed to reduce the height of the attachment for endosseous implants. The 1.5 mm height of the attachment makes this one of the shortest on the market, providing a convenient and aesthetic solution for the patient.



With an extended range of components, the system enables restoration of a non-parallel implant of up to 20° of angulation. This adds up to an extensive 40° of divergence between two implants and delivers maximum versatility for the clinician.

MIS Implants Technologies
www.mis-implants.com

Content sharing platform from Straumann

New StraumannPLAY series outlines digital workflows

Straumann has launched the second season of StraumannPLAY. The season focuses on digital workflows, and in it, Dr Hugo Madeira, founder of the advanced implantology clinic Clínica de Implantologia Avançada in Lisbon in Portugal, takes the audience on a five-part journey in digital dentistry.

Digital workflows offer dental professionals accuracy and reliability and save a considerable amount of time. For patients, this means higher levels of comfort. In the new StraumannPLAY season, Dr Madeira delves into how dental professionals can manage these workflows and discusses the essential tools for successful treatments. Each 10-minute episode provides a glimpse into a specific topic, such as intra-oral scanning or the perfect smile. The first episode of Season 2 examines the rapid adoption of the intra-oral scanner in practices in order to replace conventional impressions or models. The next episodes are “Implant planning and guided surgery”, “Designing and printing the surgical guide”, “How to plan a smile” and “Prosthetic design and milling”.

StraumannPLAY, which is created by peers for peers, was launched as a means of sharing content on dentistry and beyond. The platform meets a growing need and interest in easily accessible content and formats. It is ideal for mobile devices when on the go. Season 1, titled “Digital for your dental practice”, was a major success, registering close to 3,000 views—and counting.

Episodes of StraumannPLAY can be viewed at www.straumann.com/play.

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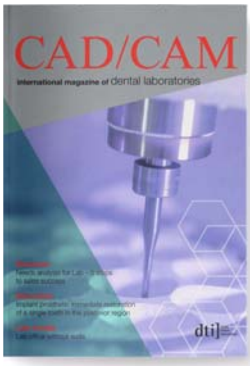

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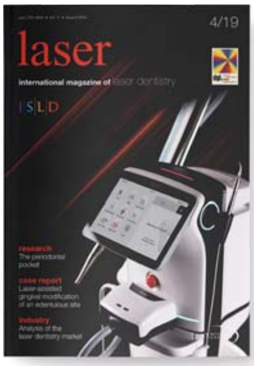

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Dental startups are harnessing artificial intelligence

By Jeremy Booth, DTI

A new wave of startup companies are developing artificial intelligence solutions for dentistry. (Image: Zapp2Photo/Shutterstock)

Artificial intelligence (AI) has broken free from the pages of science fiction to become fact. Machines and software that can think and learn are now a reality and a wave of dental startups are developing new AI-assisted technologies for dentists. So what are some of the youngest companies in the industry hoping to achieve? And how can they bring their AI solutions from the drawing board to the dental practice?

Most readers will have first been introduced to AI as the fodder of fiction in comic books, novels or films screened on late-night television. AI typically impressed but usually came with the ominous caveat of potentially outsmarting its creators. The murderous Hal 9000 computer in Stanley Kubrick's 1968 film *2001: A Space Odyssey* is just one example in a litany of bad introductions to AI. Nowadays, science has caught up with science fiction. Around 16,000 peer-reviewed scientific papers are published in the AI field each year, and smart software has proven its worth in applications spanning a range of fields from the automotive industry to health care. According to dental startups, AI has the potential to make a big impact in dentistry in areas such as diagnostics, smile design and treatment monitoring. These companies are focusing on research and development and obtaining the funding that will help them to make AI a part of daily business in dental practices.

Getting smart with medical imaging

Medical imaging is a valuable source of information in diagnostics and quick advances in the segment mean its availability may grow to outstrip the capacities of medical specialists. Tasking machine learning algorithms with lightening the workloads of doctors and dentists need not be seen as a compromise.

A systematic review and meta-analysis, published by the *Lancet Digital Health* on Sept. 25, 2019 compared the performance of deep learning—a type of AI—with that of health care professionals in the detection of diseases using medical imaging. Based on a review of 14 studies conducted between 2012 and 2019, the review found that the diagnostic performance of deep learning models was equivalent to that of health care professionals. The researchers noted that AI models have become more accurate in diagnosing diseases in the last few years, hinting at the possibility of a continued improvement that may see AI models outperform medical professionals in diagnostics in the near future.

AI in dentistry is now a reality, and both the literature and the practice show a broad application. From digital smile

design through to cutting drug prices, visualizing a patient's pain in real time during treatment and detecting oral cancer, the question is no longer whether but how dentists and dental technicians can harness this technology. The range of reasons that they should be interested in AI include improving patient care, streamlining workflows and increasing revenues. The Canadian startup Denti.AI, for example, is using cloud-based AI to interpret dental images for diagnostics using machine learning algorithms. Denti.AI's promise to customers, according to company information, is to increase revenue per patient while addressing problems related to quality assurance and liability.

Dental startups are leading the way

The recent Charité BIH Entrepreneurship Summit 2019 in Berlin, Germany, focused on global trends in health care, including AI. Jurors selected a pitch by Dr. Falk Schwendicke, Deputy Director of the Department of Restorative and Preventive Dentistry at Charité—Universitätsmedizin Berlin and Chief Medical Officer of the dental startup dentalXr.ai, as the winner in the digital category. Schwendicke and his colleagues have focused on digital radiography to develop a tool that helps dentists to diagnose, document and make decisions based on digital radiographs. The tool—a decision support platform—seeks to improve the reliability of using this staple of diagnostics while also speeding up what can be a time-consuming process for dentists.

Schwendicke told DTI that the treatment application for using AI to screen digital radiographs varies widely, improves accuracy and saves time.

"We help dentists detect dental pathologies, such as caries, apical lesions, periodontal bone loss; and plan for restorations like crowns, implants and fillings quicker and more accurately—up to 40 per cent higher accuracy—thereby allowing them to make better treatment decisions for their patients. As well, multiple tests with dentists have shown that our product supports dentists in reducing the time spent on documentation of dental radiographs by 50 per cent." Schwendicke added that the platform has also had a positive effect on patient relations. "All dentists have confirmed that the use of our product enables them to have a more transparent and trustworthy communication with their patients," he said.

DentalXr.ai is a new startup company based in Berlin that will be begin business in the fourth quarter of this year. Numerous dentists in Germany have tested the company's product and dentalXr.ai is currently running a beta test with a broader dentist population. After receiving the CE marking product certification, dentalXr.ai plans to launch its product in Europe in the first half of 2020.

According to Schwendicke, in order to gain acceptance among dentists, newly introduced AI technologies, such as the decision support platform, need to deliver what they promise. If they can do this, then the potential in the practice is considerable.

"At the beginning, it will be important for us to deliver our value proposition—better diagnostic decisions in less time—to dentists with our initial product. In the future, we see the potential to move from AI-assisted diagnostics for numerous dental pathologies to AI-based prognostics supporting dentists in making the best and most informed treatment decisions at any given time. Given our access to substantial longitudinal datasets—radiographic data, patient data, claims data—and our outstanding network of renowned dentists from the Charité and many other clinical partners worldwide, we are in the best position to create the maximum value for dentists."

Funding will bring AI into more dental practices

VideaHealth says AI is the future of dental care and can help dentists detect dental diseases earlier and more reliably. The Cambridge, Massachusetts-based dental startup spun out of the Massachusetts Institute of

Technology (MIT) in 2018 after two years of research into how AI can improve dental care. It says its product VideaDetect can identify up to 25 per cent more dental diseases than the average dental practitioner and that it collaborates with dentists around the world to continuously improve its algorithms.

VideaHealth has partnered with dental organizations to bring its AI-assisted diagnostics to dental practices across the U.S., and a recent cash injection will help the startup company to make an even bigger impact. A September U.S. Securities and Exchange Commission filing showed that the 1-year-old company raised $5.4 million in equity through reported investment by Zetta Venture Partners, Pillar and the MIT-affiliated Denta V.

After the funding round, VideaHealth CEO Florian Hillen told TechCrunch that dental practitioners are proving more receptive to automation technologies than other health care professionals are. He explained that dentists perform multiple roles within their practices and therefore see technologies like image recognition software not as a threat but as a something that can increase efficiency. “AI in radiology competes with the radiologist,” Hillen told TechCrunch. “In dentistry we support the dentist to detect diseases more reliably, more accurately, and earlier.” VideaHealth will reportedly use the funds to increase its team and conduct further research and development.

From startup to major player

The Paris-based orthodontics technology specialist Dental Monitoring is no longer a startup because it has a range of products that have successfully found their markets. Founded in 2015 and now employing over 200 staff members in Europe, the U.S. and Asia, the company is an example of how AI-oriented startups can quickly have an impact of scale on dental care.

Dental Monitoring has three AI-powered solutions for dentistry. SmileMate is a mobile app-driven system that analyses the oral cavity to identify a rage of oral, dental and orthodontic conditions. The company’s DM Vision solution uses AI to generate simulations of future smiles as the outcome of potential treatment. The third solution is Monitoring, which helps patients to photograph their own teeth at set intervals using a smartphone. The app crops the photographs and organizes them by date and angulation and helps to streamline the treatment experience for patients and minimize practice visits.

The company’s claims of helping dentists to provide treatment that is more efficient are backed up by science. Researchers from Virginia Commonwealth University in Richmond, U.S., investigated the company’s smartphone-based orthodontic treatment app in a study published online by the *Angle Orthodontist* journal in March. The study compared tooth movement calculated by the software using intraoral video scans taken by patients with actual tooth movement data gathered during practice visits using plaster models. The researchers found only a negligible average difference between the movements calculated by the app—those for intercanine and intermolar varied on average by 0.17 mm and –0.02 mm, respectively. The researchers concluded not only that the in-office and software measurements were equivalent within 0.5 mm but also that the at-home intraoral scans done by patients were just as good as those done in the practice by clinicians.

The Straumann Group announced in April 2018 that it had invested in the French company. At the time, Marco Gadola, CEO of the Straumann Group, said the company’s technology and its mobile applications would change dentistry. “Our investment in DM provides us with a proven orthodontics tracking system and access to artificial intelligence technology. It also secures an innovative partner with the expertise to develop further leading-edge solutions in our field.”

The agreement gave Straumann distribution rights to the company’s technology and an unspecified stake in Dental Monitoring.

The future of AI in dentistry remains unwritten

AI has experienced several “winter” periods. The most notable of these was between 1974 and 1980 and between 1987 and 1993, when the thread of progress was lost and funding and research initiatives for AI technologies went cold. The level of research and development currently being invested indicates a strong resurgence period for AI, particularly in health care. Obtaining funding is crucial for AI startups in dentistry, but the industry’s thirst for new technologies means that cash is available. Established dental companies, meanwhile, will be keeping a close eye on the potential of new AI solutions.

Is AI a panacea for streamlining dental care? This remains to be seen, because the technology’s ultimate impact rests also on future developments. As the American professor of cognitive science Dr. Douglas Hofstadter wrote in 1979, the “AI effect” tells us that the definition of AI is constantly evolving. He continued: “[Once] some mental function is programmed, people soon cease to consider it as an essential ingredient of ‘real thinking.’” Hofstadter quoted the prominent computer scientist Larry Tesler, who said: “Intelligence is whatever machines haven’t done yet.” If Tesler was right, in the future, AI may be used in dentistry in ways we have not yet considered.

“As dental coaches, we are servants in a noble profession”

An interview with Kirk Behrendt, founder and CEO of ACT Dental. By Iveta Ramonaite, DTI

Kirk Behrendt is founder and CEO of ACT Dental, a practice performance coaching company that helps dental practices increase their profitability. *(Image © Kirk Behrendt)*

Dental consulting and coaching services provide advice on dental management and marketing and help dentists grow their practices. Just recently, Dental Tribune International spoke with Kirk Behrendt, founder and CEO of ACT Dental, about his experience as a dental coach. In this interview, Behrendt talks about some common mistakes in dental practice management and discusses the role that social media and continuing education play in dentistry.

Mr Behrendt, could you tell us something about yourself and about what prompted you to found ACT Dental?
I fell into the dental profession by accident. I worked for a few dental labs after graduation and this experience lit my fire for the dental profession. I love people and I’ve always wanted to be a teacher, so I wanted to create value for the people in this awesome profession. I spent a few years at a consulting firm, where I had a ton of fun and became one of the top sales representatives. It was actually when I saw the movie *Jerry Maguire* that I realised that I could do this on my own. I grew ACT Dental one client at a time, and here we are, 23 years later.

As dental coaches, we are servants in a noble profession. I’m so grateful for the opportunities that have led me here. Our tagline “better practice, better life” rings true every day. We’re so excited to be doing purposeful work, truly helping to change people’s lives.

In your experience, what are some of the biggest management mistakes that dental practices make?
The biggest mistake that a dental practice can make isn’t a tactical decision; instead, it involves thinking. It’s not really the problems themselves that matter, but rather how the team looks at those problems. Dentists limit themselves with thoughts like “I have to practice in an insurance-only environment” or “I purchased this business, so I need to run it as it was always run.” These aren’t actual problems once you sit down and decide how you want your business to operate.

The most catastrophic scenario for a dentist is waking up to realise that the practice isn’t being run in the way he or she wants to run it. People go into dentistry for a reason, and part of that reason is often the flexibility it affords you outside of work. It’s up to you to create the practice you have envisioned and to build the perfect team.

Social media is an integral part of the digital age. How can dental professionals effectively use social media to build their dental practice?
Like it or not, your online presence is something patients take into consideration when choosing a dentist. They are seeking out your digital footprint. Regardless of whether you participate, they are making assumptions about you and your practice based on what they find on the internet. Authenticity is critical to building a strong social media presence. If there’s a misalignment between what’s on your social media and what’s on your

> “The biggest mistake that a dental practice can make isn’t a tactical decision; instead, it involves thinking.”

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site or in your office, people will pause. Telling your own story and using your own images will help to build trust between you and your patients before they even set foot inside your office.

What role does continuing dental education play in ensuring high standards of care in dentistry, and what opportunities are open to dental professionals who want to engage in continuing professional development?

Continuing education is crucial to the future of dentistry. Once you assume you know it all, you're dead. It's important to keep learning, to keep thinking and to keep challenging yourself. Dentists must continually refine their thinking both in order to learn about changes in the field and to keep growing personally and professionally.

"Authenticity is critical to building a strong social media presence."

Fortunately, there are now more opportunities than ever for continuing education in a variety of formats. We're no longer constrained by time and geography. Webinars, virtual conferences and online courses are all easily available. But continuing education can also be as simple as creating a Facebook group with your colleagues to share the latest news and to ask each other for help. Dentistry is a profession of passionate lifelong learners, and the opportunities are endless.

Owing to the current COVID-19 crisis and resulting travel restrictions, Nobel Biocare has decided to reschedule its 2020 Global Symposium. It will take place at a later date and in a new location. (Image: No-Mad/Shutterstock)

Nobel Biocare Global Symposium 2020 postponed to early 2021

After careful consideration and monitoring of the ongoing spread of the virus SARS-CoV-2, Nobel Biocare has decided to postpone its 2020 Global Symposium, which was originally scheduled for 16–18 April in Las Vegas in the US. The symposium is now scheduled for early 2021. The company will communicate the new date and location as soon as details are available.

The unprecedented circumstances presented by COVID-19, the increasing health and safety concerns, as well as the current travel restrictions, have made it impossible to hold a global event like the Nobel Biocare Global Symposium at this time. The company believes that this decision is in the best interests of the health, safety and well-being of its customers, employees and business partners.

For those who have already registered, registrations will be automatically transferred and will become valid for the 2021 event. In case participants wish to cancel their attendance, Nobel Biocare has relaxed its original cancellation policy and will refund registration fees in full. The company urges participants who have already made travel arrangements to expedite hotel and flight cancellations.

Nobel Biocare remains committed to helping dentists advance at every level. Because education is an essential tool in achieving this goal, the company will host a series of virtual educational sessions from 16 to 18 April and make them available to all those who had registered for the symposium. Details about access to these virtual educational sessions will be communicated soon.

Interested parties can find more information at www.nobelbiocare.com/international/en/nobel-biocare-global-symposium, contact their local customer service teams or write to symposium.lasvegas@nobelbiocare.com.

How to send us your work

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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.

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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.

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- We require images in TIF or JPEG format.
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- 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.)

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You may submit images via e-mail, via our FTP server or post a CD containing your images directly to us (please contact us for the mailing address, as this will depend upon the country from which you will be mailing).

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.

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An abstract of your article is not required.

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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?

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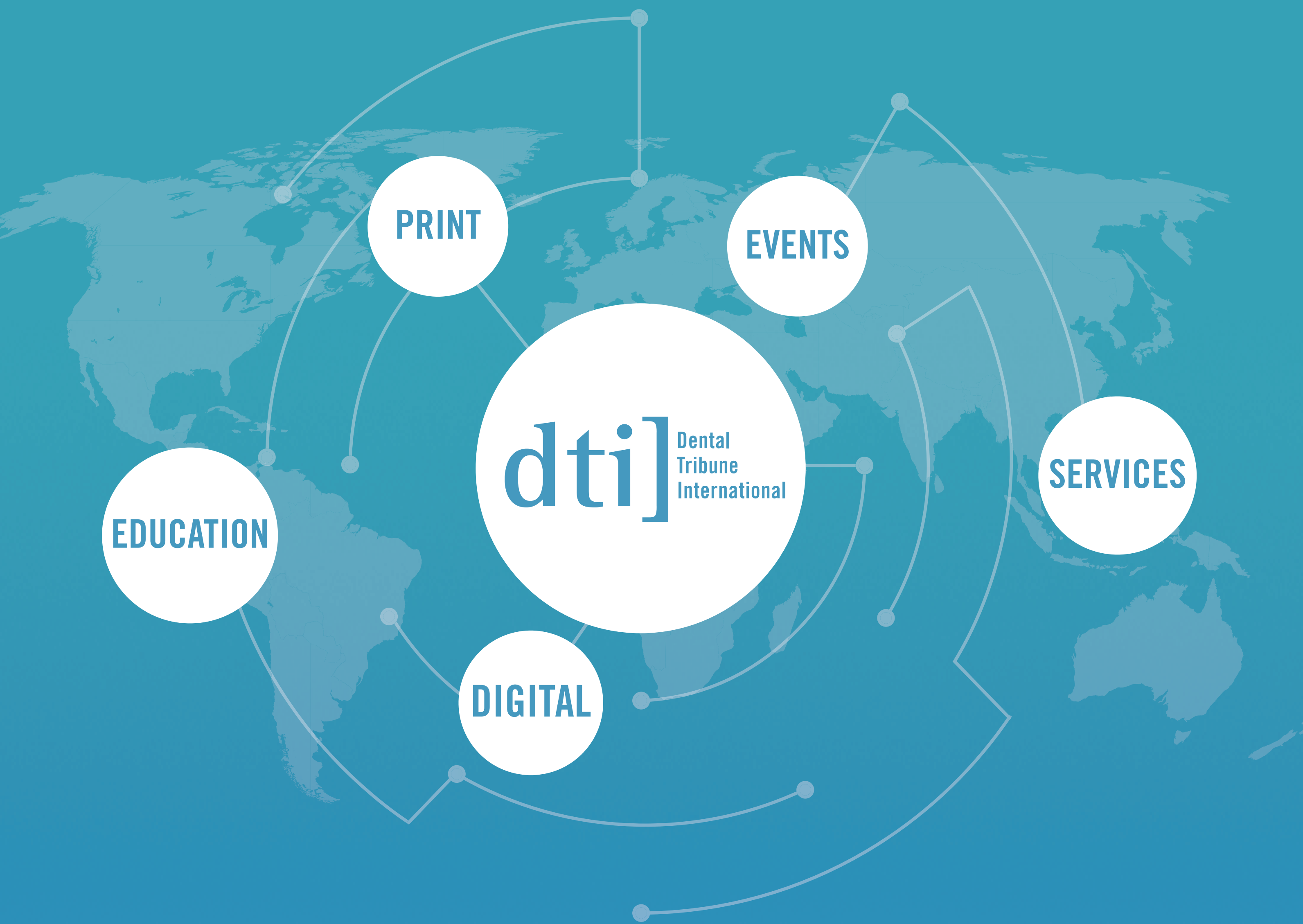
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