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CAD/CAM

international magazine of dental laboratories

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dti] Dental Tribune International

Magda Wojtkiewicz

Managing Editor

The world has changed

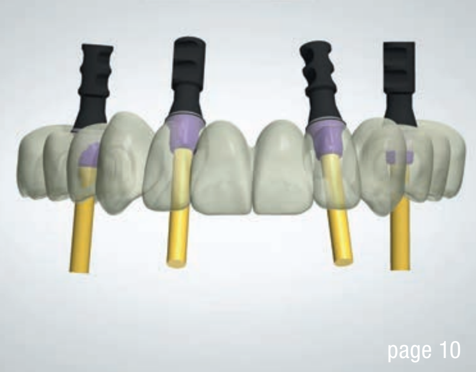
The COVID-19 pandemic has changed the world, and this change goes far beyond the obligation to wear masks and the excessive use of sanitisers in public spaces. The new reality requires the redesign of the micro- and macroeconomy, rethinking of marketing strategies, and adaption of social activities and habits. This, of course, also applies to dental offices and laboratories.

All major international congresses and exhibitions, including specialty-specific events, have been cancelled this year, and some have been postponed to 2022. Does this mean that there are no new concepts, technologies, materials or products to launch? Of course not! Progress is being made continually; it has just continued its shift to the digital arena at a faster pace than before the global pandemic.

Many dental events have been held virtually and attracted thousands of dental professionals worldwide. Others have taken the form of hybrid meetings, combining on-site and online features, and have been very successful. Some dental companies have built virtual exhibition stands with video product presentations, webinars and the possibility of live one-to-one chats with their representatives. All these efforts have been aimed at keeping dentists and dental technicians updated on the latest developments in the field.

It will probably take some time before we fully understand the impact of the COVID-19 pandemic on the dental industry, but what we have learned so far has made it clear that the ability to adapt to change is key not only to survival but also to success and development. There is always something to learn, and even in severe economic downturns and recessions, some businesses are able to gain advantage and grow. The ability to adapt is crucial; it has become necessary to shift our attitudes and develop our capacity to find opportunities in the new reality.

Magda Wojtkiewicz
Managing Editor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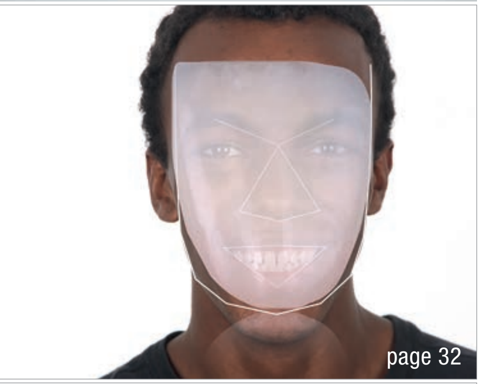
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The latest generation of temporary restorations

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VOCO
THE DENTALISTS

“Dental laboratories will be left in an extremely vulnerable position”

By Iveta Ramonaite, Dental Tribune International

Close cooperation between dentists and dental technicians generates synergy and helps to ensure high-quality prosthetic dentistry. However, the COVID-19 pandemic has diminished the confidence of many professionals working in the dental field and has created much uncertainty about the future of dental technology. In this interview, Dental Tribune International discussed the topic with Barry Tivey, an accomplished dental technician and owner of Ceramic Techniques, a dental laboratory that produces crowns, bridges, implants and aesthetic restorations.

President of the Dental Technologists Association, Barry Tivey, told Dental Tribune International that financial difficulties, new staffing requirements and uncertainty about the future are posing a great threat to the sustainability of many dental laboratories. *(Image: © Barry Tivey)*

Mr Tivey, could you tell us something about yourself and your background in dentistry?

I completed my apprenticeship over 35 years ago in a crown and bridge laboratory. On leaving school, I joined the civil service; however, I used to watch my future father-in-law in his laboratory and was fascinated by the intricacies and artistry of the profession. After much persuasion, he agreed to train me, and I enrolled on a day-release course at a local college. He was an old-school technician, and when I presented most of my early work to him, it was greeted with a shake of the head and a trip to the waste bin. I took over the running of the laboratory 25 years ago, and since then, we have introduced implants and digital technology into our portfolio of services.

Continuing education has always been important to me, and I completed a Master of Science in Dental Technology in 2015. I am currently president of the Dental Technologists Association (DTA) in the UK. In my spare time, I like to play golf and ride my motorcycle.

In light of the pandemic, many dental offices were instructed to close their doors and to provide emergency care only. How has the COVID-19 pandemic affected work in your dental laboratory?

Let me try to put this into perspective. Five years ago, we moved into a purpose-built laboratory, and I thought that it was the most stressful situation I would ever encounter. How wrong I was! In the week before the lockdown, work had started to slow down quite dramatically, and that was the situation until dental surgeries started to reopen on 8 June. Work is returning slowly, but it is nowhere near pre-lockdown levels. Our laboratory provides crown, bridge and implant restorations, and we have a mix of private and National Health Service (NHS) clients. However, according to my experience, it is mostly private surgeries sending work at present, and only a handful of cases are coming from NHS practices.

A great deal of research has been done on the economic, social and psychological effects of COVID-19 on general dentists. What impact has the pandemic had on you?

The pandemic has had an impact on every aspect of life. From a business perspective, turnover has been dramatically affected, as no work has come into the laboratory for over three months. It has been a very fast-moving situation, and a lot of information has been posted by government and professional bodies daily. Just trying to keep up with that has been, in itself, very stressful. On a personal level, my daughter was working abroad when the lockdown began and had to try to arrange a flight home, and I had several elderly relatives who were in the SARS-CoV-2-vulnerable category and needed suitable care arrangements to be put in place.

The DTA kept members informed of the financial help that was available to them, as well as provided them with general health and welfare advice; however, there was very little constructive guidance specifically offered to dental technicians by any governing bodies. I spoke to other dental technicians and laboratory owners and found that the majority of them are small business owners. There is much anxiety surrounding cash flow, future business and how to manage staffing requirements with so much uncertainty surrounding the volumes of work that can be expected in the future. Many staff members fear that they may be made redundant owing to the current lack of work in the industry.

Most dentists use a dental laboratory to manufacture dental prostheses. Have dental laboratories recently experienced a reduction in the number of prescriptions for custom-made dental appliances?
Yes, we have experienced quite a substantial drop in the number of cases coming into the laboratory every month. In fact, owing to the restrictions on aerosol-generating procedures (AGPs), many of us face receiving very little or even no work at all in the coming months. The 60-minute fallow time significantly reduces the number of appointments a clinician can offer to patients, and I feel this will potentially reduce the amount of work a dental laboratory can expect to receive. When you combine the AGP restrictions and the phasing out of government-funded schemes in October, I think that dental laboratories will be left in an extremely vulnerable position.

Dentists in the UK have received continuous support from the government during the pandemic. Has this also been the case with dental technicians? Has the government shown tangible support for dental technologists and dental laboratories in terms of rescue packages, grants or value-added tax (VAT) cuts, for example?
My understanding is that the majority of dentists are being supported via the NHS and continue to receive a percentage of their monthly payments, though private dentists do not benefit from this. Dental technologists do not receive any support directly from the NHS or via clinicians. In fact, I have been made aware that some technicians still have unpaid invoices for work that they completed in March. My business was fortunate enough to be eligible for several grant schemes, and I am aware of technicians who have been able to apply for grants through the Self-Employment Income Support Scheme or the Coronavirus Job Retention Scheme; however, unfortunately, some technicians have been unable to claim either. I have heard of a number of laboratories that have closed as a result of the financial impact of the pandemic.

There was a brief VAT cut on personal protective equipment, which helped purchases when preparing to return to work, but nothing specifically relating to dental laboratories. I suppose that, on the whole, we are a small profession, of which not many members of the government are aware. Many people do not realise that their restorations are custom-made by highly skilled technicians, rather than being taken from a shelf marked "Mrs Smith's teeth"!

> "We have experienced quite a substantial drop in the number of cases coming into the laboratory every month."

The DTA was very proactive in supporting technicians during the lockdown and provided some excellent advice for technicians starting back to work. It also provided the Dental Laboratory Crisis Management Pack.

The coronavirus is changing business practices around the world. Do you think that the pandemic will create any lasting workplace changes in dental laboratories?
Yes, from a technical view, we are already used to cross-infection control and disinfection procedures. However, in the long term, there may be a quicker move to intraoral scanning by dentists rather than taking impressions. This will push forward the digitalisation process.

From a business aspect, the dental technology profession is made up of many small businesses that are extremely concerned for their future. I fear that many will not survive this pandemic, resulting in a loss of skills which will have an impact on the whole dental team and could result in patients suffering long delays for their custom-made appliances.

As president of the DTA, I am also very concerned about our dental technology students currently in training. Closure or downsizing of dental laboratories will have a great impact on many of them. However, the DTA will continue to focus on education to meet and cope with future challenges.

"Owing to SARS-CoV-2 concerns, an in-house workflow has become the centre of interest"

Franziska Beier, Dental Tribune International

Fig. 1: Dr Andreas Kurbad has published more than 100 titles on subjects including ceramic restorations, aesthetics, computerised dentistry, implantology and epidemiology.

Dr Andreas Kurbad, who runs a private practice in Viersen in Germany, has lectured widely on the topic of computerised dentistry. For 3Shape's 24-hour global online symposium, Kurbad gave a presentation on an in-house workflow for CAD/CAM-based single-tooth restorations. Prior to the event, the expert had talked to Dental Tribune International about his own in-house workflow and why such procedures offer advantages, especially in light of the restrictions imposed by SARS-CoV-2.

Dr Kurbad, I understand that you were the first in the world to use the TRIOS intra-oral scanner and TRIOS Design Studio with PrograMill One. What has been your experience with these products in your own daily practice?
Yes, I believe I was the first-ever clinical user of the PrograMill One, and I am very happy with the workflow. Scanning with the TRIOS intra-oral scanner works very well, especially with the new generation of the TRIOS Design Studio software, which includes artificial intelligence scans. Hence, many of the working steps with the optical impressions are managed automatically, speeding up the process. This is also why the in-house technology allows treatments to be performed in only one appointment.

The PrograMill One is revolutionary in many ways. You can manage the whole machine with an app which allows you to be connected to the machine at any time and from any place.

In addition, you can process up to five mills in a row without accessing the machine. In my dental practice, we use it every day, and my experience with this product has been very good. In 2017, I published a scientific


Fig. 2: The practice team of Dr Andreas Kurbad uses the TRIOS intra-oral scanner and the TRIOS Design Studio every day. **Fig. 3:** The PrograMill One can be managed with an app which allows users to be connected to the machine at any time and from any place. *(Images: © Andreas Kurbad)*

article about the ProgaMill One milling machine in the *International Journal of Computerized Dentistry.*

There are many scanners and a great variety of software on the market. In your opinion, why should dentists familiarise themselves with 3Shape/Ivoclar Vivadent products and use them in their daily practice?
They possess some extraordinary features. An example is the wireless camera, which allows you to use only the scanner and perhaps a screen in the treatment room. Everything else can be stored in a different place.

Also, the workflow with the software offers some unique opportunities for design. The milling machine differs from all other milling machines in that the ceramic block from the material is held by a robotic arm. This technology is unique and the milling results are a great improvement on the results of the other 5XT (five-axis turn-milling technique) milling machines that I know of.

What are the advantages of an in-house workflow?
Owing to SARS-CoV-2 concerns, an in-house workflow has become the centre of interest, on the one hand, because you should make as few appointments as necessary in order to reduce infection risk and cover as many treatment steps as possible in one appointment. On the other hand, this workflow is also very economical. Of course, we need a dental laboratory for larger restorations, but single-tooth restorations do not have to be manufactured off-site. Another advantage is that the entire treatment takes only one hour or a maximum of two hours, making it very comfortable for patients.

What has changed through PrograMill One in terms of materials?
The new technology allows the use of modern materials made from composites such as Tetric CAD, which cannot usually be processed with conventional methods in a dental laboratory. With the help of CAD/CAM technology, the use of these materials becomes very simple. For example, the Tetric CAD material produces very satisfying results and can be produced within a short time. It also shows good results for longevity.

> "...many of the working steps with the optical impressions are managed automatically, speeding up the process. This is also why the in-house technology allows treatments to be performed in only one appointment."

Processing zirconium dioxide is also possible, but I think it is not very useful for an all-in-one appointment, since it needs sintering. However, small restorations made of zirconium dioxide will be possible in the future.

Editorial note: Dr Andreas Kurbad's webinar, titled "The in-house treatment concept for CAD/CAM-based single-tooth restorations—the TRIOS and PrograMill One workflow", was broadcasted in June. Dental professionals who would like to rewatch the webinar may register at www.3shapesymposium.com.

Compromised maxillary dentition treated with Straumann Pro Arch and a digital workflow

Dr Tran Thanh Phong, Vietnam


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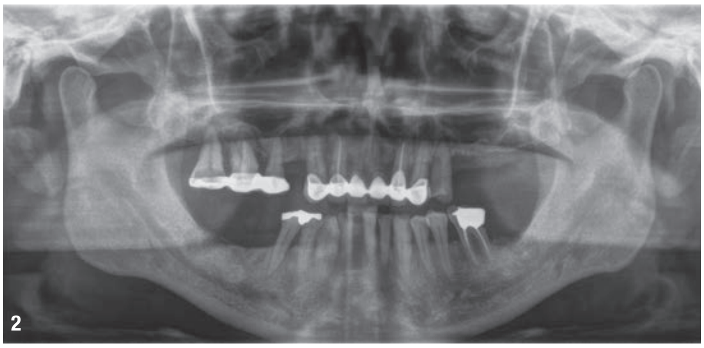
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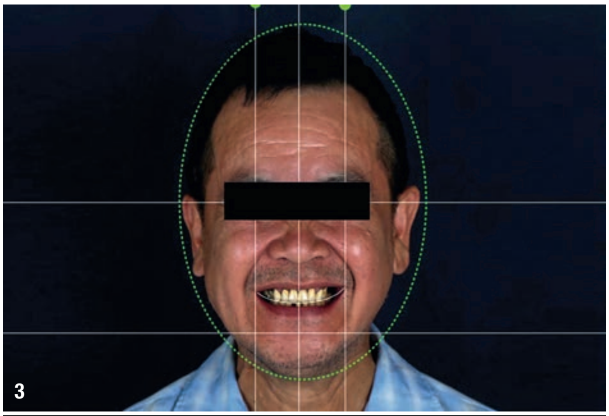
Introduction

Successful immediate implant placement associated with immediate loading remains one of the greatest clinical challenges. In addition to the placement of an implant immediately into the socket, the creation of an immediate screw-retained CAD/CAM temporary restoration is critical for an optimal aesthetic outcome. When using a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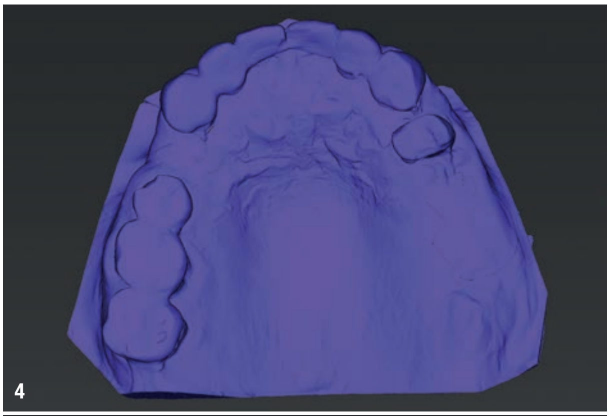
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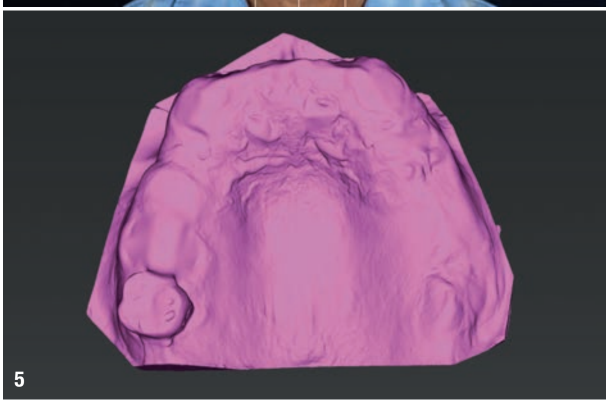
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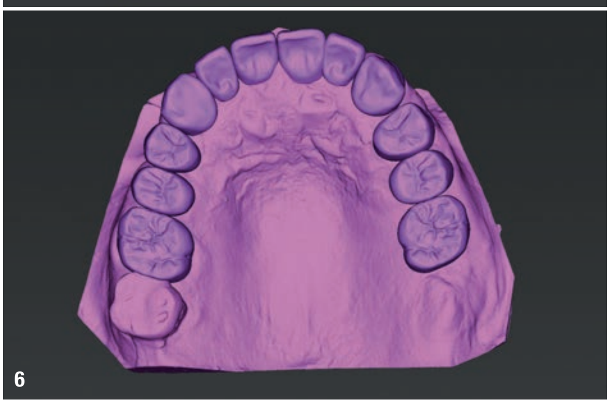
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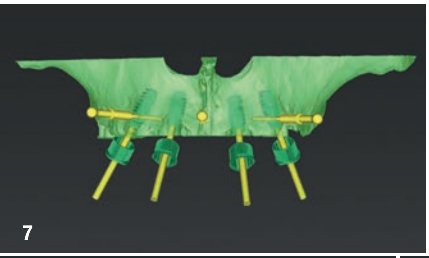
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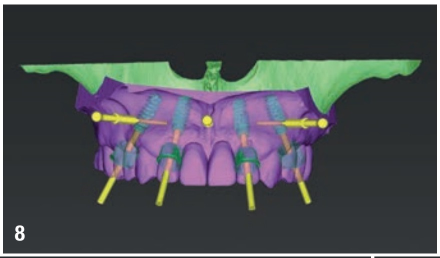
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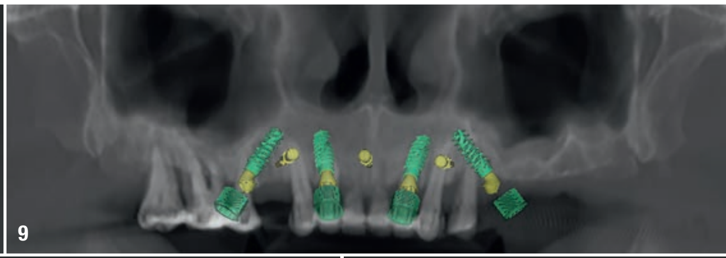
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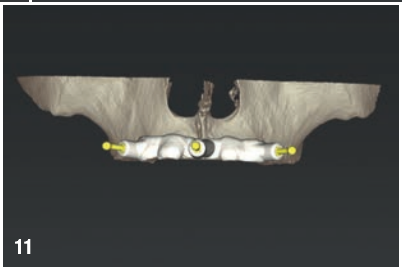
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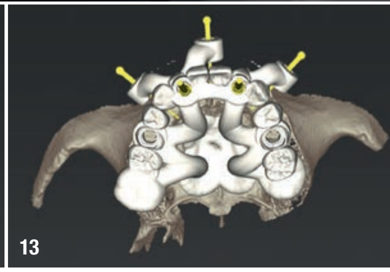
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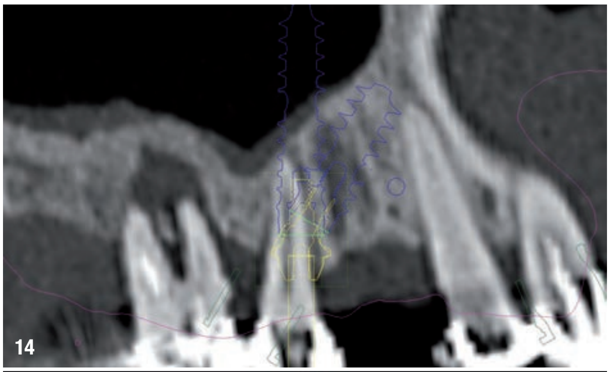
conventional approach, the procedures require an extensive number of patient appointments and chair time for the dentist and the patient. Fortunately, nowadays digital workflows can be implemented, allowing treatments to be considerably shortened.

This case report describes how a full-arch rehabilitation employing digital planning (coDiagnostiX, Dental Wings) and guided surgery with the Straumann system to provide immediate implant placement and immediate screw-retained CAD/CAM provisionalisation led to an outstanding treatment outcome. The digital workflow allowed us to develop an efficient and predictable treatment protocol for the immediate implant placement and the prosthetic design, including the individual emergence profiles prior to the surgery. This also led to an excellent patient experience and satisfaction. The goal of this clinical report is therefore to introduce an innovative one-surgery approach for immediate screw-retained CAD/CAM provisionalisation by using the latest technological improvements in prosthetic and surgical planning software and seamlessly integrating the dental technician into the development of the digital treatment planning and new prosthetic options.

Initial situation

A 51-year-old male patient who was a smoker (< 10 cigarettes per day) and in good general health presented to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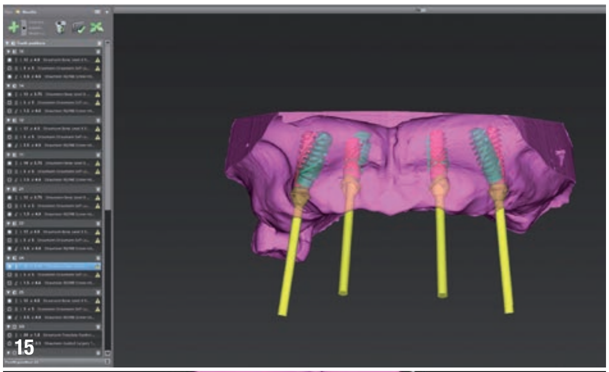
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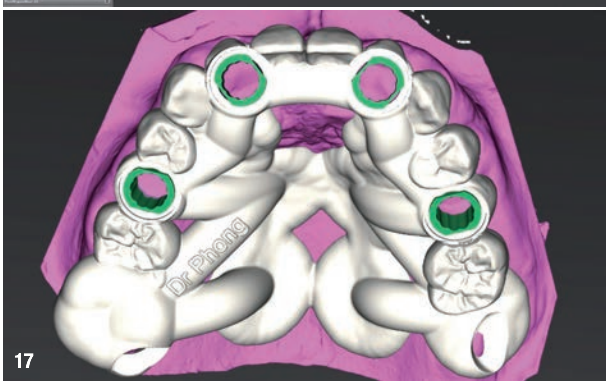

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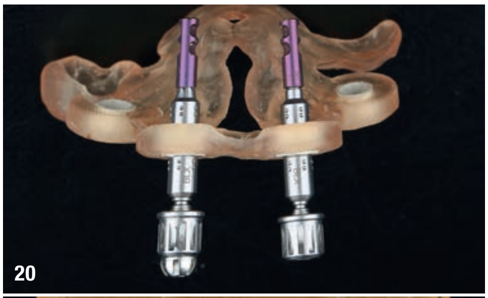
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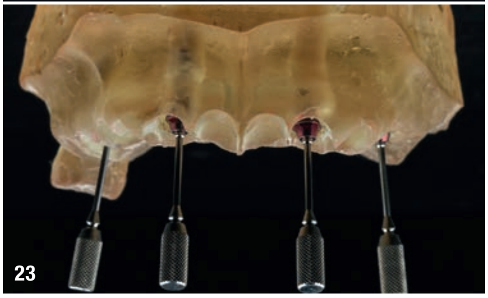
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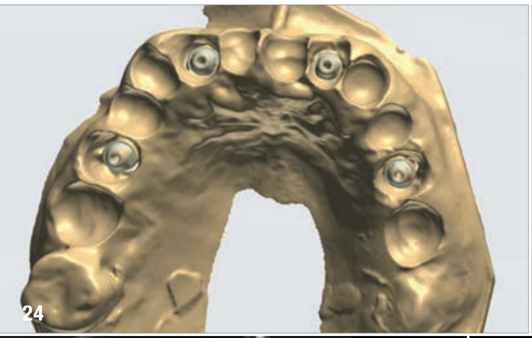
the clinic with missing molars in the second and fourth quadrants, Grade III mobility of teeth #24 and 17, decayed roots and gingival inflammation, and without abscess or sinusitis of tooth #16. The anterior zone showed different extents of recession, bone resorption and deep periodontal pockets around teeth #12 and 22, which led to the patient complaining about an aesthetically unsatisfying restoration (Figs. 1 & 2).

Treatment planning

After the clinical and radiographic assessments, the patient was offered two different treatment options. The first one would include the maintenance of the maxillary canines by treating their recession and bone resorption, which had exposed more than half of the roots, implant placement in the maxillary incisor region with soft-tissue grafting, and extraction of the remaining maxillary posterior teeth and implant treatment after guided bone regeneration and sinus lift. Moreover, the definitive restoration would be an implant-supported bridge in regions #14–16, 12–22 and 24–26 and crowns on teeth #13 and 23 after three months.

The second treatment option would entail extraction of all the remaining maxillary teeth and restoration of the full arch according to the Straumann Pro Arch concept. This would entail placement of four Straumann BLX implants immediately after extraction in regions #15, 12, 22 and 25 employing a fully digital approach and guided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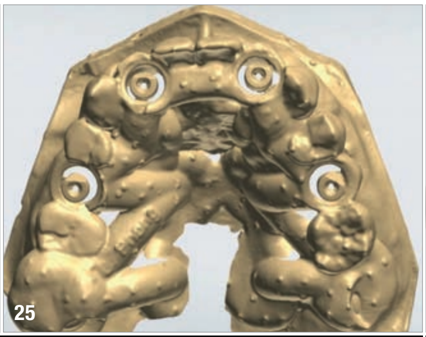
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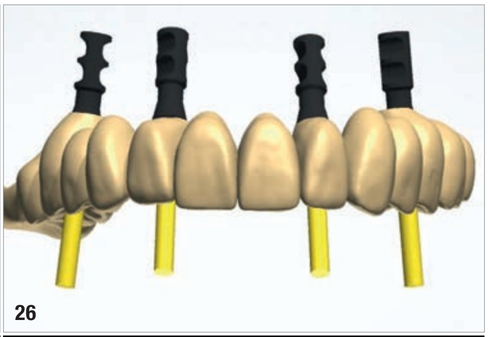
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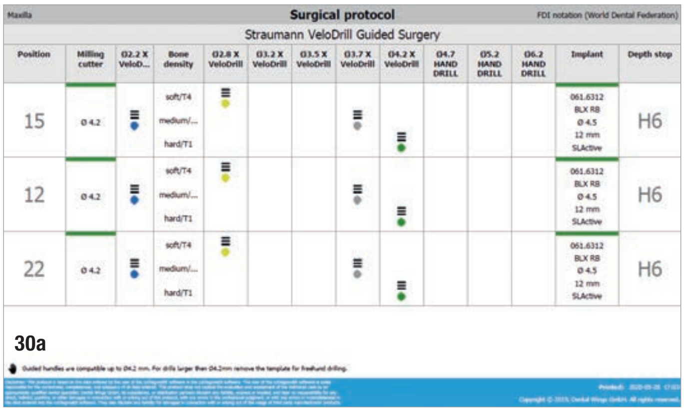

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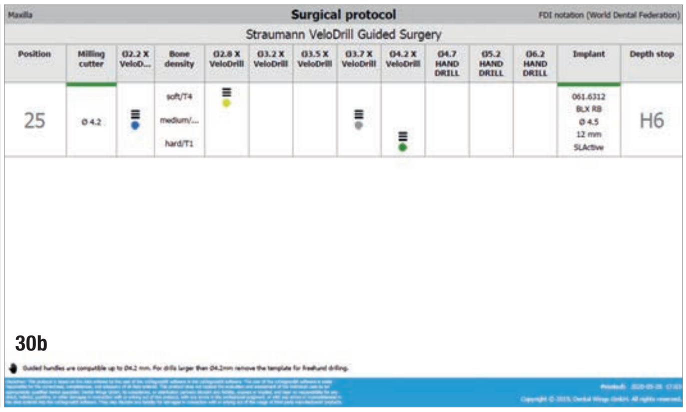

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surgery and placement of a preoperatively fabricated screw-retained CAD/CAM restoration that would be functional and aesthetic right after surgery and a definitive restoration placed six to 12 months later.

The first option would take one year and eight months to complete, resulting in a higher number of visits, longer chair time and higher costs in comparison with the second option. The reliable and short treatment protocol and the patient's unavailability for clinic visits for a considerably long period led to the patient choosing the second option. A holistic treatment approach for the mandibular dentition was envisioned; however, the COVID-19 situation forced a delay in treatment.

Implant placement planning

An intra-oral scan was taken to record the patient's current oral situation, and the resulting STL file and the DSD file (2D smile design image) were used to create the future prosthetic design with software for the laboratory (Figs. 3–6). The 3D radiographic DICOM data and the prosthetic design project STL file were superimposed in coDiagnostiX (Figs. 7–9) The fixation pin guide, bone reduction guide, surgical guide and bite registration guide were designed with coDiagnostiX (Figs. 10–13) and produced using 3D printing technology.

Prosthetic design planning

To design the prosthesis digitally, we first selected the screw-retained abutment (SRA) angle and gingival height (Fig. 14) and then we created the patient model on which we could connect the BLX implants with the SRAs selected from the Straumann library (Fig. 15). The implant placement guide was on the model, leveraging the high stability that we could gain from palatal support (Figs. 16 & 17). After printing the model, the BLX implant analogues were positioned using the template for navigation. The digital planning using coDiagnostiX (Version 9.14) allowed the dental technician to identify

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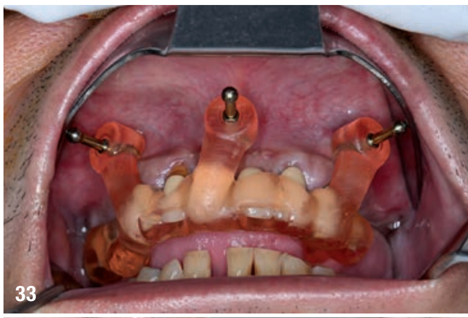

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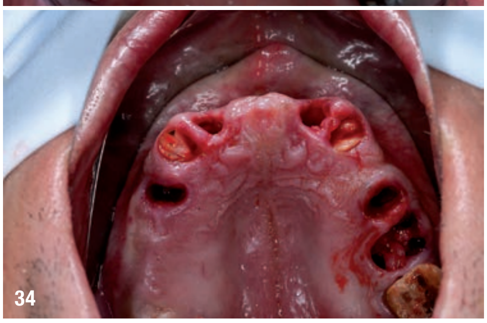

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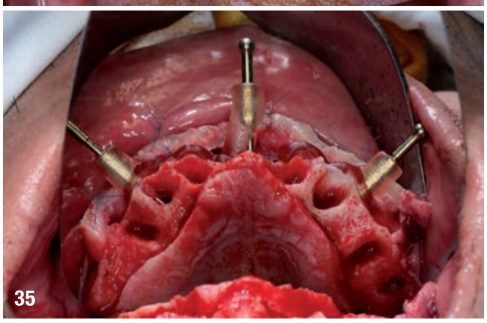

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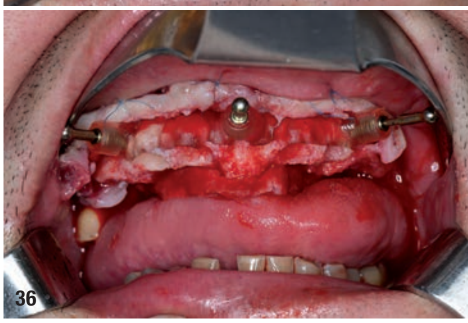

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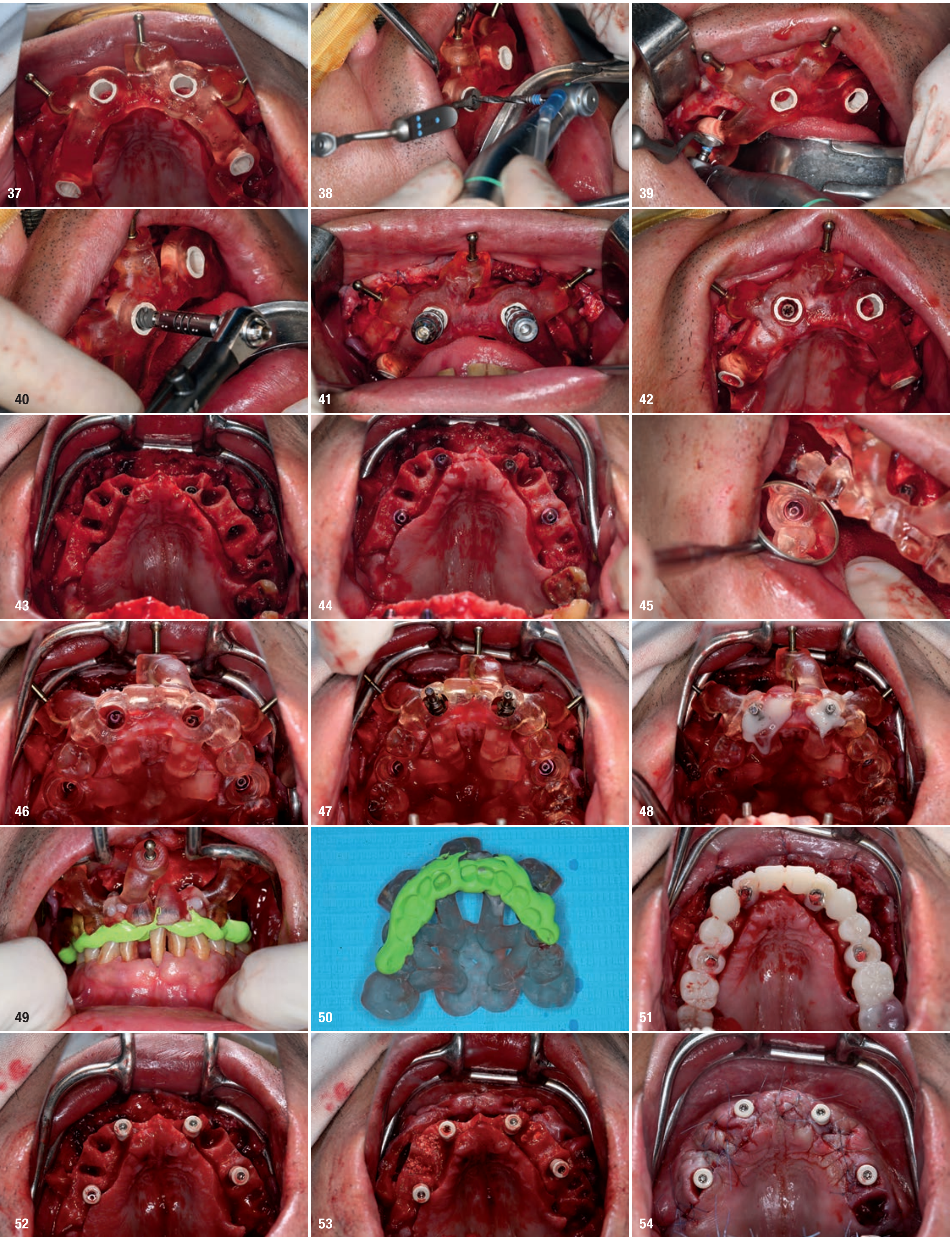
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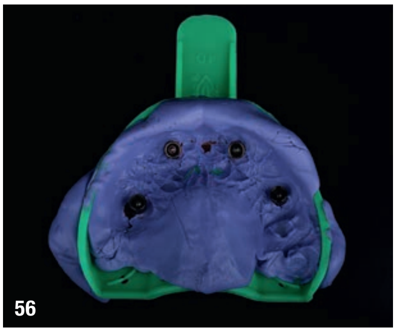
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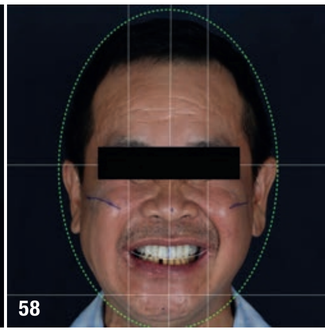
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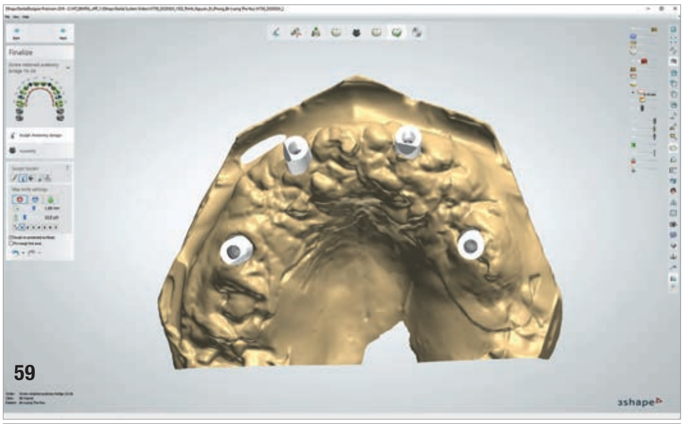
all the necessary parameters related to implant position (Figs. 18–22). Emergence profiles were set-up on the model (Fig. 23). The model was scanned using scan bodies, and a CAD/CAM temporary restoration was designed and milled in a PMMA-based restorative material (Figs. 24–29).

Guided surgery

On the day of surgery, we prepared for the surgical protocol provided by the implant planning software, which guided us on the drilling sequence and the use of the appropriate instruments for the implant bed preparation (Figs. 30a & b). After the fixation pins had been allocated, teeth #17, 16, 15, 13, 12, 22, 23 and 24 were atraumatically extracted and alveolectomy was performed using a bone reduction guide (Figs. 31–36). Four implants (Straumann BLX; regular base; diameter: 4.5 mm; length: 12.0 mm) were placed, two straight implants in the anterior and two titled implants in the posterior. All the implants were stabilised to a torque of 50 Ncm (Figs. 37–43), and the SRAs were placed on top. The SRAs on the posterior implants had an angulation of 30° (diameter: 4.6 mm; gingival height: 3.5 mm) and on the anterior implants an angulation of 17° (diameter: 4.6 mm; gingival height: 3.5 mm; Figs. 44 & 45).

The bite registration guide was fixed with pins, and the open-tray impression copings were placed on the SRAs of the anterior implants, which were fixed with the guide using flowable composite and then sent to the laboratory (Figs. 46–50). Afterwards, we checked the CAD/CAM temporary restoration which had been designed and milled before surgery (Fig. 51), and protective caps were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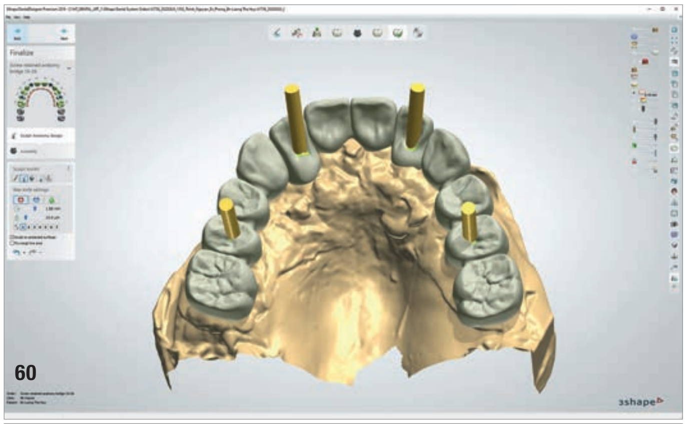
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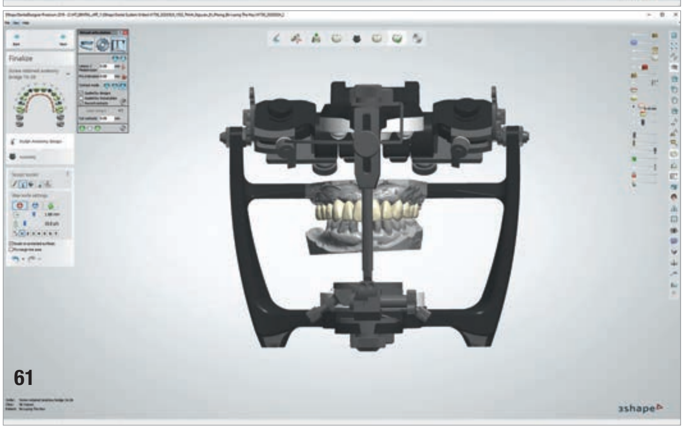
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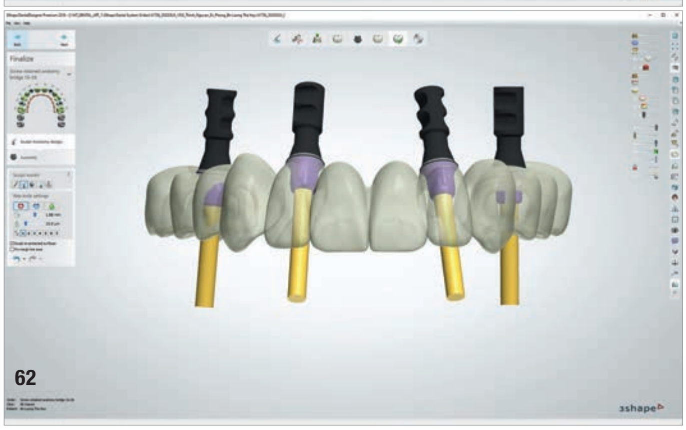
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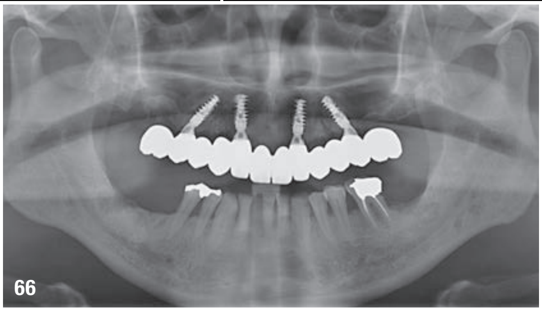
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placed on the SRAs, followed by bone grafting using cerabone granules (botiss biomaterials) with a 1–2 mm grain size in the extraction sockets and suturing (Figs. 52–54).

Impression taking for the zirconia temporary restoration

Owing to circumstances, the patient was not able to visit the clinic periodically for follow-ups; therefore, we decided to use an immediate PMMA restoration for a short time and design an immediate temporary restoration on zirconia material to optimise the condition and patient experience while he was not able to visit our clinic.

For the impression taking, we used open-tray impression copings (Fig. 55), and the impression and the bite registration were transferred to the laboratory (Figs. 56 & 57). The PMMA restoration was screwed on to the SRAs, and the DSD 2D file was taken (Fig. 58).

Laboratory procedures for the zirconia temporary restoration

After creating the master cast, we were able to scan and design the zirconia restoration (Figs. 59–62). The design of the zirconia frame was done by obtaining the information from the bite registration, the image of the temporary prosthetic design (Fig. 6) and the mock-up copied by DSD based on the PMMA temporary restoration (Fig. 58).

At this time, we were able to make a few modifications to the zirconia frame. The design of the zirconia temporary restoration was sent to the milling unit and produced on a full-contour zirconia disc. The zirconia frame was then cemented on Variobase copings (Straumann) as an interface to be screwed on to the SRAs (Figs. 63 & 64).

Five-day follow-up

After five days, the patient returned to the clinic, and the PMMA temporary restoration was removed and the zirconia temporary restoration was placed, allowing a passive fit on the abutments with initial hand tightening of each SRA up to 5 Ncm. After the seating had been checked, the torque of each SRA screw was increased up to 35 Ncm, and the restoration was screwed in at a torque of 15 Ncm. The occlusion was checked, and the contacts were inspected. The screw holes were sealed with PTFE and a temporary filling material (Fig. 65). A panoramic radiograph was taken, and the SRA screw positions were evaluated to confirm the perfect fit of the temporary restoration (Fig. 66). Oral hygiene and dietary instructions were given to the patient, and a one-week follow-up appointment was scheduled.

Treatment outcomes

Immediate implant placement associated with immediate loading is a predictable protocol with some variables. The digitally planned tooth extraction was integrated with the production of a screw-retained CAD/CAM temporary restoration prior to the surgery and was successfully achieved. The entire treatment workflow was done fully digitally. Only a single surgical step was required to provide an entire individualised restoration.

about

Dr Tran Thanh Phong holds a DDS from University of Medicine and Pharmacy in Ho Chi Minh in Vietnam and completed the Master Clinician Program in Implant Dentistry of the gIDE Institute in Santa Monica in California in the US. He is an experienced oral surgeon and runs a private practice focused on oral implantology in Ho Chi Minh City in Vietnam. An expert in digital implant dentistry and merging CAD/CAM processes with digital workflows, he is a well-known speaker for the International Team for Implantology in Vietnam.

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

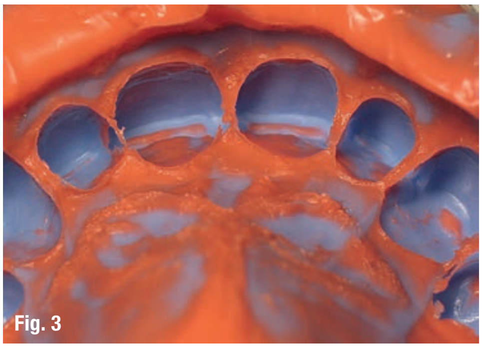
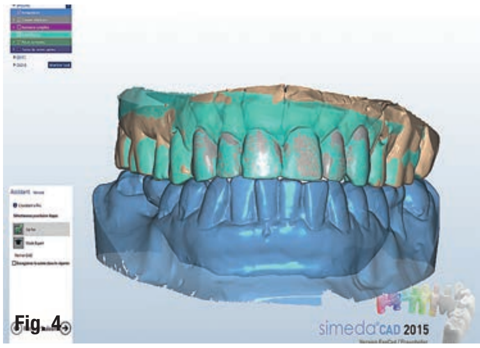


Fig. 3

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



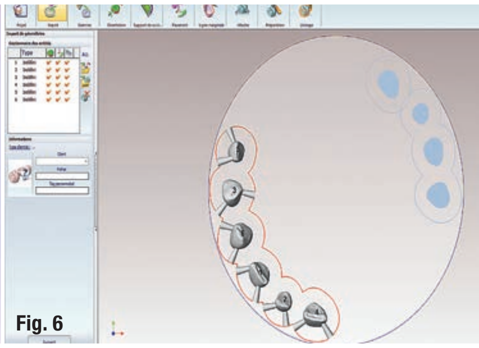


Fig. 4: Screenshot of the design software. **Fig. 5:** Structur CAD disc. **Fig. 6:** Screenshot of the nesting software.

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

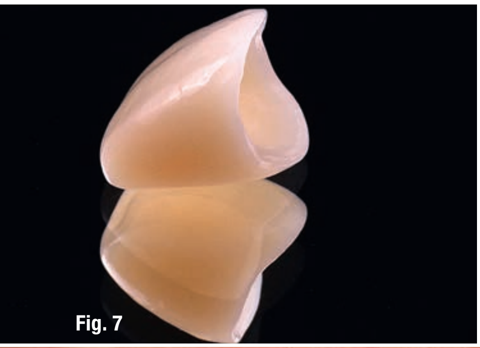


Fig. 7: Structur CAD provisional crown. **Fig. 8:** Try-in of provisional crowns. **Fig. 9:** Smile with provisional crowns. **Fig. 10:** Porcelain crowns luted with Futurabond DC and Bifix QM (VOCO). **Fig. 11:** Final result.

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.

Guided soft-tissue emergence profile techniques using CAD/CAM technologies—Multiple case reports

Drs Christian Brenes & Wally Renneb, USA

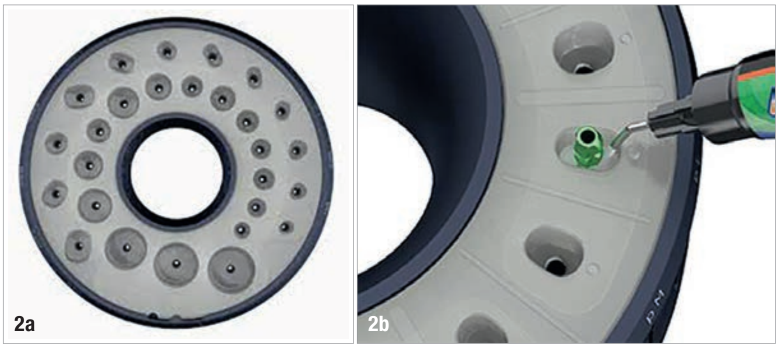
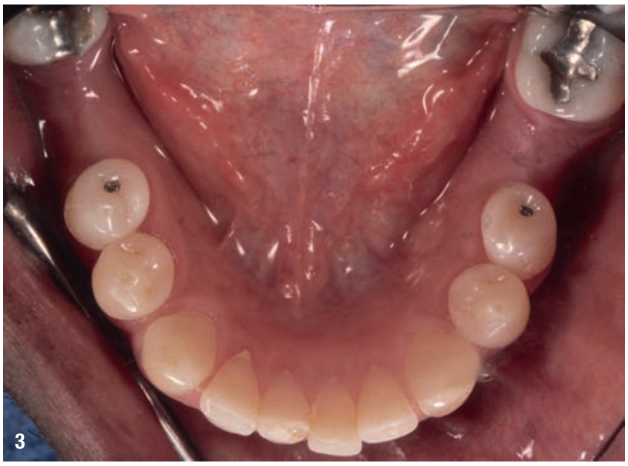


Fig. 1: Contour Healer PEEK abutment. **Figs. 2a & b:** VPI EPI system.

Introduction

Since 1989, Smith and Zarb incorporated appearance into the criteria for dental implant success.[1] Decades of evidence supports the importance of generating implant-supported aesthetic restorations, with little attention to improving the soft-tissue emergence profiles or natural contours of the teeth.[2] Immediate provisional restorations are generally a good way to manage soft-tissue contours, aiding during the healing process with obvious aesthetic benefits. Several authors have reported great results during decades of using traditional provisional techniques by minimally altering the biology of the soft tissue during the healing process.[3] The main limitation of traditional techniques is the chair time needed during or after the surgical procedure to fabricate such provisional restorations; when determining the efficiency of a protocol, the time factor is critical and most clinicians choose standard cylindrical abutments to guide tissue contours before the final impression. Abrahamsson et al. reported that subsequent disconnections and reconnections of abutment components might compromise the mucosal barrier, and this could lead to retraction or apically positioned



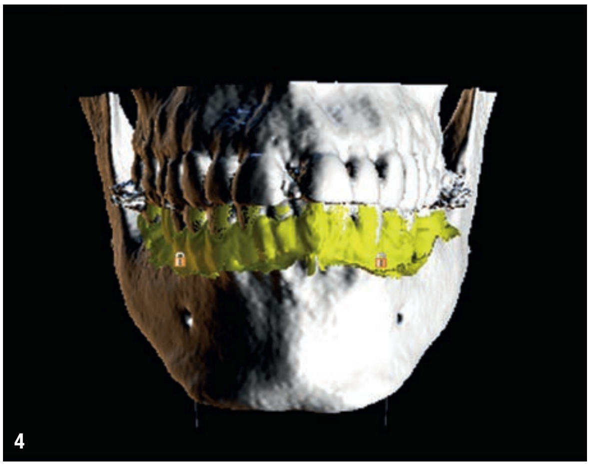


Fig. 3: Intra-oral occlusal view of missing teeth #36 and 46. **Fig. 4:** STL model aligned to DICOM 3D reconstruction.

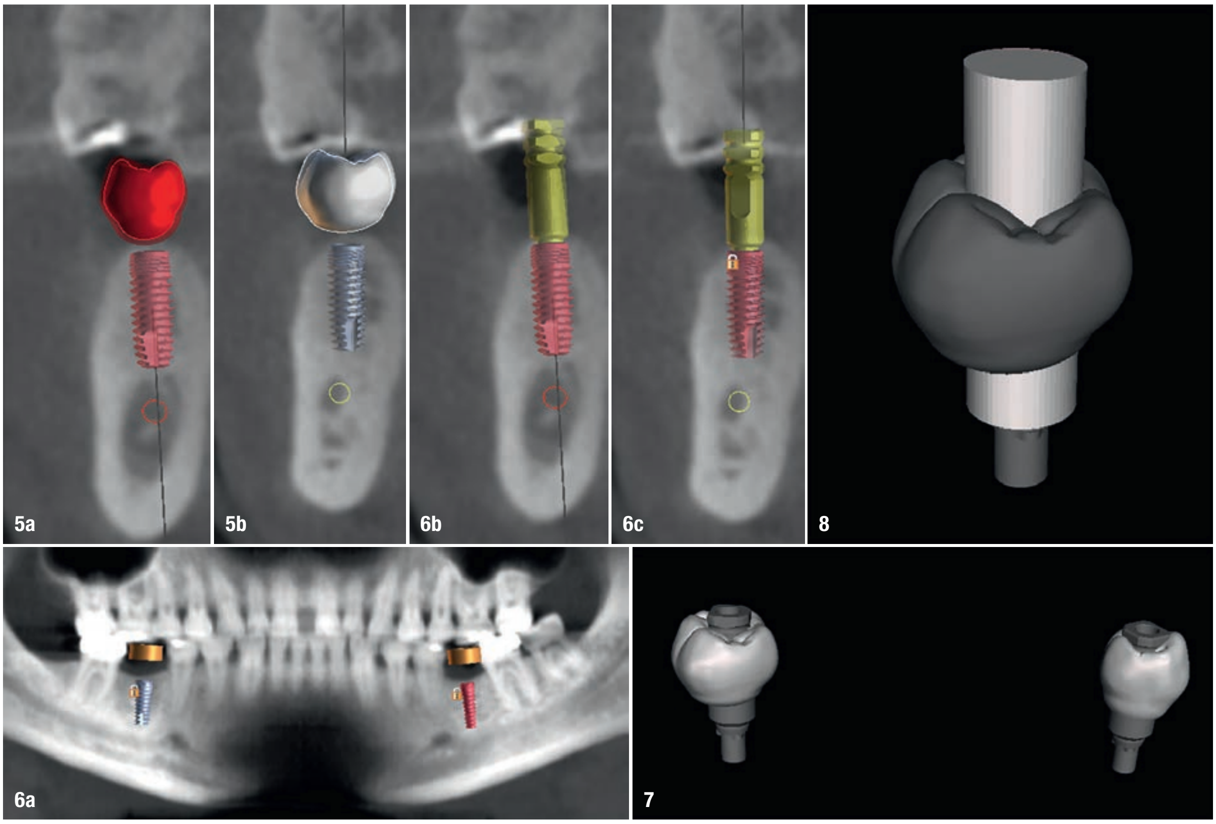


Fig. 5a: Digital wax-up using Brenes pontic library of tooth #35 owing to lack of mesiodistal space to replace tooth #36. **Fig. 5b:** Digital wax-up using Brenes pontic library of tooth #46 to recreate the desired natural emergence profile. **Fig. 6a:** Implant planning of 2 implants (NobelReplace Conical Connection) in positions #36 and 46. **Figs. 6b & c:** Proper implant planning with corresponding digital temporary abutments. **Fig. 7:** Teeth with temporary abutments to visualise the final position of the screw access holes. **Fig. 8:** Tooth with generated cylinder in Meshmixer.

connective tissue due to increased bone remodeling.[4] In addition, most cylindrical and unnatural emergence profiles could lead to food impaction and possible biological complications due to poor emergence profiles, food impaction and potential peri-implantitis.

In the past, several authors described accelerated dental implant protocols such as immediate placement and immediate provisionalisation.[2,5] Recently, some companies have developed anatomical healing abutments that, in contrast to custom healing abutments, have an anatomical shape based on average standardised healing profiles. Systems such as Contour Healer (Common Sense Dental Products), which are anatomical PEEK abutments that can be shaped, and the VPI EPI mold system (VP Innovato Holdings), which helps fabricate composite anatomical abutments from a silicone mold, are among the most popular systems. The limitations of using such analogue systems are reliance on the limited implant brands they are compatible with,

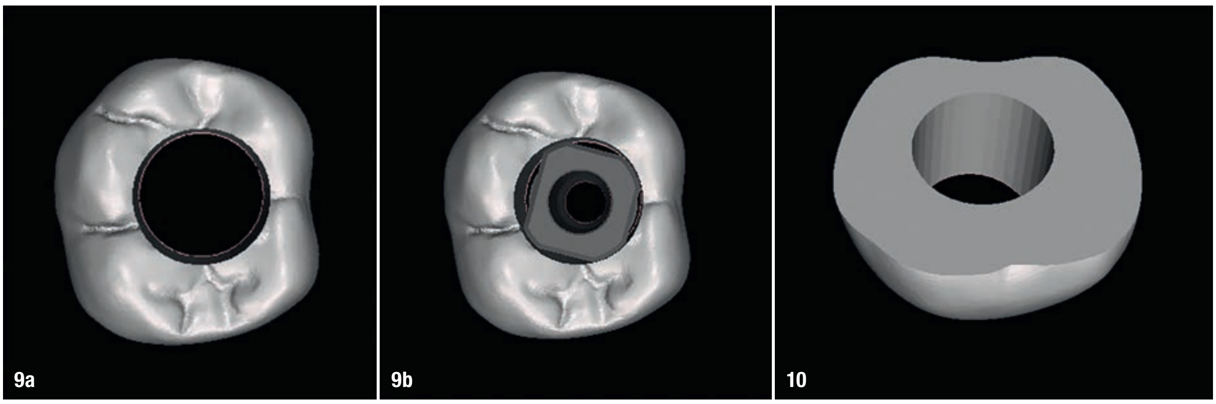
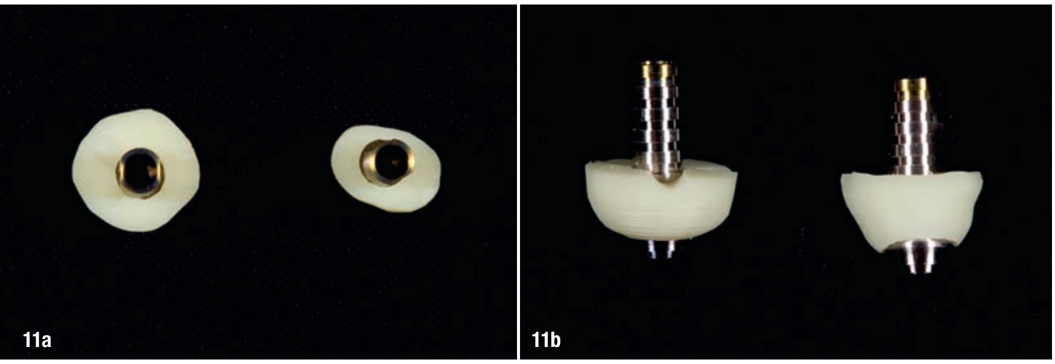


Fig. 9a: Hole created on tooth after Boolean difference operation. **Fig. 9b:** Visualisation of temporary abutment through the hole. **Fig. 10:** Healing abutment created after cutting the tooth with the plane cut function in Meshmixer.



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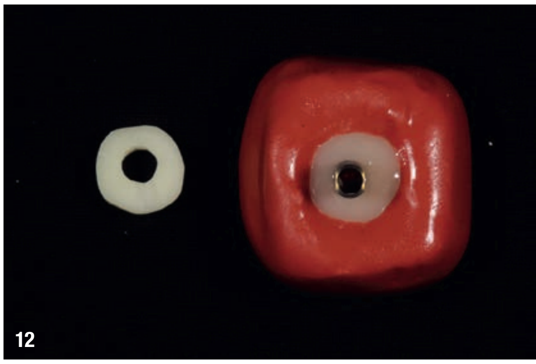

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Fig. 11a: Occlusal view of printed healing abutments seated on the nonengaging temporary abutments. **Fig. 11b:** Lateral view of printed healing abutments seated on the nonengaging temporary abutments and their emergence profiles. **Fig. 12:** Alternative copy of printed pre-surgical custom healing abutment using putty and flowable composite to copy the emergence profile.

the healing process not being guided from the emergence profiles of the final restoration or wax-up, and being able to fabricate healing abutments only, but not provisional crowns (Figs. 1–2b).

The use of CAD/CAM technologies has offered different techniques to generate custom restorations. Most systems allow for the scanning of scan bodies after implant placement to generate an implant-supported provisional restoration, but this technique only allows the clinician to generate the provisional restoration after the surgery. The use of guided surgery in combination with pre-surgical customised healing abutments or provisional restorations with natural emergence profiles can provide the clinician with a very cost-effective and predictable way of replicating nature and minimising soft-tissue trauma.

Two different techniques are described for the creation of a pre-surgical custom healing abutment or provisional restoration. The first case describes the use of digital libraries with pontic emergence profiles. The 3D object (tooth) is manipulated to replicate or to establish a natural contour of a tooth. The second technique describes the use of segmentation and mirroring of a natural tooth to generate an exact replica and emergence profile of the patient's dentition.

Clinical case 1

A 52-year-old man presented to the Dental College of Georgia at Augusta University, Augusta, Georgia, USA, with the chief complaint of two missing posterior teeth (Fig. 3). During the first appointment, clinical and radiographic examinations were completed for proper diagnosis and formulation of treatment plan. The periodontal condition was stable, no endodontic lesions were found, and the patient reported good hygiene. After proper diagnosis, it was determined that the patient could be a candidate for dental implant therapy. Digital impressions were taken using the Medit i500 intra-oral scanner (Medit), along with a CBCT scan. With the diagnostic information acquired, the data were imported into the free implant planning software used

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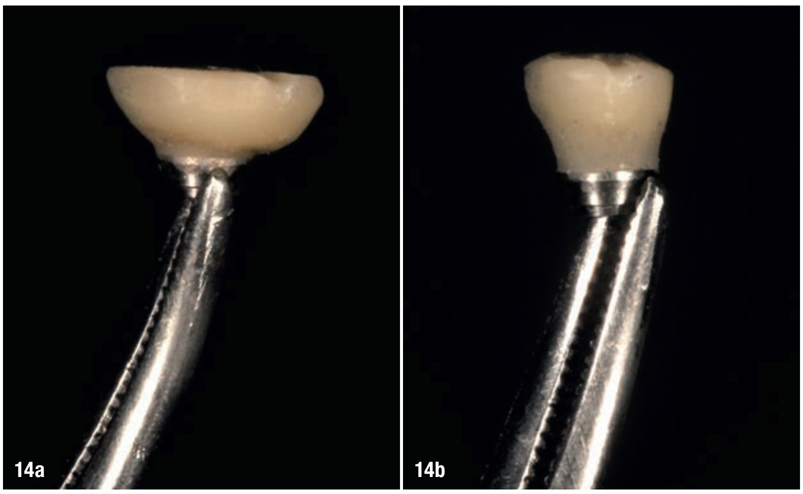

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Fig. 13: Printed surgical guide with metal cylinder. **Fig. 14a:** Pre-surgical healing abutment for tooth #46. **Fig. 14b:** Pre-surgical healing abutment for tooth #36 with a premolar shape owing to lack of restorative space.

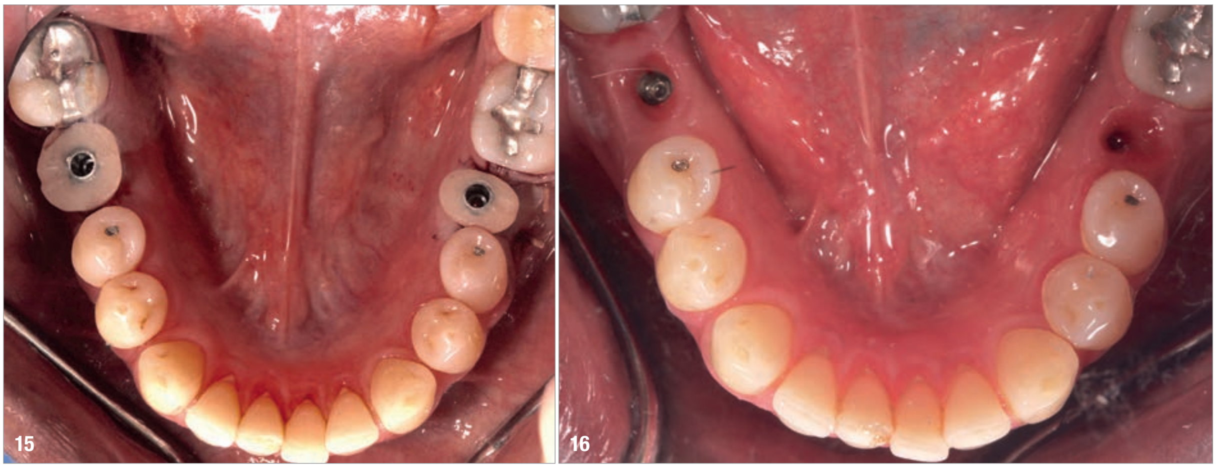


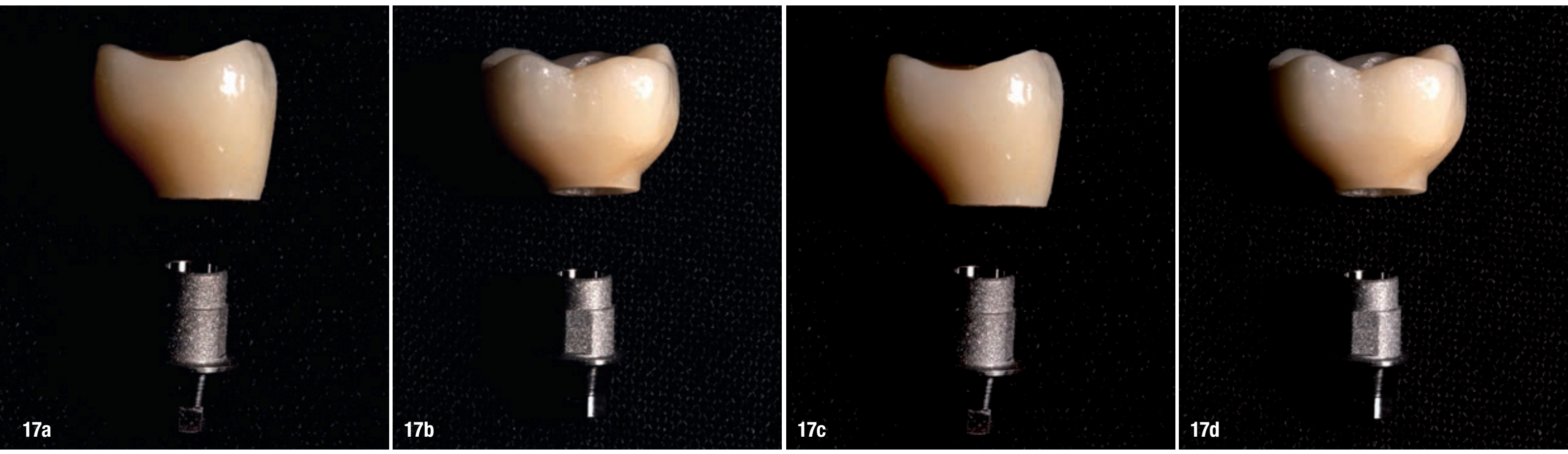
Fig. 15: Intra-oral occlusal view of pre-surgical healing abutments immediately after surgical procedure. **Fig. 16:** Intra-oral occlusal view of the natural emergence profiles of the tissue 3 months post-surgery.

in this case (Blue Sky Plan, Blue Sky Bio) and the STL model aligned to the DICOM volume using match points (Fig. 4).

The following steps describe the technique of using digital libraries for a pre-surgical custom healing abutment or provisional restoration:

1. A 3D wax-up is fabricated in the implant planning software. In this case, the Brenes pontic library was used to recreate the natural emergence profile of the restorations (Figs. 5a & b).
2. Proper implant planning and positioning is done. In this case, two NobelReplace Conical Connection implants (Nobel Biocare) were planned with their corresponding digital temporary abutments to visualise the final position of the screw access holes (Figs. 6a–c).
3. The digital wax-up and temporary abutments are exported from the open architecture software (Blue Sky Plan) in STL format and the files imported into Meshmixer (Autodesk) or any software that allows for 3D data manipulation (Fig. 7).
4. A cylinder that has the same width of the temporary abutment is generated and positioned according the position of the restoration (Fig. 8).
5. The crown and the cylinder are selected and a Boolean difference function is performed to subtract the cylindrical shape from the crown (Figs. 9a & b).
6. Alternatively, the provisional restoration is cut using the plane cut function to generate a healing abutment or a provisional restoration with flat anatomy that is not going to be in occlusion (Fig. 10).
7. The new restoration, with an occlusal access hole, is exported as an STL binary file to be manufactured.
8. The restoration can be manufactured by means of milling technologies using PMMA, can be printed with biocompatible materials, or printed and used as a scaffold for a composite healing abutment (Figs. 11a–12).

Two surgical guides (1 for each side) were exported from Blue Sky Plan software and printed using the Asiga MAX printer (Asiga) and NextDent SG resin



Figs. 17a & b: Lateral view of final restorations and Ti-bases. **Figs. 17c & d:** Frontal view of final restorations cemented on Ti-bases.

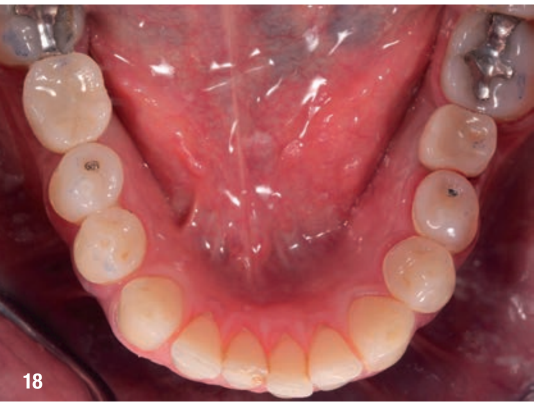


Fig. 18: Intra-oral occlusal view of final screw-retained restorations. **Figs. 19a & b:** Lateral view of final screw-retained restorations.

(NextDent; Fig. 13). The pre-surgical custom healing abutments were printed using NextDent C&B MFH resin and attached with premise flowable composite (Kerr Dental) to the temporary nonengaging abutments. The remaining metal structure of the temporary abutments was cut with a diamond disc and polished (Figs. 14a & b).

Two horizontal incisions were made over the edentulous ridges after a proper anaesthetic effect was achieved; no vertical incisions were required for a flapless approach. The surgical guide was used to create 2 guided osteotomies using a set of guided stoppers (Digital Dentistry Education) in conjunction with Densah drills (Versah) to place two 4.3 × 11.5 mm implants (NobelReplace Conical Connection) in positions #36 and 46. Excellent primary stability was achieved and the two pre-surgical custom healing abutments screwed in place (Fig. 15).

Three months later, the custom healing abutments were removed for the final impression, the natural emergence profile of the tissue was created and the tissue was healthy (Fig. 16). An intra-oral digital impression was taken to capture the natural emergence profile of the soft tissue using the Medit i500 and Nobel-compatible intra-oral DESS scan bodies (DESS). Two screw-retained crowns were designed using exocad (exocad) over two DESS Ti-bases and cemented with Maxcem Elite Chroma resin cement (Kerr Corporation; Figs. 17a–d).

At the delivery appointment, the final restorations were torqued following the manufacturer's recommendation, and the access screw channel was covered with PTFE tape and composite resin. The occlusion was checked and the patient was satisfied with the treatment outcome (Figs. 18–19b).

Clinical case 2

A 56-year-old patient presented to the Medical University of South Carolina with the chief complaint of a missing anterior tooth (Fig. 20). After a thorough, but unremarkable health history and clinical examination, an intra-oral digital impression was taken (Planmeca Emerald, Planmeca) at the consultation appointment and an Ultra Low Dose CBCT scan (Planmeca ProMax 3D Max) was also taken (Fig. 21). A mirror of the patient's tooth #9 was waxed into site #8 using the mirror contralateral tooth feature in Planmeca Romexis Version 5.2 (Planmeca; Fig. 22). The intra-oral scan

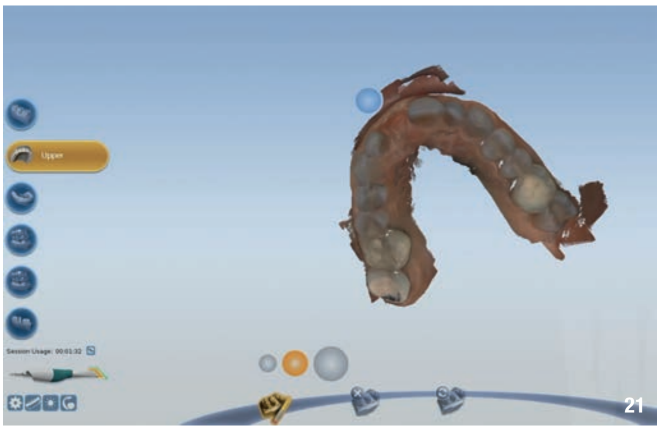
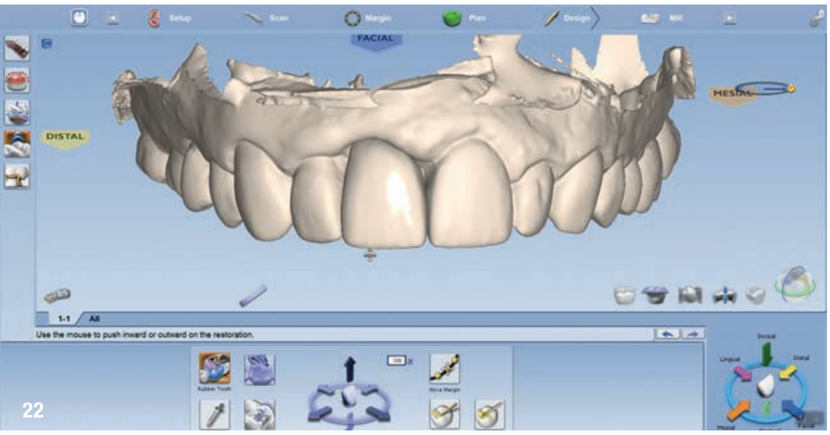


Fig. 20: Patient preoperative condition. **Fig. 21:** Image captured from Planmeca Emerald scanning module.



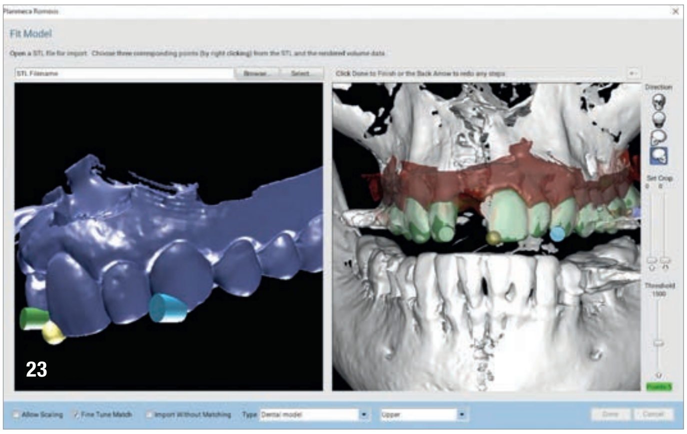
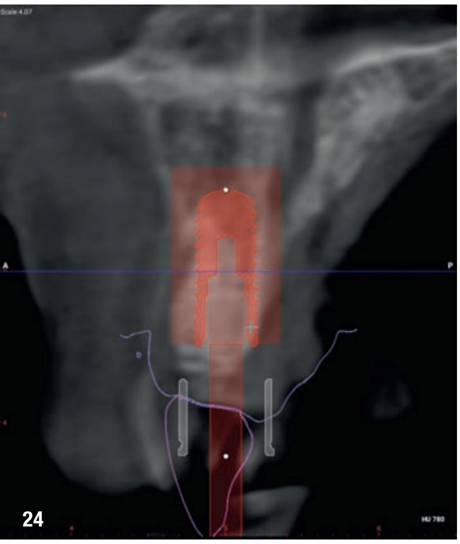


Fig. 22: Mirror contralateral tooth feature. **Fig. 23:** Software best algorithm alignment using the 3 common points of the intraoral impression STL and CBCT scan.

and wax-up were merged with the CBCT scan and an Astra Tech OsseoSpeed EV implant (Dentsply Sirona) was planned, the adjacent root segmented and a surgical guide created. All elements were exported into Meshmixer, and the adjacent root was mirrored and then merged with the original wax-up of tooth #11. Boolean difference was then used to cut a perfect hole in the digital design. The restoration was then imported into the Planmill 30S (Planmeca) and milled out of a resin nanoceramic material (Lava U, 3M). Custom resin stains were used (Light Art, BISCO).

The guided soft-tissue emergence profile techniques using the segmentation approach can be done using the following steps:

1. A digital wax-up is produced on the basis of an intra-oral digital impression. The digital wax-up in the edentulous space is made using an exact mirror image of the contralateral tooth in Planmeca Romexis Version 5.2 (Fig. 22).
2. The intra-oral digital impression and the wax-up are merged with the CBCT scan using common data points and then a best-fit algorithm is utilised to merge the two data sets (Fig. 23). Proper digital planning and implant placement are performed. In this case, the implant was placed 3 mm apical to the cementoenamel junction of the wax-up and 2 mm palatal (Fig. 24). The corresponding manufacturer's temporary abutment was designed in the Planmeca Romexis abutment editor and attached to the digital plan (Fig. 25).
3. The surgical guide is exported and then manufactured (Fig. 26).
4. The contralateral tooth and root were then isolated and segmented using a fairly automated tooth segmentation feature in Planmeca Romexis (Fig. 27).
5. All elements are exported as STL files, including the implant location, abutment, surgical guide, intra-oral scan, mirror tooth wax-up and contralateral root.



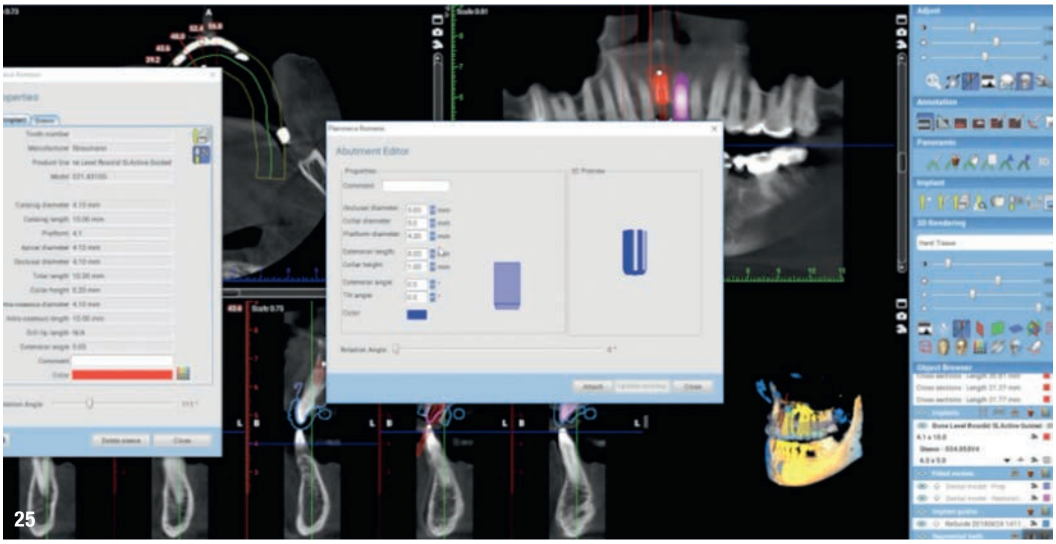
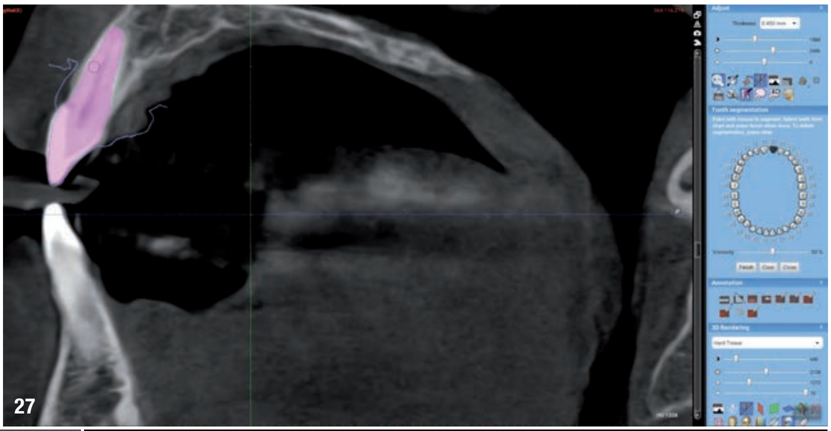


Fig. 24: Virtual implant placement. **Fig. 25:** Abutment design in Planmeca Romexis abutment editor.

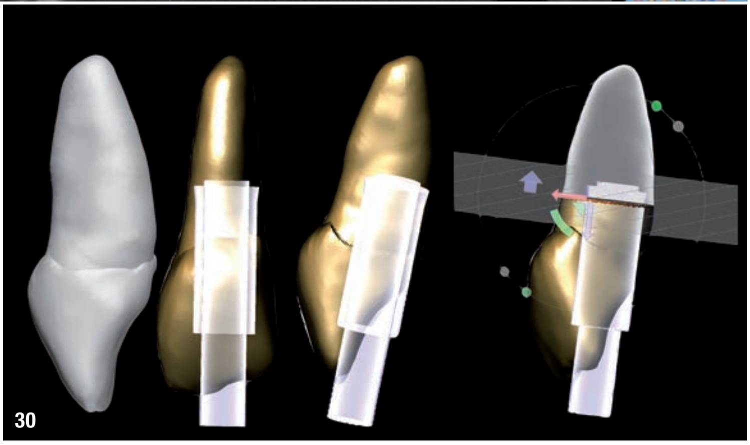



Fig. 26: Planmeca Romexis surgical guide module. **Fig. 27:** Tooth segmentation feature in Planmeca Romexis. **Fig. 28:** Segmented tooth and root mirrored and then overlaid in Meshmixer. **Fig. 29:** Combined CBCT segmented tooth and digital wax-up. **Fig. 30:** Sectioned tooth at the margin of the abutment.

6. Using Meshmixer, a mirror image of the segmented root is produced and then merged with the digital wax-up (Figs. 28–30).
7. The new mesh is made solid and sliced right at the location of the margin in the exported abutment from the implant planning software (Fig. 31).

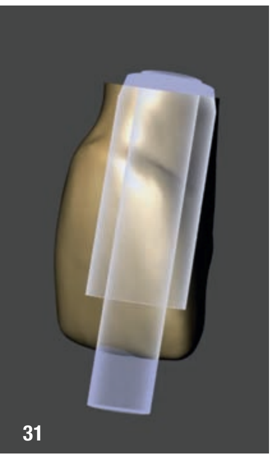
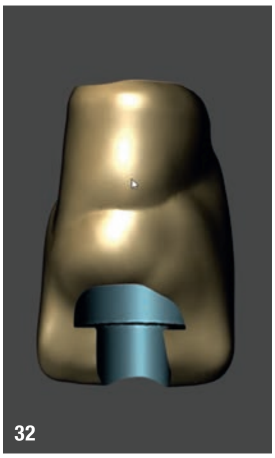




Fig. 31: Transparent view in Meshmixer. **Fig. 32:** Tooth with hole after Boolean difference operation. **Fig. 33:** Printed and characterised tooth on stock temporary abutment.

8. The crown and the cylinder are selected and a Boolean difference function is performed to subtract the cylindrical shape from the crown (Fig. 32).
9. The new restoration is exported for additive or subtractive manufacturing and the fit verified on the temporary abutment (Fig. 33). Owing to timing, the restoration is not attached to the abutment until the day of surgery.
10. Therefore, after the initial consultation and data collection, a surgical guide is printed and a pre-surgical provisional restoration is fabricated using a mirror image of both the clinical crown of the contralateral tooth and the root to gain a natural emergence profile.
11. The surgical guide in this case was exported from Planmeca Romexis and printed using Dental LT Clear Resin (Formlabs) with the Form 2 printer (Formlabs).

During the surgical procedure the guide is evaluated for fit, and a flapless approach is taken (Fig. 34). After the osteotomy the implant is placed through the guide to the proper depth (Figs. 35 & 36). The manufacturer's temporary abutment is seated, the custom pre-surgical provisional restoration is seated and flowable resin composite is injected around the space of the provi-

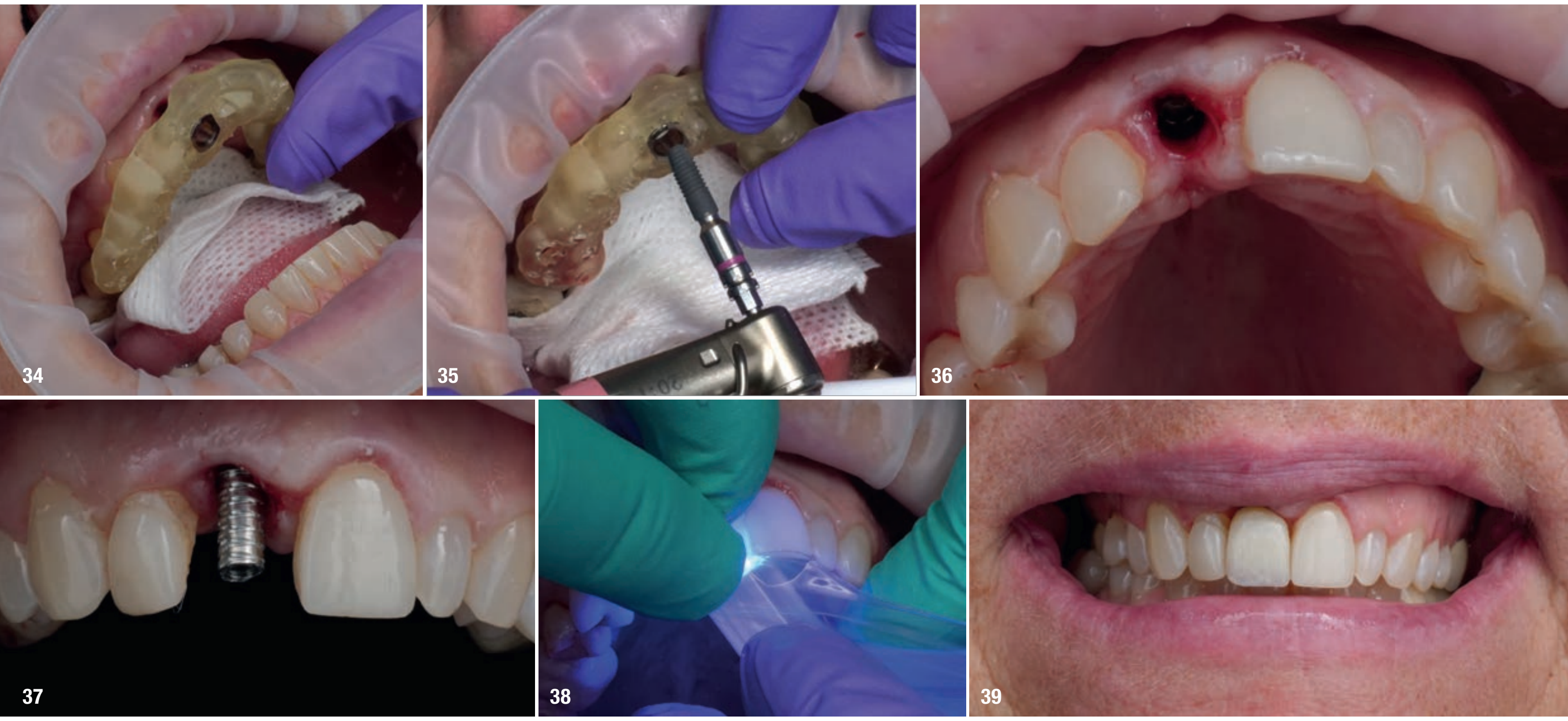


Fig. 34: 3D printed surgical guide. **Fig. 35:** The implant is placed after the manufacturer's osteotomy sequence has been performed. **Fig. 36:** Flapless approach and implant placement. **Fig. 37:** Placement of temporary titanium abutment. **Fig. 38:** Pre-surgical provisional restoration pressed to depth in the temporary abutment and picked up with flowable resin. **Fig. 39:** Frontal view of restoration immediately after delivery.

sional restoration and abutment (Figs. 37 & 38). The restoration is removed, polished and reseated for delivery (Fig. 39), and the access screw channel is covered with PTFE tape and composite resin.

Conclusion

Even though particular CAD/CAM systems were used in the workflow described, the user is able to use other open architecture systems and software to develop the techniques. The techniques described in this article can be used in every implant case to guide soft-tissue emergence profiles to achieve adequate aesthetics and function; an inadequate emergence profile can lead to food impaction, gingivitis and possible peri-implantitis. The use of CAD/CAM technologies allows clinicians to have predictable results in a consistent manner allowing the clinicians to also reduce chair time and be more efficient.

Competing interests

The authors declare that they have no competing interests.

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Veneer restoration: Calibrated preparation to close diastemas

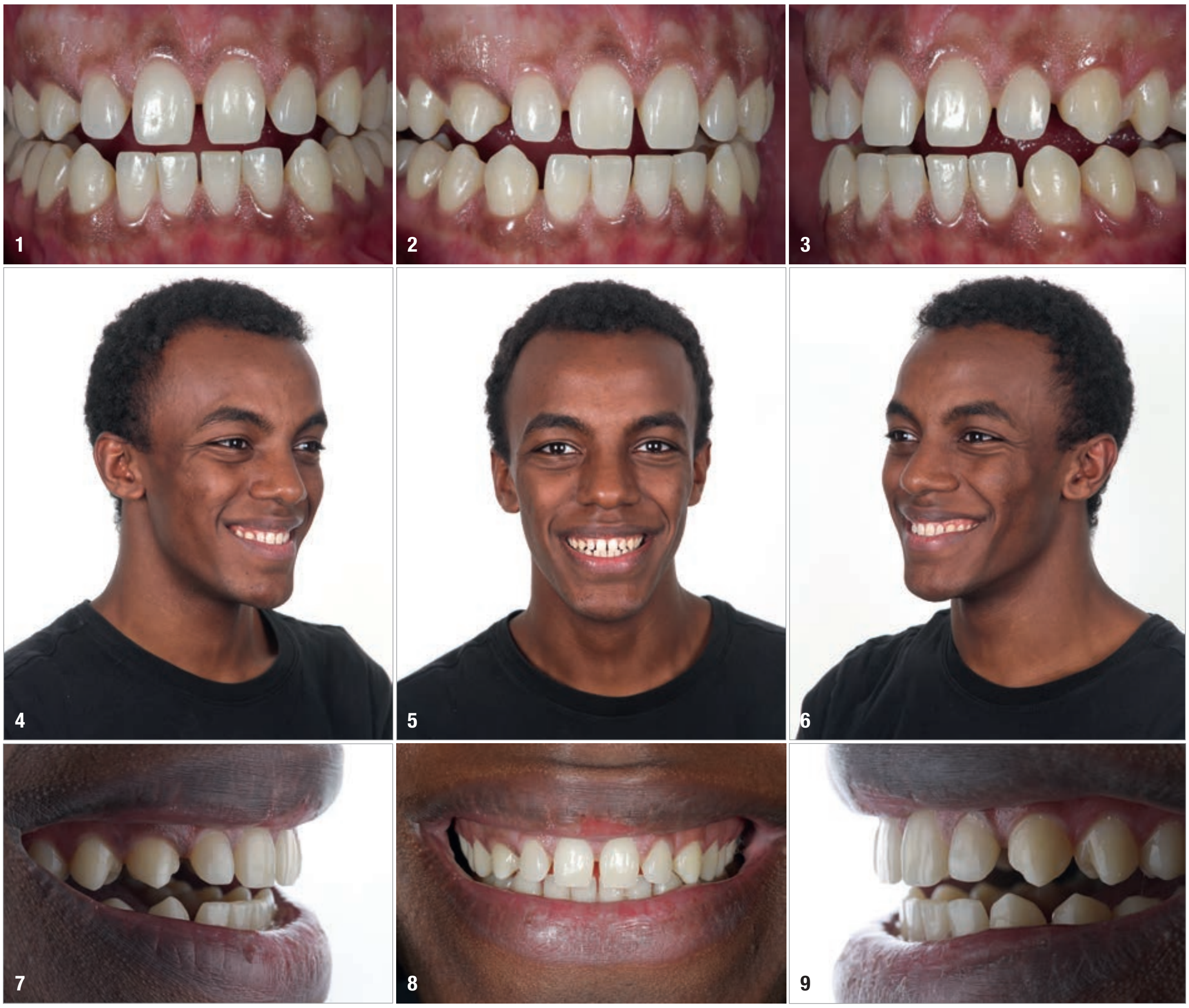
Technical planning for a new dental shape configuration

Giuseppe Romeo, Italy/USA

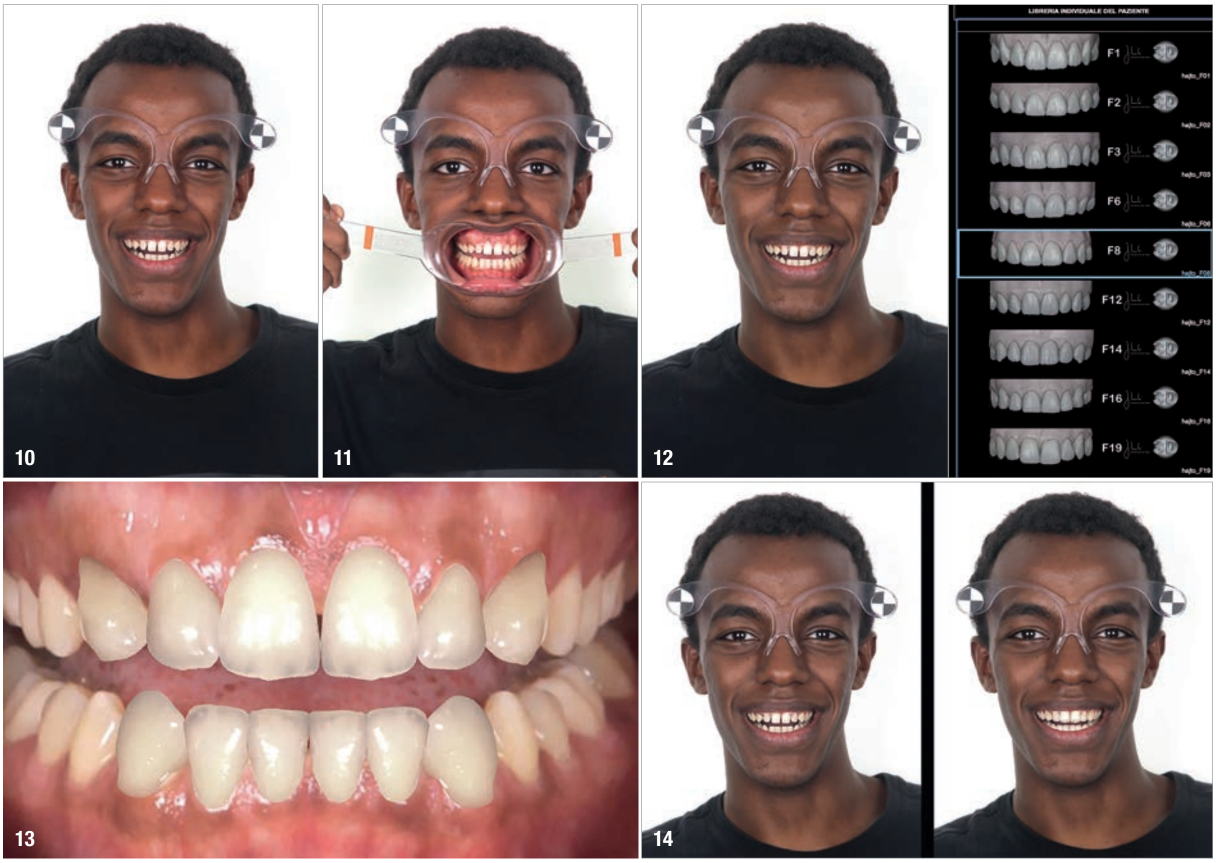
Introduction

Tooth structure preservation is the best way to avoid more invasive therapies. In young patients especially, more conservative techniques should be applied. Bonded porcelain veneers and even more so direct composite restorations are two therapeutic procedures that require the sacrifice of less dental tissue, finalised to the optimal recovery of aesthetic and functional outcome. Although the two techniques employ different methods and materials, it is possible to achieve correct integration of both techniques by certain technical and procedural measures.

In the case presented, restoration of the eight anterior teeth of the maxilla using ceramic veneers and six anterior teeth of the mandible using direct composite restorations was planned. Care was taken in the surface



Figs. 1–3: Initial situation with diastemas in the upper and lower jaws. **Figs. 4–6:** Initial situation on smiling. **Figs. 7–9:** Initial situation on smiling, lateral and frontal views.



Figs. 10–12: Digital smile system glasses and digital dental library selected by the software for the smile planning. **Figs. 13 & 14:** Intra-oral and extra-oral final digital result.

treatment of ceramic restorations with the objective of achieving integration, not only between the natural teeth and restorations but also between the different materials in use. The purpose of this article is to show how proper design of the treatment plan leads to predictable results with both direct and indirect techniques.[1]

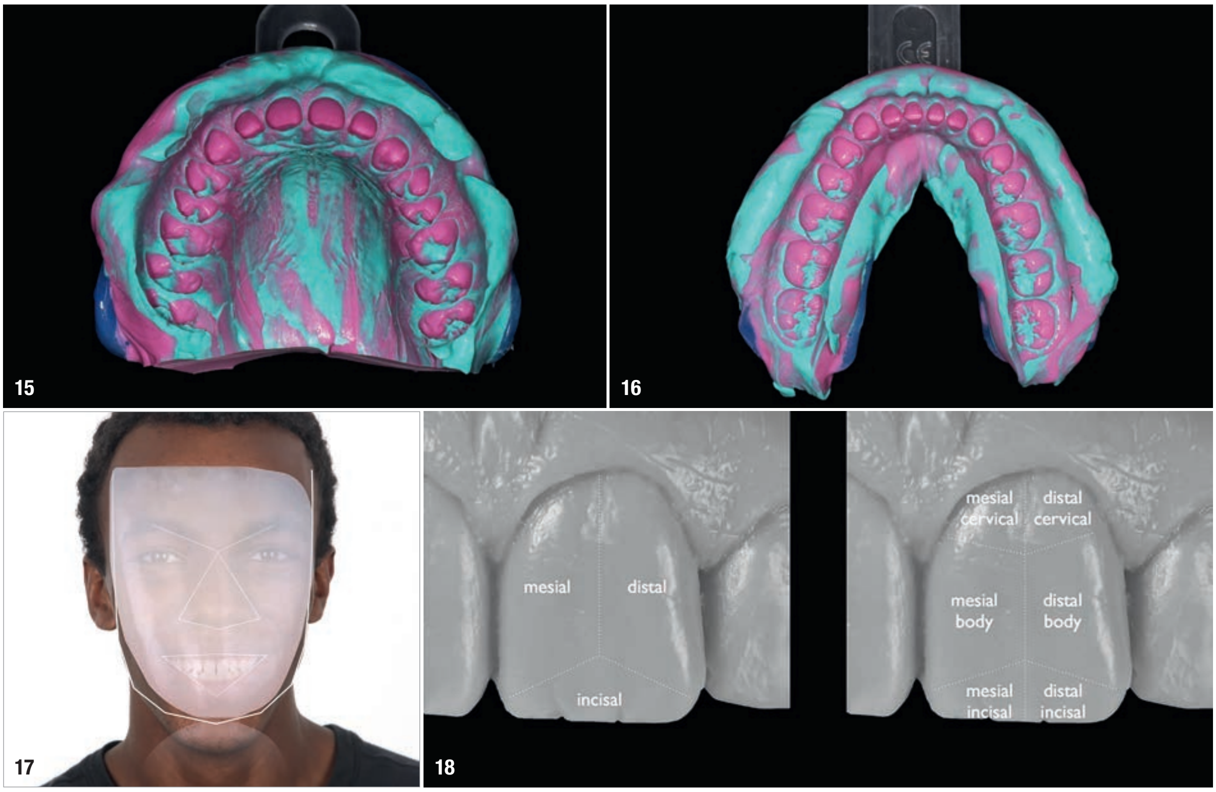
Ceramics and composites present different superficial nano-textures, and this leads to different reflection of light on the surface. In the aesthetic zone, this difference could represent a limit in the choice of restorative material because the two substances interact differently with light. If a little amount of saliva wets the surface, this difference can be seen as shiny and well-defined glassy reflections on ceramics and as matte and blurred reflections on composites. There are techniques that allow manual polishing of the ceramic surface in order to maintain a certain grade of nano-roughness at the surface such to obtain a composite-like reflection of light. In the case presented, a technical workflow to obtain fine integration between the two materials is described.

Case presentation

A 30-year-old male patient presented to the office complaining about his smile. He was uncomfortable with the diastemas between his maxillary anterior teeth and the diastemas on the mandibular arch between the two central incisors and between the two lateral incisors and canines (Figs. 1–9). His expectations were improvement of his smile and the shape of the teeth in order to close all the diastemas.

After consultation with the dentist, the first clinical decision was to employ a digital smile system to create the hypothetical definitive restoration to show directly to the patient on the computer.[2–4] This system is employed using special glasses worn by the patient and by capturing extra-oral and intra-oral photographs (Figs. 10–12). All these photographs are exported to the software that will analyse several shapes for the new aesthetic restoration. This software also takes into consideration the facial details of the patient in order to elaborate the anatomical shapes to use for the case. The dental shape chosen from the library is digitally adapted in the intra-oral photograph in order to achieve the new smile configuration. The dentist has the possibility of comparing the harmonious aesthetics between the face and the new smile to show to the patient for his or her approval (Figs. 13 & 14).

All this information will be sent to the laboratory for the wax-up procedures. It is a tool for communication between the dental office and the laboratory employed in



Figs. 15 & 16: Maxillary and mandibular impressions for the diagnostic models. **Fig. 17:** Facial analysis for planning the individual tooth shape. **Fig. 18:** Segmentation of the tooth and full segments divided into half segments.

planning a manual wax-up. The laboratory always needs guide references for the patient before starting the work. Without the requisite information, the future wax-up done by the dental technician will only be an artistic performance that cannot assure the success of the resin pre-visualisation in the patient's mouth.[5,6]

The laboratory received the impressions and the facebow record; all the digital information was sent via online communication (Figs. 15 & 16). The indications from the dental office was a diagnostic wax-up for veneers from canine to canine and for partial veneers on the two first premolars. The diagnostic models were poured in Class IV dental stone and mounted on the articulator using the facebow record.

Before starting the manual wax-up, a digital analysis of the face was evaluated in order to plan the individual dental shape of the patient. This procedure evidences the clinical and technical planning cooperation between the dental office and the laboratory. The facial analysis was done employing several parametric lines, such as

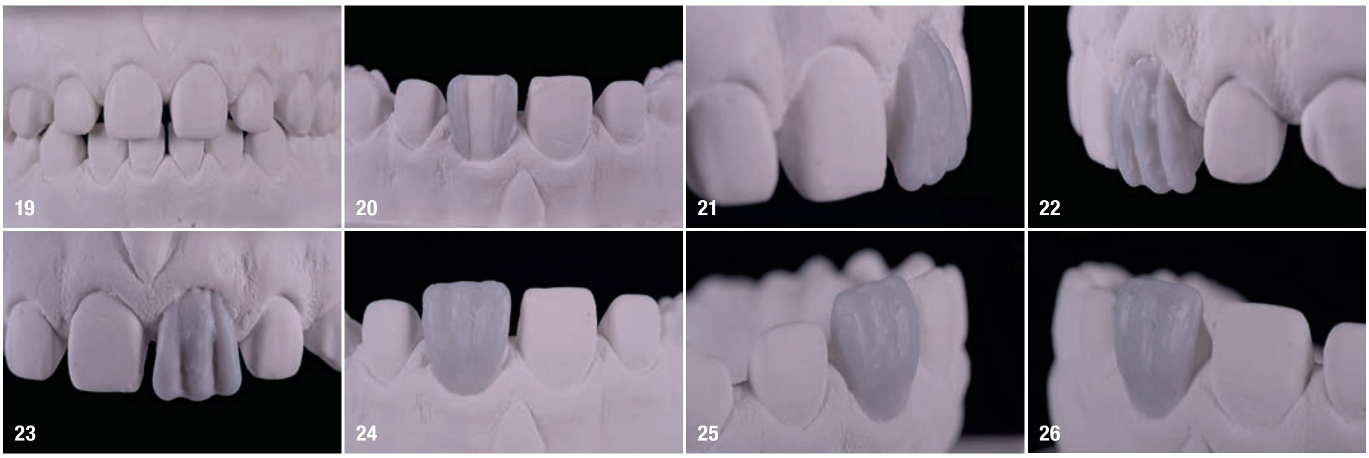


Fig. 19: Plaster model of the pre-op maxillary situation. **Fig. 20:** Facial transition lines. **Figs. 21 & 22:** First wax-up unit, lateral view. **Fig. 23:** Central lobe and incisal cones. **Figs. 24–26:** Wax-up of the entire facial area, frontal and lateral views.

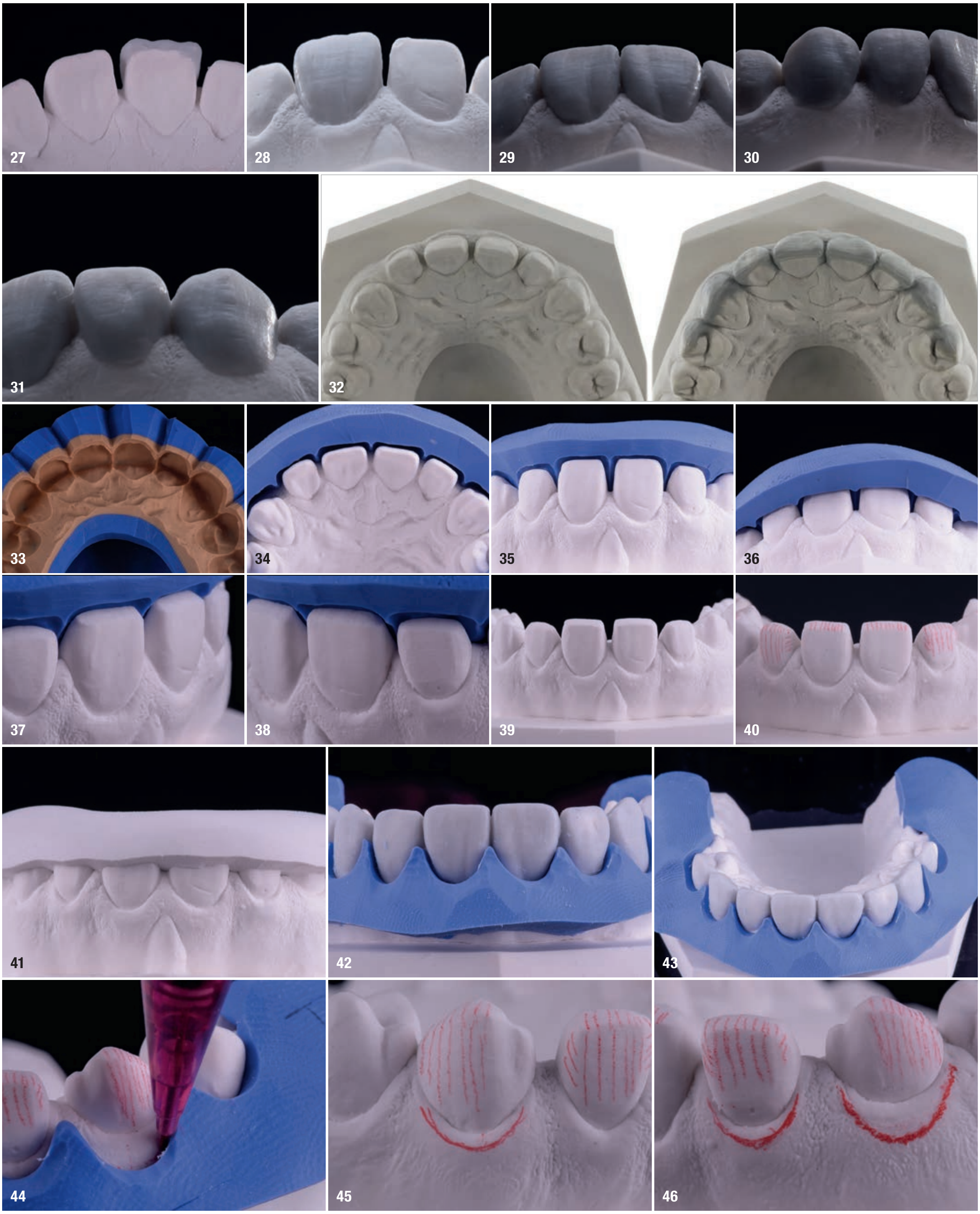
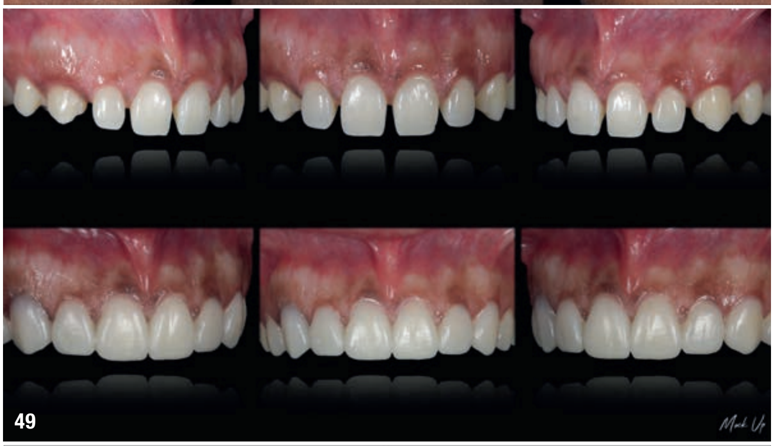


Fig. 27: Lingual view of the waxed up incisal edge. **Fig. 28:** Final wax-up and texture. **Figs. 29–31:** Final wax-up of all units. **Fig. 32:** Comparison of the pre-op situation and final wax-up. **Fig. 33:** Silicone index for the mock-up in double material. **Figs. 34–38:** Sectioned silicone key on the plaster model for laboratory reduction. **Figs. 39 & 40:** Calibrated reduction completed by the laboratory and red marked areas. **Fig. 41:** Silicone index of the preparation for clinician control. **Figs. 42–46:** Surgical silicone index for crown lengthening and cervical contours marked with a red pencil.



Figs. 47–50: Mock-up procedures and result in the mouth in order to evaluate the aesthetic relation between the face and the smile.

the bifrontal, bizygomatic and bigognatic areas.[7] In these facial perimeter references, the planned tooth shape was digitally drawn as an initial technical aesthetic approach before performing the wax-up (Fig. 17).

The diagnostic models mounted on the articulator are ready to use for the diagnostic wax-up. Based on the digital planning of the individual shape, the dental technician will start to perform the wax-up by first establishing the position of the two facial transition lines. The position of the two facial transition lines is determined by the cervical contour design. When we have cases where diastemas have to be closed, the final shape of the teeth will be always different from the original one. The findings of the relative importance of facial geometry were different and depended on the segments they formed. The perimeter of each tooth form was sectioned into smaller segments employing the Dental Anatomical Combination technique.[8] If necessary, these full segments can be further divided in half, resulting in six half segments: mesial cervical, mesial body, mesial incisal, distal cervical, distal body and distal incisal (Fig. 18).[9]

This system will enable dental professionals to go beyond the usual creative standards in aesthetic restoration. The entire shape of the tooth will be produced creating the central lobe and the incisal cones in order to achieve the final dental configuration. The characteristics of tooth form are not separate entities; rather, they combine to create a single feature. In other words, a tooth is crossed by grooves that determine the 3D anatomical areas.[10,11]

Once the wax-up had been done, all the silicone keys for the dental office could be created (Figs. 19–32). On the basis of the wax-up, several silicone tools were made. The first silicone key was done in double material and used for the mock-up (Fig. 33). Other sectioned silicone keys with different cuts were made for intra-oral positioning to check the spaces during the preparation procedures (Figs. 34–38).[12–14] The laboratory fabricated a preparation tooth on the replica of the master model using the sectioned silicone keys. All the ground areas of the teeth were marked with a red pencil for better communication with the dental office (Figs. 39 & 40). Furthermore, an extra sectioned silicone key of the preparation was created to fit in the mouth in order to compare the laboratory and the clinical preparation (Fig. 41). In this way, the dentist can improve and calibrate the final preparation design, supporting the laboratory in the final ceramic build-up. This step will be documented and moved into a Keynote file (Apple) in order to allow the dentist to evaluate the future calibrated preparation. This work protocol is very helpful for the clinician to see where and how to grind areas of the teeth before grinding teeth in the patient's mouth. Furthermore, a soft-tissue cervical silicone index was created for crown lengthening on

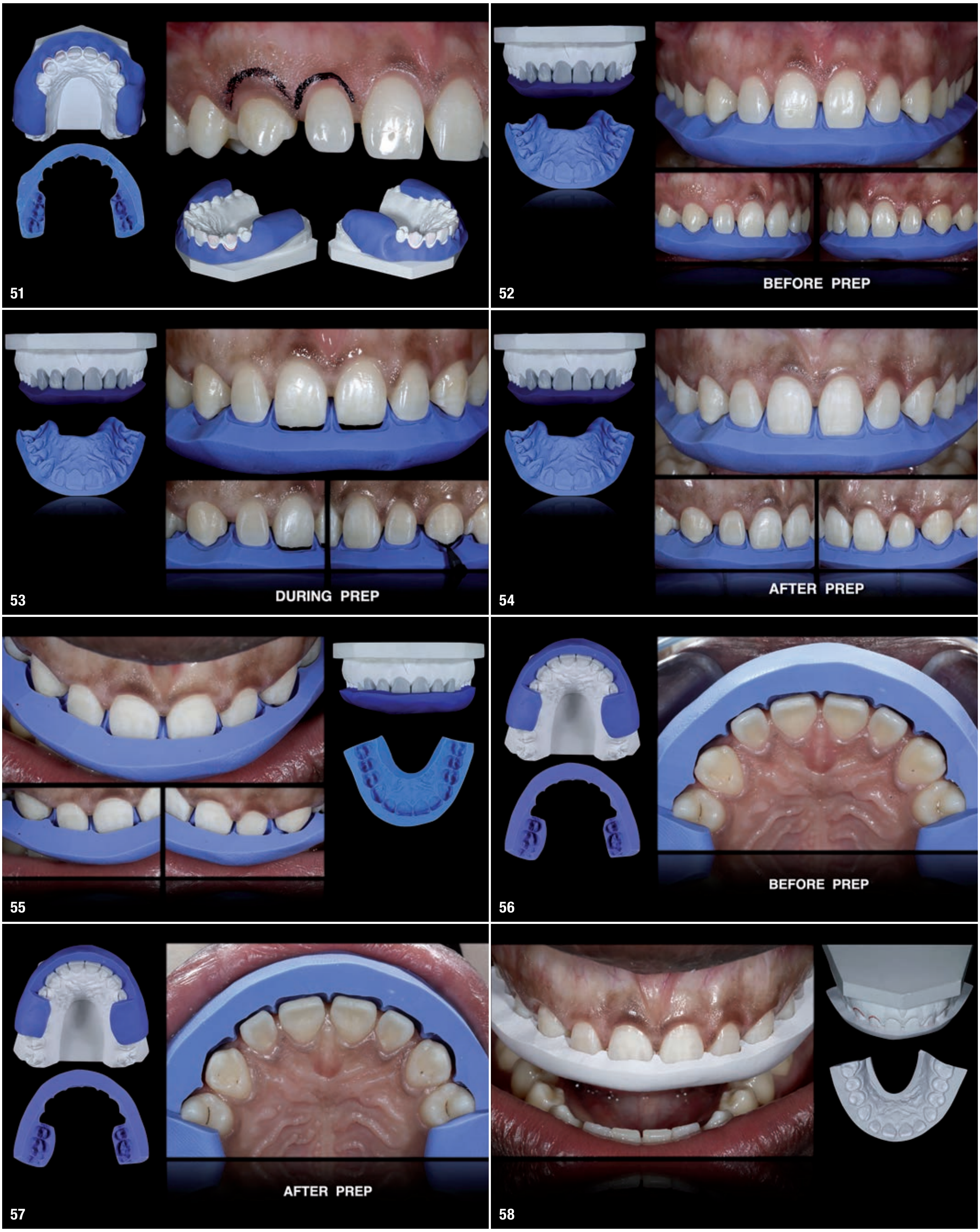


Fig. 51: Silicone index for crown lengthening and the new prosthetic marginal design marked in the cervical area with a black pen. **Figs. 52–54:** The palatal-incisal silicone index was used to establish the space on the incisal margin. Steps before, during and after preparation. **Fig. 55:** Silicone index used to check incisal-facial reduction. **Figs. 56 & 57:** Silicone index used to check facial reduction. **Fig. 58:** Laboratory prepared silicone key adapted to the clinical calibrated preparation.

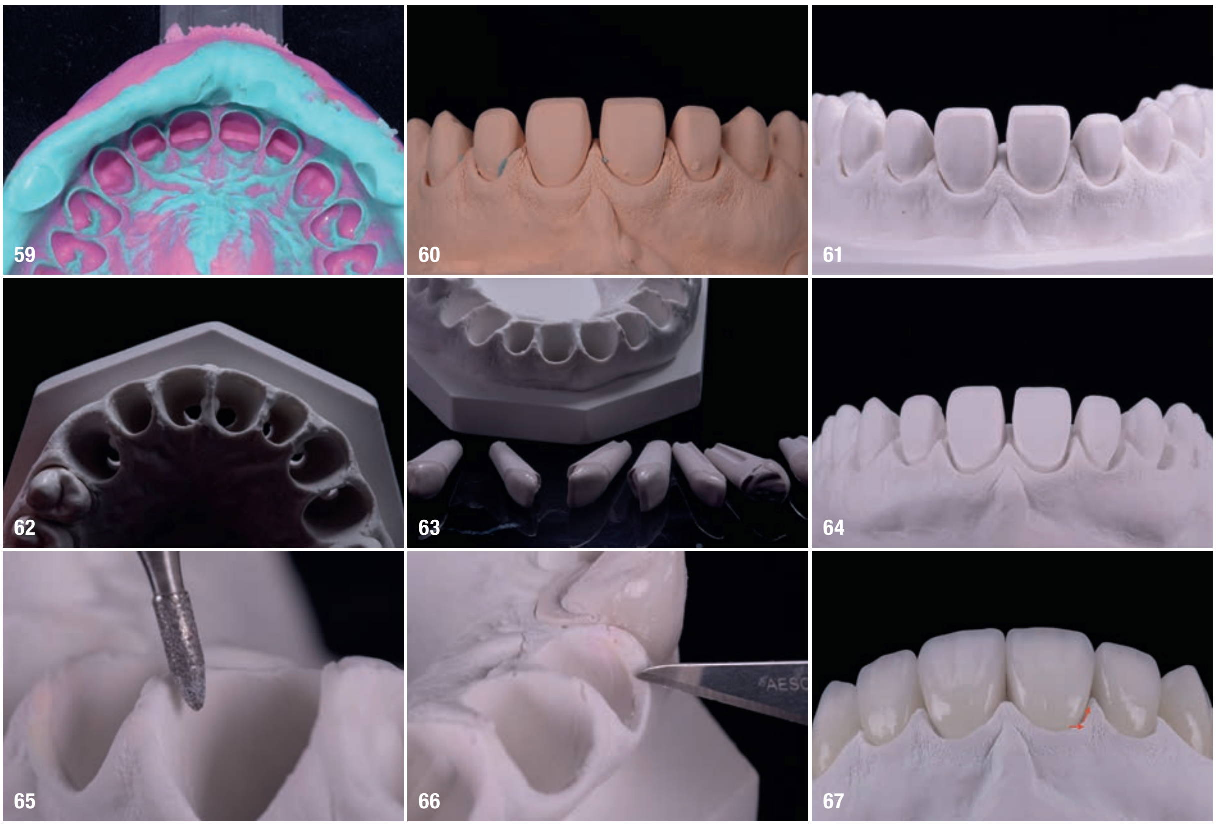


Fig. 59: Final impression. **Fig. 60:** Master dies after pouring, ready to be sectioned and manually worked. **Figs. 61–63:** Alveolar model. **Fig. 64:** Solid model for checking contact points and positions of the veneers. **Figs. 65 & 66:** Cervical contouring for the new cervical design. **Fig. 67:** Horizontal emergence angle and emergence profile of the veneers.

teeth #12, 13, 22 and 23 (Figs. 42–46).[15,16] The technical approach and planning are at this point complete and ready to be delivered to the dental office with all the necessary information to treat the patient.

The clinician began executing the pre-visualisation of the new technical project by injecting resin material into the mould and pressing it in the mouth to show the new dental anatomical configuration to the patient (Figs. 47–50).[17–19] The patient accepted the new dental plan, and the clinician scheduled the next chairside appointments for crown lengthening, tooth preparation and impression taking. In cooperation with the dental technician, the dentist evaluated all the details to perform a suitable preparation to allow the laboratory to build up the ceramic veneers appropriately. The Keynote file from the laboratory on the pre-preparation was carefully analysed by the dental office.

The first appointment was for crown lengthening, and an appointment for tooth preparation was scheduled a few days later (Fig. 51). The sectioned silicone keys were placed in the mouth to start calibrated preparation of the teeth (Figs. 52–57).[20] The dentist performed the preparation of the teeth in the same areas as the laboratory did previously. The final control of the preparation was done using the silicone key of the final laboratory preparation that has to have a close adaptation in the mouth like on the plaster model (Fig. 58).

With this procedure, the dentist prepared only some areas of the tooth, avoiding aggressive reduction of the tooth structure. Once all these clinical steps had been completed, a final impression was taken for fabrication of the veneers. The mock-up silicone index was used to create the provisional restoration for the patient with a direct technique.

The laboratory received the final maxillary impression with the opposing plaster model already poured in the beginning for the technical treatment plan. This time, a facebow record was not performed because the mandibular opposing model was already mounted on the articulator for the diagnostic wax-up in the previous individual registration.

The maxillary model was fabricated in Class IV dental stone in several pours: the first pour was of the master dies, the second pour was of a solid model and the third pour was of an alveolar model. The master dies are used only to fit the veneers once they have been removed from the refractory flask. The solid model is used only to check the contact points and the position of the veneers carefully. The alveolar model is used only to fabricate the veneers according to the soft-tissue references (Figs. 59–64). This last detail is very important for establishing the position of the facial transition lines of the tooth. Furthermore, the cervical contour concept for the new cervical design was applied.

When there is no preparation on the cervical margin, both the dentist and dental technician have to establish the more apical position of the veneer margin. The choice of this apical position has to be manageable for the clinician during cementation procedures. The emergence angle profile of the veneer has to start with a horizontal design to sculpt the soft tissue and subsequently change direction in order to build the desired emergence profile of the tooth (Figs. 65–67).

The model used to build up the veneers is an alveolar model. The dies are removable, and the operator has the soft tissue cast in dental stone.[12] The refractory flask is placed into the alveolar site, and a connector paste is applied on the preparation surface to create a glassy surface in order to allow the dental technician to layer ceramic. The stratification of the ceramic is a sophisticated multilayer technique using a variety of ceramic masses to simulate the natural contrast effects inside the tooth. After the first firing the dental technician created some grooves on the ceramic surface for applying the stain technique procedures, firing the colours at a different final temperatures (Figs. 68–72). The last ceramic layering modification was performed at the end, achieving the desired anatomical contour after the correction firing In the incisal area, a double incisal wall technique was executed.[21,22]

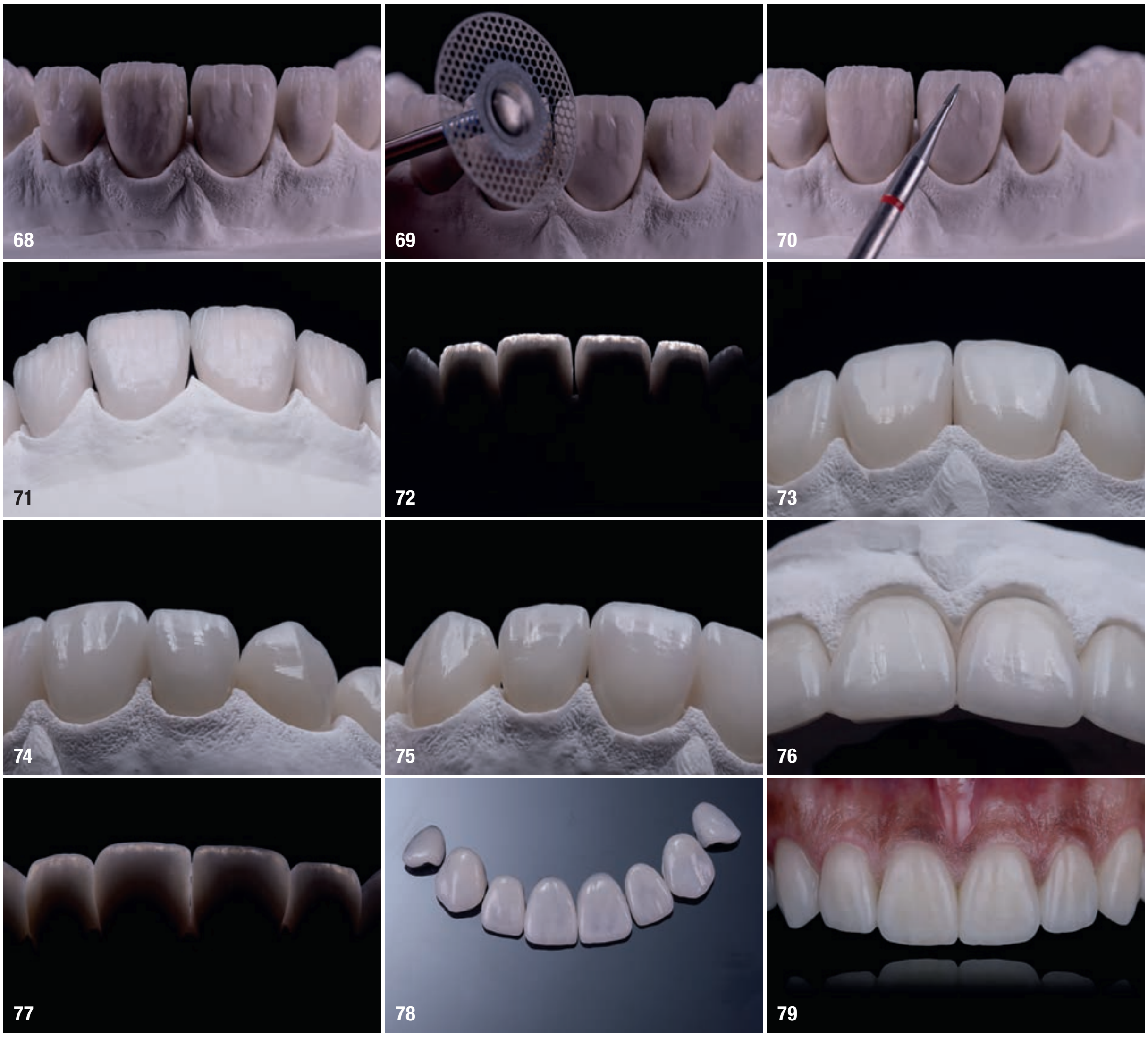


Fig. 68: Ceramic after the first firing. **Fig. 69:** Disk bur being used to groove details. **Fig. 70:** Tungsten bur being used for waving grooves. **Fig. 71:** Restoration units after staining. **Fig. 72:** Incisal edges of units with reflected light to view incisal effects. **Figs. 73–76:** Glazed ceramic veneers on the plaster model. **Fig. 77:** Ceramic opalescence and incisal effects. **Fig. 78:** Veneers adapted to the master dies and ready to be delivered to the dental office. **Fig. 79:** Definitive restoration of the maxilla.

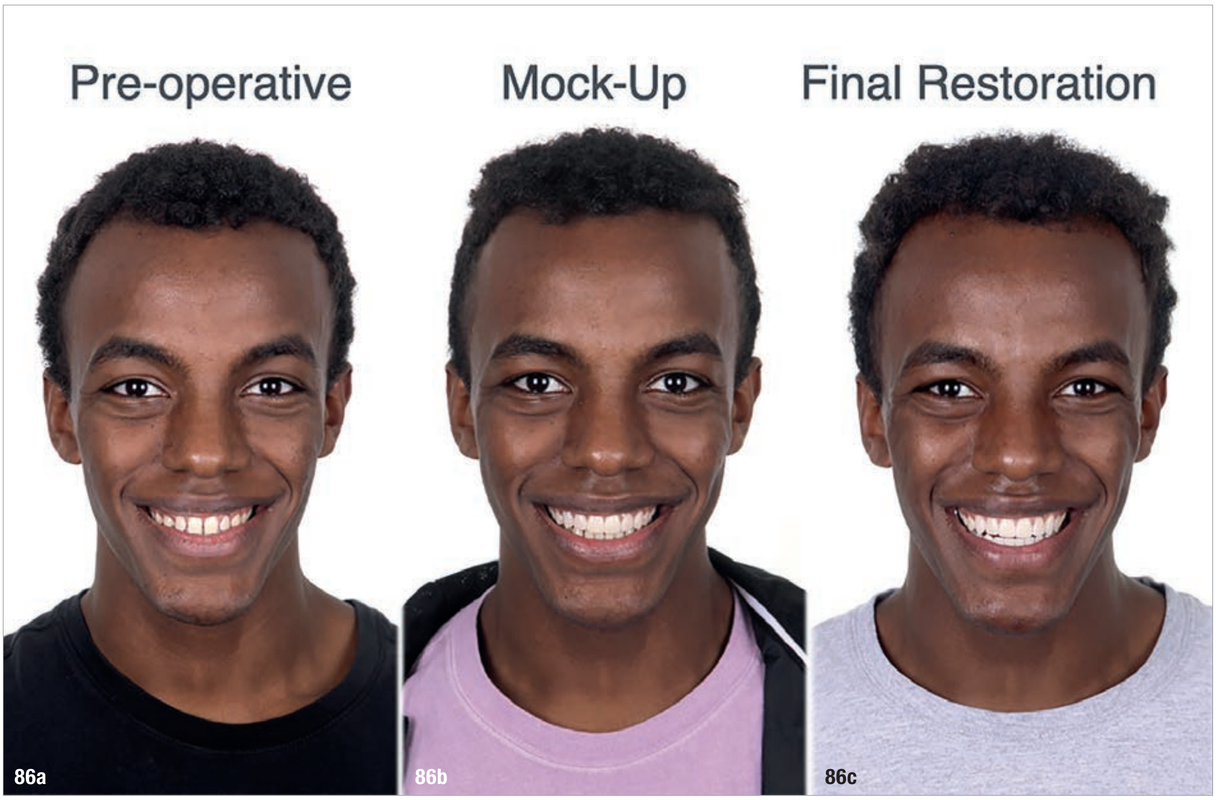
Figs. 80 & 81: Pre-op and post-op situations. **Figs. 82 & 83:** Initial and final lingual situations.

The dental technician used a handpiece to shape the restoration for the final glaze appropriately. After this step, the final texture was evaluated and different lines were marked on the entire facial surface of the veneers with several burs.[12,23,24] The veneers were then ready to be glazed and manually polished (Figs. 73–77).

The next step was the removal of the veneers from the refractory dies with a sandblasting procedure using glass beads. After this step, the veneers were adapted to the master dies under the magnification of a microscope. In this procedure, the operator has to create stability of the veneers on the master dies, catching up the most suitable contact points on the intaglio surface.[12,25] Once all the veneers had been adapted to the master dies, they were moved on to the solid model to check the contact points. After this, the veneers were sent to the dental office for a final try-in and cementation (Fig. 78).

The cementation was performed using a dental dam for complete total isolation of each unit, and the dentist restored the mandibular teeth employing a direct composite technique.[26] The entire restoration was completed with ceramic restorations in the maxilla and composite in the mandible. The patient's individual anatomical shade and smile were personalised in relation to his facial configuration (Figs. 79–86).

Figs. 84 & 85: Smile before and after the treatment.



Figs. 86a–c: Pre-op smile and customised smile in facial harmony **(a)** wearing the mock-up **(b)** and after definitive restoration **(c)**.

Discussion

The patient had a wide smile and elevated expectations in terms of aesthetics and conservative treatment The optimal treatment options for the anterior teeth were different owing to the residual healthy substance: porcelain veneers in the maxilla and direct composite restorations in the mandible. The surface finish of ceramic generally leads to bright glossy surfaces, and the result is long-lasting. In contrast, composite resin surfaces seems to lose their polish over time, owing to functional wear and abrasive toothpastes, acquiring a typical matte and opaque surface. This difference may not be noticeable on wet teeth, but may be revealed when the teeth are dry. For aesthetic restorations, both porcelain veneers and composite restorations are predictable treatments.

Calibrated preparation using technical tools is fundamental for preserving more tooth structure and performing aesthetic veneers. Because there is no cervical finishing line, the dental technician manages the most apical margin position of the veneer by creating the suitable emergence angle in order to establish the right emergence profile subsequently. The soft tissue is conditioned according to the cervical contour concept, and the model is based on the cervical design. This allows the dental technician to maintain the suitable anatomical proportions of the tooth from the cervical surface to the incisal edge.

In order to achieve good integration in appearance and form, close collaboration with the dental technician is essential, facilitating correct design of the case through the basic steps of the diagnostic wax-up and direct mock-up.

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Pioneers at heart: 3Shape aims to become go-to resource for digital dental learning

Claudia Duschek, Dental Tribune International

Fig. 1: Lars Christian Lund, senior vice president of corporate business development and marketing at 3Shape. **Fig. 2:** Dr Rune Fisker, senior vice president of product strategy at 3Shape. *(Images: © 3Shape)*

Digitalisation is one of the most important trends that have reshaped dentistry in recent years. Copenhagen-based dental company 3Shape has been one of the major players in the field and is advancing continuing education about digital dentistry to a new level with its 24H Global Symposium, which took place as an exclusively online event on 19 and 20 June. Prior to the symposium, Dental Tribune International had spoken with Lars Christian Lund and Dr Rune Fisker, senior vice presidents at 3Shape.

3Shape has been at the forefront of digital dentistry over the past two decades. What have been the greatest milestones that your company has achieved during that time?
Fisker: As a company, 3Shape has surpassed many of the milestones we set for ourselves when Nikolaj Deichmann and Tais Clausen first started the company in 2000. However, there are always new goals to achieve. CAD/CAM workflows and solutions present endless opportunities for making dental treatment more predictable, efficient, profitable and, in the words of Dr Alan Jurim, "fun". Our intra-oral scanner, TRIOS, is the industry's benchmark for scanning speed. It has also been one of the intra-oral scanners featured in the accuracy studies that have documented digital impressions as being as good as, or even better than, analogue impressions.

TRIOS power has meant that doctors and laboratories can plan and create everything from implants to clear aligners. In addition, TRIOS is, as far as we know, the only digital impression solution on the market used in scanning fully edentulous patients. Dentures are being made with totally digital workflows based on TRIOS intra-oral scans and our denture software. That is remarkable!

And remember, TRIOS is still the market's only wireless intra-oral scanner.

Despite the growing trend towards digitalisation in dentistry, the majority of dental professionals have not yet transitioned into digital dentistry. What do you think are the greatest advantages of going digital and the major obstacles to the move?
Fisker: We find that the majority of professionals who haven't gone digital are concerned about the quality of the treatment based on a digital impression.

When intra-oral scanners were first introduced, there were questions around the accurate capturing of subgingival margins or the lack of physical models in order to verify a restoration's fit before seating.

Studies have since proved these concerns unnecessary. Clinical studies and the documentation of successful digital workflows by colleagues are important in order to address such concerns. Seeing is believing. Peer-reviewed articles in dentistry are very important because we work in an industry driven by word of mouth—no pun intended.

If we agree that treatment quality is paramount, then professionals should strongly consider digital workflows. Studies and clinical cases have consistently documented the quality and predictability of digital workflows. Unlike analogue workflows, with digital workflows, the planning, design, production, and in the case of surgeries, the placement are all pre-planned using surface and CBCT data. The data is saved and never changes. Software cannot move things around or change measurements, unless you tell it to do so. Analogue workflows, however, require gypsum models that

> "If we agree that treatment quality is paramount, then professionals should strongly consider digital workflows"—Dr Rune Fisker, 3Shape

can be lost, chipped or contaminated. Digital workflows are uniquely suited to dentistry because they enable not only proper planning and better communications but also the proper documentation of the treatment, if a review is ever needed.

Lund: Another reason why dental professionals are reluctant to go digital is that they are concerned about the cost of scanners, especially in view of the current financial climate. We suggest that they speak to colleagues who have already invested in a scanner. They will be surprised to learn that the investment in an intraoral scanner with the right software pays back very quickly. They can also take their own expenses and insert them into 3Shape's ROI calculator. Here, they will see that investing in a scanner is a vehicle not only to improve quality of treatment and patient experience but also to increase profit, in many instances, within a year or less.

What measures is 3Shape taking to promote the use of digital technologies among dental professionals, and what role do you think dental education and the symposium in particular play in this regard?
Lund: 3Shape was founded on innovation. We are driven by research and development. As a company, we have the most developers in the industry; we have more than 80 patent families, but we have found that professionals need more help in using digital technology then has previously been available to them. Especially when we keep developing new features and solutions every year, it can be hard to keep up.

For the past couple of years, we have begun focusing more on education. We expanded the 3Shape Academy and launched the 3Shape Community. We get out and teach classes. We created an online learning hub, and now, we will be hosting an around-the-clock learning marathon, the 3Shape 24H Global Symposium.

Many professionals want to go digital, but hesitate because they have no place to turn for digital dentistry education. We hope to become a go-to resource for their digital learning. We are becoming just as innovative in our educational offerings as we are in our product development.

Although the range of digital dentistry products on the market is growing, there are few universal solutions for dentists or laboratories available. How is 3Shape addressing this?
Fisker: Dental professionals want to choose the solutions they use to treat their patients. Therefore, we stay active in creating software integrations with other companies, including our competitors. 3Shape's open ecosystem has the industry's widest range of integrations with third-party implant libraries, tooth libraries, orthodontic treatment providers, clear aligners, bracket libraries, 3D printers, milling machines and more. No other company in the dental industry is as dedicated to opening the doors to treatment opportunities for professionals. Within an industry that is constantly evolving, it is best to be open.

In general, the dental industry is expected to experience significant growth in digital dentistry technologies in the future. What will the future look like, and how do you see the future of your systems and product solutions?
Fisker: We expect dentists to adopt intra-oral scanning technology very quickly now, and we see that the majority of dentists who have not already gone digital are considering doing so within the next few years—similar to what we have already seen from dental laboratories.

3Shape will continue to lead the way. We are pioneers at heart, so we will keep pushing the boundaries.

3Shape is lucky in that we have many dental professionals willing to work with us on our product development. We conduct a tremendous amount of user research and take field trips to laboratories and practices. We hold co-creation workshops where dental professionals get to drive product development and ideas. So, we are confident that the solutions we develop will continue to provide the most predictable and efficient outcomes.

In the aftermath of the SARS-CoV-2 pandemic, it is likely that countries worldwide will suffer an economic crisis and show a negative trend with regard to dental investments. Which short- and long-term effects do you foresee for your business and for the whole dental industry?
Lund: The pandemic has sadly impacted our industry and our way of life. However, the tide seems to be turning. Recent numbers from the American Dental Association show that businesses are beginning to reopen at a very fast pace.

The pandemic will lead to a change in the way practices need to operate. The SARS-CoV-2 outbreak has shown us that the transition to digital platforms can happen fast, and the need for solutions which reduce the risk of infection and ensure dentists a fast return on their investment has increased. For this, intra-oral scanners and fully digital workflows are ideal.

More information about the 3Shape 24H Global Symposium can be found at www.3shapesymposium.com.

Multilayered zirconia in different translucency levels

Attila Kun, Germany

Kuraray Noritake Dental's KATANA Zirconia ML was the first zirconia on the dental market with integrated shade gradation. First presented at the International Dental Show in 2013, this material has revolutionised the world of zirconia. Over the course of time, KATANA Zirconia UTML and STML and the change from ML to HTML have created a complete product portfolio. This article highlights the different characteristics of each of these varieties.

In daily clinical and laboratory routines, we quickly become aware of the diverse characteristics of natural teeth. Natural teeth impress with their individual optical properties, shape and texture. The challenge of imitating these aspects in ceramic restorations is a task that is handled in the dental laboratory with passion and motivation.

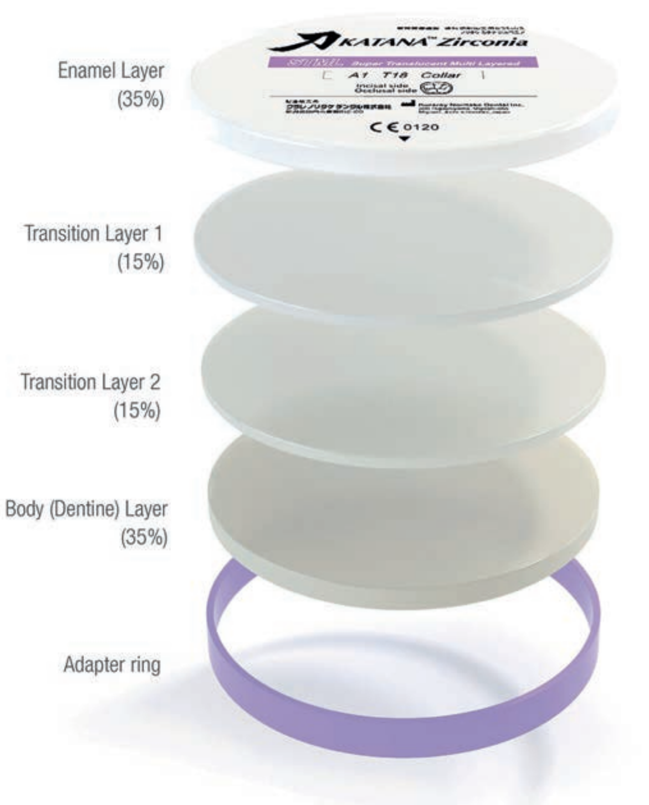

Fig. 1: The KATANA Zirconia STML layered structure. *(Image: © Kuraray Noritake Dental)*

Accurate imitation of the natural tooth requires the appropriate framework material, for example KATANA Zirconia HTML, and an appropriate veneering ceramic or stain system, such as Noritake CERABIEN ZR, together with sensitivity and skill. Although modern materials lay down an important foundation, the implementation of the restoration is, to a large extent, an artistic skill. In order to select the appropriate material, depending on the indication, the dental technician should pay attention to facts and material science. Dental sensitivity and craftsmanship are also required for the aesthetic realisation of the prosthesis.

No matter whether it is for a monolithic restoration, thin-layer veneer or an individually layered restoration, zirconia offers various advantages as a restorative material, including good mechanical properties and a high level of biocompatibility. In recent years, zirconia has been further developed and optimised through material modifications, leading to new generations of zirconia. The resulting dental materials are remarkable for their translucency and outstanding aesthetic properties. For certain indications, monolithic restorations can be created in such way that the optical properties barely differ from those of a veneered restoration.

Looking back at KATANA's history

Kuraray Noritake Dental launched KATANA Zirconia ML in 2013. It was the first zirconia on the market with a polychromatic shade gradient and has revolutionised the market. "ML" stands for "multilayered", and its chroma and saturation decrease from the cervical to the incisal layer. The market responded very well to the polychromatic discs; therefore, Kuraray Noritake Dental took the next step. In 2015, the KATANA family grew with the introduction of two new translucent materials: KATANA Zirconia STML (super-translucent) and UTML (ultra-translucent). Translucency studies have revealed the very high light transmission of KATANA Zirconia UTML (43 %) and STML (38 %). It should be noted that the strength of the material drops with rising translucency.

In 2019, KATANA ML became KATANA HTML. This change included a shade extension, from six to 14 shades, and an adaptation to the VITAPAN classical shade guide to ensure a simpler shade selection for the dental technician and better communication between technician and dentist. A few years ago, new zirconia stains (CERABIEN ZR FC Paste Stain, Kuraray Noritake Dental) were also launched on the market, thus perfecting the KATANA range of materials for highly aesthetic yet durable zirconia restorations.

The Japanese word "katana" denotes a special kind of traditional samurai sword. The katana sword combines expedient form with artistic design. Dental technicians aspire to achieve this in their work too. KATANA Zirconia offers the optimal foundation for this. The multilayered KATANA materials display a smooth progression of shade and brightness from the cervical to the incisal layer. Experience shows that a functional and aesthetic restoration can thus be implemented in an efficient way.

Application of polychromatic zirconia

Fully anatomical, partially anatomical or as a framework, the polychromatic KATANA materials can be used in a variety of ways. The integrated shade gradient displays gentle nuances of enamel, dentine and cervical shades and, in the case of STML, a translucency gradient. Depending on the indication, the zirconia blanks open up different ways of achieving an aesthetic restoration. Especially for complex repairs and anterior restorations, the set-up is an indispensable foundation, because using the correct material alone is no guarantee of success. Precise planning is called for in order to conceive an overall image. The surface structure, shape and contours are built up manually in wax, and after a double scan, the wax-up is reduced digitally. This creates a dentine structure or framework that can be milled out of the chosen zirconia option.

KATANA multilayered zirconia allows the framework to become a shade-bearing foundation. The CAD construction of the restoration is made in a reduced anatomical crown shape. A dentine core is then milled from zirconia. The ceramic veneer is reduced to a minimum. For a vivid result, the framework can also be characterised with internal staining. Shrinkage during baking is unlikely, and shade stability comes from the framework. In addition, the thin veneer layer ensures low shrinkage and lays a secure foundation for a high level of stability and a low risk of chipping. The result is a natural-looking restoration with warmth and translucency.

KATANA Zirconia HTML

KATANA Zirconia HTML has a high level of flexural strength and is typically indicated for crowns and bridges. It is available in numerous shades that cover different requirements in the dental laboratory. The material offers optimal optical properties for frameworks—as incident light is transmitted, the stump remains concealed. Its flexural strength is approximately 1,125 MPa.

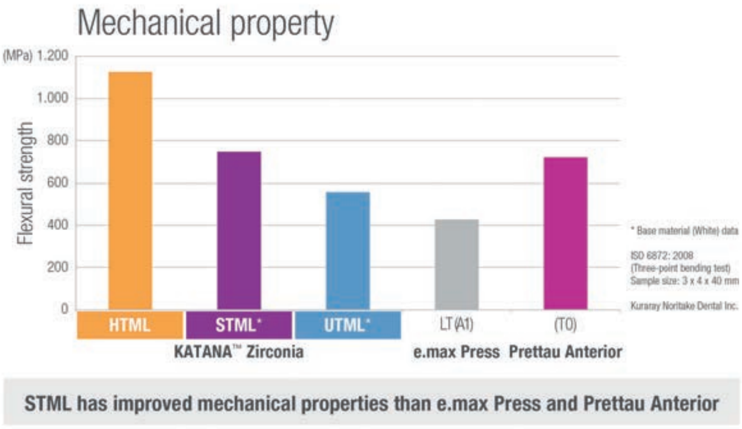

Fig. 2: Mechanical property.

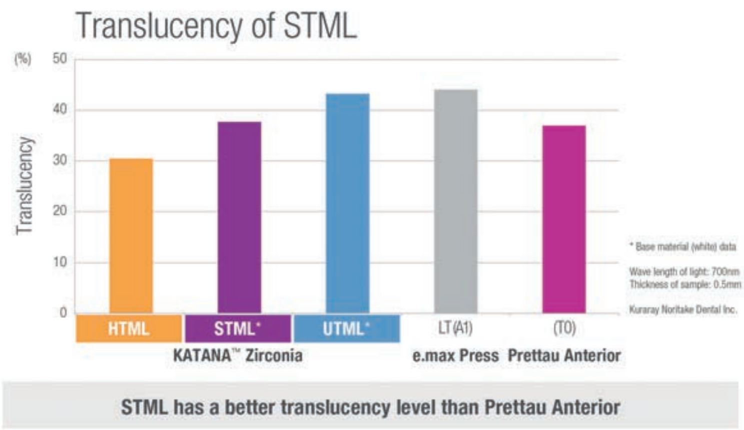

Fig. 3: Translucency level.

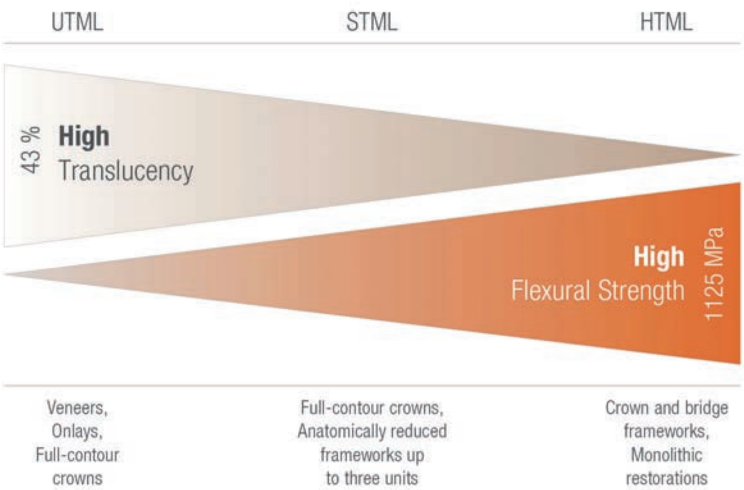

Fig. 4: Differences between and indications for KATANA Zirconia HTML, UTML and STML. *(Image: © Kuraray Noritake Dental)*

The framework is designed after cutback. The challenge of ceramic veneers lies in the subtle and often differing shading of the neighbouring natural teeth. These characteristics can be reproduced using the internal stain technique. Shade depth and three-dimensionality are created when the layering is then covered with lustre compound. Lustre compounds are a special feature of the

Fig. 5: Wafer-thin veneers (0.3 mm) of KATANA Zirconia UTML on the model. *(Image: © Kuraray Noritake Dental)*

Kuraray Noritake ceramic system, and they envelop the actual layering like a fine cocoon.

KATANA Zirconia STML

Aesthetic restorations need light and translucency, which KATANA Zirconia STML offers. The manufacturer's addition of yttrium oxide modifies the zirconia, and this leads to greater variance in particle size and increased translucency. KATANA Zirconia STML also has a polychromatic shade gradient from the cervical to the incisal layer. In addition to the shade intensity, its translucency also varies. Therefore, this material is ideal for frameworks in the anterior region (up to three units). The lower translucency in the cervical area is optimal for the shade-bearing framework foundation. The balanced combination of varying chroma and translucency allow for the optical properties of natural teeth to be imitated to the best effect. The flexural strength of KATANA Zirconia STML is 748 MPa.

KATANA Zirconia UTML

UTML offers the highest translucency of the KATANA family. The material's optical properties come close to those of glass-ceramics, which extends its range of indications to include monolithic restorations in the aesthetic region, for example veneers. KATANA UTML has a lower chroma than does conventional zirconia. This is achieved through a consistently high degree of transparency, which brings out the intrinsic shade of the dentine. KATANA UTML is indicated for veneers, onlays and full-contour crowns, and its flexural strength is approximately 550–600 MPa.

For the purpose of phantom work, we used KATANA UTML to produce full-contour veneers. The wafer-thin veneers were milled with a minimum thickness of 0.3 mm. Despite the thinness of the layer, there were no fractures or chipping at the edges. Individual characterisation was achieved through the staining technique. The milled veneers display beautiful transparency. In order to perfectly bring out the optical properties, an adhesive bonding cement such as PANAVIA V5 from Kuraray Noritake Dental can be used for such delicate restorations.

Light and shadow

"What is essential is invisible to the eye" is a phrase that can be applied to aesthetic restorations. In order to obtain a perfect ceramic restoration, the shape, contour and surface texture are important factors that need to be considered. Therefore—no matter whether monolithic or veneered—the appropriate preparation of micro- and macro-textures should never be overlooked. The application of gold powder, for example, has proved to be helpful, since even very fine structures become visible under gold powder. As with black and white images, the eye is not distracted by shade effects. After incorporating the textures and the final touches, manual polishing and adjustment of the shine are undertaken.

Conclusion

The KATANA Zirconia series allows flexible applications and the possibility of reproducing the variety of natural teeth in an efficient way. The materials differ in their translucency and mechanical properties. To summarise:
- KATANA Zirconia UTML is suitable for full-contour crowns in the anterior and posterior regions and veneers, inlays, onlays and single crowns in the posterior region.
- KATANA Zirconia STML is ideal for crowns and small posterior bridges.
- KATANA Zirconia HTML is a high-strength framework material for crowns and bridges.

With this selection of zirconia materials, dental technicians will be well equipped and prepared for everyday work and can thus devote themselves to precise dental work based on individual specifications.

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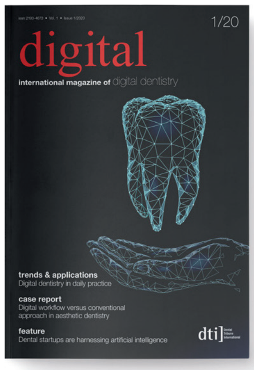

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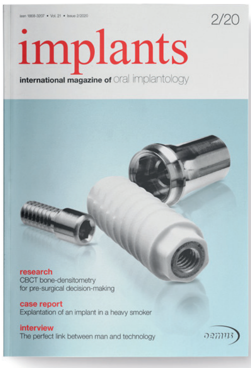

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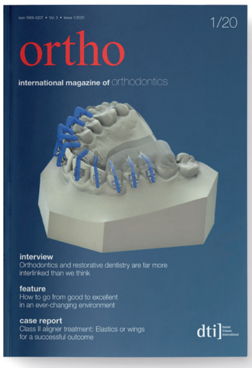

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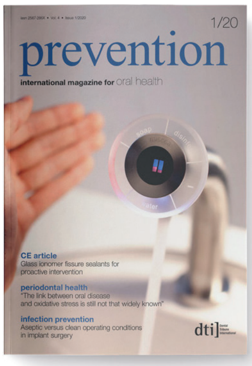

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How to maximise the potential of multilayered zirconia

By Kuraray Noritake Dental

The use of pre-shaded zirconia with a highly translucent gradient brings greater efficiency into the dental laboratory. Owing to the advanced properties of materials like KATANA Zirconia multilayered discs, true-to-life restorations can be created without any, or with only a thin vestibular layer of, veneering porcelain. This saves considerable time in the laboratory.

To leverage the high aesthetic potential and balanced mechanical properties of these types of zirconia, it is essential that the restorations be processed under ideal conditions, especially during sintering. Unwanted optical effects that may otherwise occur and suitable measures to help avoid them are summarised below.

Optimising the milling process

Blue or grey traces visible in the final restoration are usually the result of contamination of the cooling water with extrinsic particles in the context of wet milling, which is usually conducted in chairside procedures. In most cases, silica particles left over from the processing of glass or silicate ceramics with the same milling unit are the root of the problem. The effect is easily avoided by thorough cleaning of the milling chamber, the water tank and the filter insert of the milling machine every time a different material needs to be processed. Another solution is employing dry instead of wet milling. Dry milling offers additional benefits, such as shorter processing time and better-quality edges and surfaces.

Decontamination of the furnace chamber

In general, the chamber of the sintering furnace should be cleaned before sintering. Important measures include the removal of dust inside the sintering chamber and cleaning of the heating elements, both done with a soft brush. The use of compressed air is contraindicated.

Unwanted optical effects that occur on restorations owing to contamination of the sintering chamber include white spots on the restoration surface, a blue-grey appearance and low chroma, and green or yellow traces in the material. White spots on a restoration surface are usually indicators of contaminated alumina sintering beads (Fig. 1) or the use of the wrong instruments for surface modification and sprue removal. The effect is avoidable through monthly or even more frequent replacement of the sintering beads (as soon as they show any signs of discoloration) as well as through the exclusive use of

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Fig. 1: Alumina sintering beads may be the cause of white spots on a restoration surface if not replaced on a regular basis. **Fig. 2:** Pieces of a white zirconia blank left over after milling.

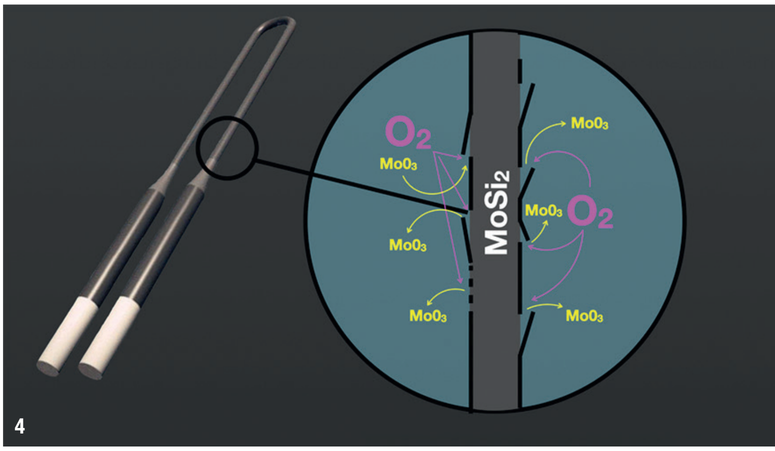

Fig. 3: Restorations displaying greenish surface pigmentation. **Fig. 4:** A molybdenum disilicide heating element with a protective silica layer bursting off, leading to pest oxidation and contamination of the elements in the sintering chamber. MoSi2 = molybdenum disilicide; O_2 = oxygen; MoO_3 = molybdenum oxide.

fine-grit diamond instruments for adjustments prior to sintering.

A blue-grey appearance and low chroma may be attributed to mineral residues from dipping liquids in the chamber. They are effectively removed with the aid of a decontamination program selected in the furnace menu and run after inserting several residual pieces of a highly translucent white zirconia blank (Fig. 2). As soon as the decontamination cycle has been completed, the chromatic intensity of the residual blank parts indicates whether a second cycle is required. In order to prevent the occurrence of a greyish appearance in new restorations, it is recommended that a decontamination program be performed at least once per month.

Molybdenum disilicide heating elements: Regeneration needed

If a restoration appears to be greenish or yellowish (Fig. 3), it is likely that the furnace is equipped with ageing molybdenum disilicide ($MoSi_2$) heating elements in need of regeneration or replacement. The inner part of the elements is made of molybdenum, which is usually covered by a protective layer of silica. This layer is naturally built up during sintering at a temperature range of between 1,000 °C and 1,600 °C. As the layer grows thicker, its intrinsic residual compressive stress increases. This stress, as well as possible extrinsic influences, for example originating from acidic dipping liquids, may ultimately lead to cracks and break-up of the protective layer (Fig. 4). Once damaged, the molybdenum core is exposed. At a low temperature range of 400 °C to 600 °C, the molybdenum reacts with oxygen in the sintering chamber, a process referred to as pest oxidation. The resulting molybdenum oxide, together with ions or metal oxides from colouring agents, is responsible for the green-yellow discoloration on the surface of the restorations.

Aimed at regenerating the layer of silica, regeneration firing, which involves a rapid heating rate and a long firing phase at approximately 1,450 °C, works only a limited number of times, as the repeated process of pest oxidation and regeneration leads to ageing of the heating element. Hence, the element will ultimately need to be replaced. The whole issue of pest oxidation may be effectively avoided by employing a furnace with silicon carbide heating elements, which are highly resistant to ageing and do not cause any discoloration. A positive side effect is that these types of heating elements deliver more constant temperatures.

Temperature control

Variations in the translucency, chroma or pigmentation of restoration surfaces (Figs. 5a–c) are often due to deviations of the actual sintering temperatures from the recommended temperature curve. The only way to solve this issue is temperature calibration. This measure is a prerequisite for aesthetic results, but also has a decisive impact on the mechanical properties of the restorations: if the maximum temperatures are too high, for example, the flexural strength of the zirconia materials may be expected to decrease.[1]

Temperature control is usually carried out with the aid of TempTABs (Fig. 6) or process temperature control rings (PTCRs). They are placed into the furnace on a sintering tray and typically processed by running a calibration cycle. After sintering, the tab or ring diameter is determined. As TempTABs and PCTRs exhibit controlled shrinkage, it is possible to calculate the actual sintering temperature based on the measured diameter. A conversion table supports the user in determining the deviation of the actual temperature reached from the temperature displayed on the furnace. Subsequently, the values dis-played on the furnace are adjusted if necessary.

Figs. 5a–c: Effect of temperature differences during sintering on restorations made of KATANA Zirconia UTML: the restorations were sintered at the same nominal temperatures in three different furnaces.

General recommendations

In order to set the stage for brilliant aesthetics and the ideal properties of zirconia restorations, it is essential to ensure optimal processing conditions. Instead of troubleshooting carried out whenever discoloration appears after sintering, it is advisable to take the following actions on a regular basis as preventive measures:

Fig. 6: TempTAB on a sintering tray with restorations ready for sintering.

- Adhere to the manufacturer's sintering protocols.
- Remove the dust from the sintering chamber and heating elements with a soft brush before each use.
- Replace alumina sintering beads at least once per month.
- Use only fine-grit diamond instruments for pre-sintering adjustments.
- Use a furnace with silicon carbide heating elements or run regeneration cycles for MoSi2 elements.
- Run a decontamination program with decontaminating powder or white zirconia residues at least once per month.
- Calibrate the temperature on a monthly basis.

With these simple measures, it is possible to maximise the potential of Kuraray Noritake's KATANA Zirconia multilayered series.

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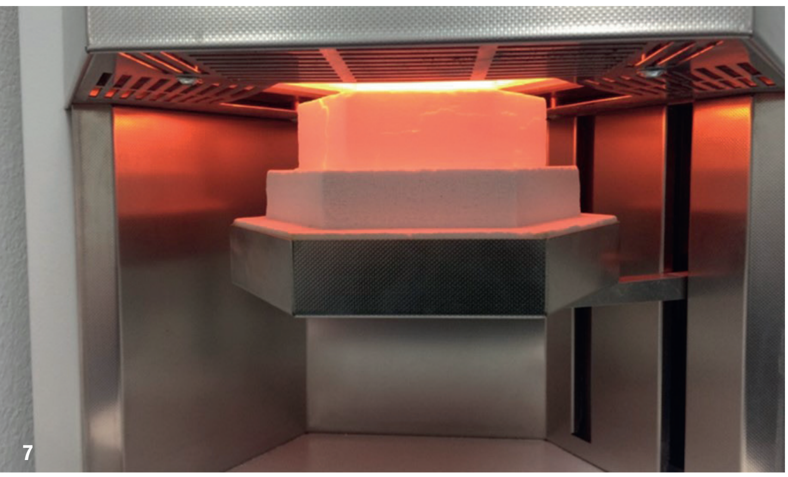

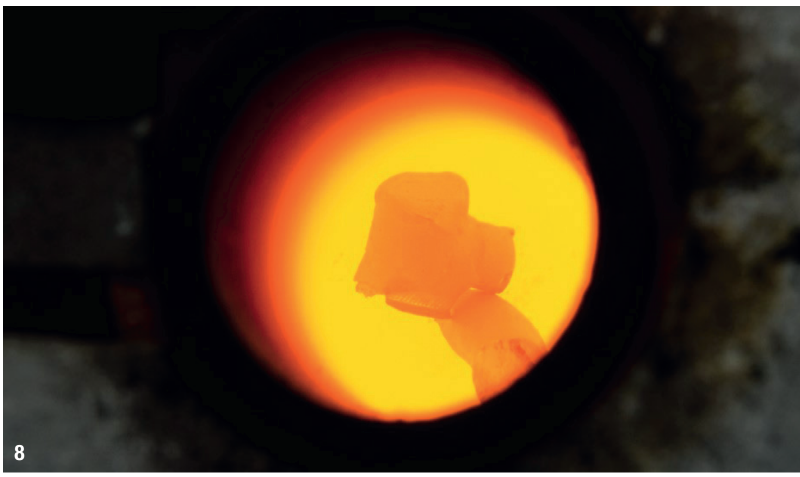

Fig. 7: Furnace prepared for sintering process. **Fig. 8:** Restoration in furnace. *(Images: © Kuraray Noritake Dental)*

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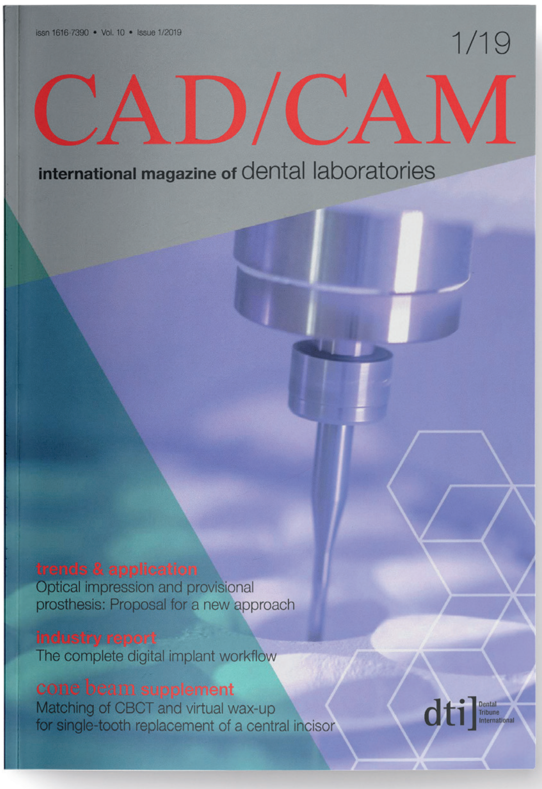

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Looking for an aesthetic long-term temporary restoration which delivers on its promises and can also be created quickly and easily? We offer the solution with Structur CAD, the composite for CAD/CAM-produced temporary restorations.

Structur CAD is a filled composite whose fillers are of high quality and thus ensure a safe and reliable wearing period, in particular for long-term temporary restorations. In this way, Structur CAD represents the latest generation of temporary restorations. This class of material also offers a whole range of advantages for processing: Structur CAD has an outstanding edge stability after milling, in addition to which polishing is easy and takes next to no time. Its fluorescence is similar to that of natural teeth and contributes to the patient's feeling of well-being when wearing the temporary restoration. CAD/CAM-produced temporary restorations fit precisely, are easy to reproduce and can be customised in exactly the same way as permanent restorations. And to round off the working process, luting can also be done to suit your exact requirements—using either a temporary luting cement or, for longer wearing periods, an adhesive.

Structur CAD is available in Shades A1, A2 and A3 in a size 40L block or as a disc with a thickness of 20 mm (diameter: 98.4 mm).

www.voco.dental/en/home.aspx

How to send us your work

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

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

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

Text length

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

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

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

Text formatting

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

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

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

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

Image requirements

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

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

In addition, please note:

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

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

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

You may submit images via e-mail, 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.

Abstracts

An abstract of your article is not required.

Author or contact information

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

Questions?

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