special
Occlusion principles for the practising dentist in the digital age

case report
Guided implant placement in the anterior zone

cone beam supplement
Dynamic navigation—The future of minimally invasive endodontics
IT’S TIME FOR TRUE LOW DOSE CBCT

X MIND trium

50% dose reduction* without compromising 3D image quality

3D mapping of bone density for improved success rate

75µm ultra high resolution image for reliable diagnosis

*Ratio based on DAP measurements from standard X-Mind Trium settings 90kV-8mA-300prjs

X-Mind™ trium, 3-in-1 extraoral imaging system (CBCT 3D, Panoramic and Cephalometric). This medical device is a class IIb device according to the applicable European Directive in force. It includes CE marking. Notified body: DNV GL NEMKO PRESAFE AS - CE 2460. This medical device for dental care is reserved for healthcare personnel; it is not covered by health insurance providers. This equipment was designed and manufactured in accordance with an EN ISO 13485-certified quality assurance system. Please read the user guide carefully. Manufacturer: de Götzen - a Company of ACTEON Group For dental professional use only.
Artificial intelligence in your daily practice—Are we already there?

The Oxford English Dictionary defines artificial intelligence (AI) as “the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages”. But what does AI mean, really? And how can this tech trend affect the dental practice?

Only a few years ago, AI was considered to be pure science fiction, and nobody was really considering the possibility of using it in the dental office. Today, AI is found everywhere in consumer technology—many of us can find it in our own smartphones—and is also present in the dental office, as was shown at the International Dental Show in Cologne in Germany in March this year.

Let’s consider a few examples of the use of AI in dentistry. Algorithms support computed tomography (CT) diagnostic tools such as the one from Diagnocat (which we covered in CAD/CAM 1/2019). Diagnocat uses multiple algorithms, which turn raw outputs from the neural nets into reports and imagery that are easy for dentists to understand. In this software, AI analyses 3D dental studies in DICOM format. The innovative solutions of Diagnocat save a dentist effort and time when analysing CT images and allow him or her to concentrate on treatment, offering the patient the best solution and retaining control of the outcome.

Straumann uses AI to simulate treatment outcomes, and this can be highly effective in motivating patients to comply with treatment. In the new DenToGo, a comprehensive suite of AI-based software solutions for tablets and smartphones, not only is patient choice facilitated by prior simulation, but progress is monitored and documented throughout the treatment period.

Artificial intelligence is also used in digital smile design and there are already applications available to help practitioners choose the best smiles for their patients.

I am quite sure that this is only the beginning of a new era in dentistry. However, at the end of the day, AI is only a branch of computer engineering, designed to create machines that behave like humans. Although it has come far in recent years, AI still lacks an essential aspect of human behaviour, namely human emotion. And dentistry is so much more than just analysing the data (although that is very helpful); it is about bringing healthy smiles to patients.

Magda Wojtkiewicz
Managing Editor
editorial
Artificial intelligence in your daily practice—Are we already there? 03
Magda Wojtkiewicz

special
Occlusion principles for the practising dentist in the digital age 06
Drs Michael Radu, Daniel Radu & Florin Lazarescu

clinical report
Digital face-bow transfer technique using the dentofacial analyser for dental aesthetics and 2D, 3D smile design: A clinical report 16
Drs Christian Brenes, Larry Jurgutisb & Courtney S. Babba

case report
Computer-aided, template-guided immediate implant placement and loading in the mandible 22
Drs Thomas Spielau, Uli Hauschild & Joannis Katsoulis
Guided implant placement in the anterior zone 30
Drs Burzin Khan & Purvi Bhargava
Immediate loading of a socket shield (partial extraction therapy) post-extraction implant with the final CAD/CAM crown 36
Drs Filipe Lopes, Bernardo Mira Corrêa & Maurice A. Salama

cone beam supplement
Dynamic navigation—The future of minimally invasive endodontics 42
Dr Kenneth S. Serota

trends & applications
Digital ecosystem: The future is not in five years, the future is now 46
Simone Matt

manufacturer news

interview
“DTX Studio suite really can be used on a daily basis” 54
Interview with Dr Pascal Kunz, Vice President of Digital Solutions at Nobel Biocare

meetings
Dentsply Sirona World 2019 fast approaching 56
International events 58

about the publisher
submission guidelines 60
international imprint 62
Perform free-hand surgery with real-time 3D guidance for your drills and implants with X-Guide.
Adapt your implant plan anytime during surgery.
Enable same-day guided surgery.
Use DTX Studio Implant and export your implant treatment plan to X-Guide for 3D navigated surgery.

Same-day 3D navigated SURGERY

nobelbiocare.com/x-guide
Introduction: What do dentists want to know about occlusion?

Occlusion may appear complicated because of the multiple factors involved, such as teeth, muscles and the temporomandibular joints (TMJs). It can also be confusing, owing to imprecise terminology and philosophies of occlusion.¹

Philosophical disagreements have led to most of the confusion and resulted in several controversies. There is no consensus in the areas of diagnostic and treatment goals for occlusion.²⁻⁴ This relates to a lack of agreement about the most physiological or functional mandibular position.⁵⁻⁶ Subsequently, the methods used to find such a mandibular position vary greatly. The techniques for interocclusal recordings are not standardised⁷ and they include the use of wax, polyvinylsiloxane and computerised recordings.⁸⁻⁹

Practising dentists are focused on how to plan a treatment and treat a patient, and occlusion is regarded as only a means to an end. Most dentists want to use simple, well-established and commonly accepted best clinical practices. Most dentists want to know how to record the bite for the laboratory.

Therefore, the purpose of this article is to clarify dental occlusion for practical clinical applications. First, the authors will propose a practical approach to occlusion based on three concepts: intercuspation, mandibular position and occlusal stability. Second, the authors will present a clinical decision guideline for occlusal recordings to use in daily practice. Third, the authors will present and compare the analogue and digital methods of occlusal recordings, placing emphasis on how to find and record centric relation.

A practical approach to occlusion

The concepts of intercuspation and mandibular position

All occlusal recordings are done at the tooth level. It appears that the recorded relationship is between the maxillary and mandibular teeth. Because the maxillary arch is fixed, the only variable is the position of the mandibular teeth. In a further analysis, the only variable is the position of the mandible. Therefore, occlusal recordings are inter-arch relationships at the tooth level.

“Occlusion” is defined in the ninth edition of the Glossary of Prosthodontic Terms (GPT-9) as: “the act or process of closure” and “the static relationship between the incising or masticating surfaces of the maxillary or mandibular teeth or tooth analogues”.¹⁰ Since the process of closure...
is of the mandibular teeth on to the maxillary ones, applying deductive reasoning, one can surmise that occlusion has two components mandibular position (MP) and intercuspation (IC). Any IC is always associated with an MP (Figs. 1 & 2). Occlusion is an MP when the teeth intercuspate. We can express it with a mathematical formula: occlusion = MP + IC.

The concept of stability of occlusion
Like any natural system, occlusion seeks stability, which is accomplished through stability of the mandible. This may be obtained through a stable IC, sometimes named intercuspual position or maximal intercuspual position, and/or musculoskeletal stable joints (condylar position on the eminence). The GPT-9 describes “occlusal stability” as “the equalisation of contacts that prevents tooth movement”. The authors refer here to the broader concept of the stability of occlusion as a total system.

McNeill describes three stable reference positions that may be used: intercuspal position, myocentric relation and centric relation. In many clinical situations, the existing IC is widely accepted as a stable MP. Another stable reference position is centric relation (CR), which is a condylar-determined MP. CR is a stable musculoskeletal position of the condyles on the articular eminence or a condylar position. To be maintained, it has to be in harmony with a stable IC.

Let us analyse the MP concept further. Three non-collinear points, that is, that are not on the same straight line, can define the position in space of any solid object (Fig. 3). For increased precision, it is advantageous to select points as far apart as possible. The two condyles (first and second points) and the incisal point (third point) can define the position in space of the mandible relative to the anatomical structure of the maxilla/articular eminences (Fig. 4). The position of the condyles on the articular eminences can be defined as condylar position (CP). One stable CP, which is widely accepted, is CR. The position of the mandibular incisal point relative to the maxilla can be defined as the vertical dimension of occlusion (VDO). Using a mathematical formula: MP = CP + VDO. Therefore, the occlusion formula becomes (Fig. 5): occlusion = CP + VDO + IC.

These are the three variables we need to operate with, and these simplify occlusion by making it practical. Here are the clinical situations to which we can apply these simple occlusal rules.

When we decide to work with what is there, we accept the existing occlusion as functional; we accept the existing IC, but also the VDO and the CP as functional and acceptable for clinical use. When the MP is acceptable, it is irrelevant for that case; it can be considered to be zero, so the formula becomes: if MP = 0, then occlusion = IC.
When we decide to change the existing occlusion, or we do not have one at all (as in edentulous situations), we have to take all three variables into account. In general, all occlusal philosophies agree that VDO can be increased within the rotational movement of the condyles for aesthetic, functional and restorative purposes. The main differences in occlusal philosophies are related to the CP. The question becomes: what is an acceptable, physiological and long-term functional CP on the eminence? In other words: in what CP and VDO shall we create the new IC?

The case for a stable condylar position (centric relation)

In a stable occlusion, the IC guides the mandible in the same position repeatedly through muscle memory. When the IC is absent, the muscles may position the mandible in an endless number of positions, making reproducibility and stability a concern. Asking the patient to close in a “comfortable” position is an unpredictable means of finding a new MP.14

When the IC is absent, or the dentist decides to change it, the stability of the mandible has to be established with the help of the condyles and the VDO. The authors will make the case that the desired CP should be CR.

To determine a stable CP, we have two main options: to load or not to load the joints. It may appear that non-loaded, relaxed muscles is preferable. We want the patient to feel good and be relaxed, rather than forced into a particular position. However, there are inherent problems with relaxed, non-loaded positions:
- Relaxed positions can be in a large variety of CPs.
- Relaxed positions are very tricky to record—when we interpose a recording medium, the position may change.
- Most importantly, function and parafunction happen with contracted muscles and not in a relaxed position.

In healthy joints, loading creates a physiological, orthopaedically correct, predictable and reproducible CP.11 Loading is actually a test of the health of the joints. There are two main ways to apply loading to the condyles: the bimanual manipulation technique5 and the anterior obstacle technique.14–16 The obstacle can be a leaf gauge, an anterior deprogramming device or a composite resin device. The anterior obstacle technique relaxes the lateral pterygoid muscles and positions the condyles in CR by contracting the elevator muscles (Fig. 6). These techniques are well documented and relatively easy to use.18, 19

---

**Fig. 6:** Methods to find a new mandibular position.

When we decide to change the existing occlusion, or we do not have one at all (as in edentulous situations), we have to take all three variables into account. In general, all occlusal philosophies agree that VDO can be increased within the rotational movement of the condyles for aesthetic, functional and restorative purposes. The main differences in occlusal philosophies are related to the CP. The question becomes: what is an acceptable, physiological and long-term functional CP on the eminence? In other words: in what CP and VDO shall we create the new IC?

The case for a stable condylar position (centric relation)

In a stable occlusion, the IC guides the mandible in the same position repeatedly through muscle memory. When the IC is absent, the muscles may position the mandible in an endless number of positions, making reproducibility and stability a concern. Asking the patient to close in a “comfortable” position is an unpredictable means of finding a new MP.14

When the IC is absent, or the dentist decides to change it, the stability of the mandible has to be established with the help of the condyles and the VDO. The authors will make the case that the desired CP should be CR.

To determine a stable CP, we have two main options: to load or not to load the joints. It may appear that non-loaded, relaxed muscles is preferable. We want the patient to feel good and be relaxed, rather than forced into a particular position. However, there are inherent problems with relaxed, non-loaded positions:
- Relaxed positions can be in a large variety of CPs.
- Relaxed positions are very tricky to record—when we interpose a recording medium, the position may change.
- Most importantly, function and parafunction happen with contracted muscles and not in a relaxed position.

In healthy joints, loading creates a physiological, orthopaedically correct, predictable and reproducible CP.11 Loading is actually a test of the health of the joints. There are two main ways to apply loading to the condyles: the bimanual manipulation technique5 and the anterior obstacle technique.14–16 The obstacle can be a leaf gauge, an anterior deprogramming device or a composite resin device. The anterior obstacle technique relaxes the lateral pterygoid muscles and positions the condyles in CR by contracting the elevator muscles (Fig. 6). These techniques are well documented and relatively easy to use.18, 19

---

**Fig. 7:** Composite resin device creating a disclusion of posterior teeth. **Fig. 8:** Leaf gauge creating a disclusion of posterior teeth.
When we accept CR as the stable CP, the MP formula becomes: $MP = CR + VDO$. Therefore, the occlusion formula becomes: $occlusion = CR + VDO + IC$.

When coupled with an anterior permissive obstacle of an adjustable size, such as a leaf gauge or a composite resin device, the mandible can simultaneously be placed at the desired VDO too (Figs. 7 & 8).

The bimanual manipulation technique is difficult to master and the mandible is difficult to stabilise, needing an interposed medium. The anterior obstacle technique is easier and allows the patient to find the individual CP on the eminences, based on the direction of the vector of force of the elevator muscles (Fig. 9).²⁰

When patients exhibit tension, tenderness or pain upon loading the joints, a complete TMJ examination, both clinical and paraclinical (radiographs and MRI), needs to be done and a diagnosis needs to be established. The consensus of the literature is that a change in occlusion shall be done only after the joint and muscle issues have been resolved. In most cases, periodically adjusted

Fig. 9: The condyle position is based on the vector of force of the elevator muscles—perpendicular to the contour of the eminence.

Fig. 10: A complete-coverage occlusal device to relax the muscles and heal the joints.

Additive manufacturing surrounds a whole world of processes. Instead of a world tour you only need one ticket – for Formnext!

Where ideas take shape.
occlusal device therapy of six to 12 weeks is recommended (Fig. 10). The authors do not address in this article the full extent of temporomandibular joint dysfunction syndrome issues, but recommend only proceeding with treatment after complete resolution of the problems.

The decision guideline for occlusal recordings to use in daily practice

Dentists have to decide how to treat the patient from an occlusal perspective. A guideline is needed because it simplifies and quantifies the decision process. The authors would like to enable every clinician to quickly evaluate, plan treatment for and treat any clinical situation from an occlusal perspective. What follows is a guideline for clinical decisions regarding occlusion (Fig. 11).

A guideline for clinical occlusal decisions

Step 1: Determine whether the patient’s present occlusion will be maintained

After a complete examination and diagnosis, the clinician designs a treatment plan regarding the three categories of problems: structure, function and aesthetics. Occlusion may be involved in all three aspects. The dentist needs to decide whether the treatment goals in each category can be achieved in the present occlusion (Fig. 12).

In the majority of clinical situations, the treatment can be done in the present occlusion. Fillings and single-unit or even multiple-unit fixed prostheses may be completed in the existing occlusion. The authors do not approve or disapprove of this process in the current paper, but only point out that, in their estimation, about 90% of dental work is performed in the existing occlusion.

In summary, the first step is to decide whether the present occlusion will be maintained. If the present IC will allow the treatment to meet the patient’s objectives, proceed with treatment in that MP. If needed, record the existing IC and send the records to the laboratory. If a change in occlusion is needed, proceed to Step 2.

Step 2: Find a new stable and reproducible mandibular position, such as centric relation

To achieve the treatment goals, in some situations, the present occlusion has to be altered. The reasons may be structural, func-

---

Fig. 11: Clinical decision guideline for occlusal evaluation and treatment.

Fig. 12: Clinical decisions regarding occlusion. IC = intercuspation; MP = mandibular position; TMD = temporomandibular joint dysfunction syndrome.
tional or aesthetic. The following is a simplified list of such instances:

1. To obtain restorative space when needed restorations require an opening of the vertical dimension (Fig. 13);[21,22]

2. when the occlusal signs are significant and the patient is made aware and accepts change to the occlusal relationship (Fig. 14);

3. when the present MP creates functional problems (muscle and joint issues; Figs. 15 & 16). The simplest way to establish whether the MP is functional, even if the patient does not report symptoms, is the loading test. When the loading test is positive, a change of MP, and subsequently of IC, may be needed.

As we have discussed, the desired MP to acquire is CR at the desired VDO. If needed, record the CR and send the records to the laboratory. Step 2 is always followed by Step 3.

**Step 3: Re-establish intercuspation while preserving the new stable mandibular position (centric relation)**

This newly acquired MP will have limited interdental contacts or no IC. An IC in harmony with the stable MP, that is, a stable CP, is needed for a functional occlusion. Therapeutic modalities to re-establish or reorganise inter-arch relations or IC are equilibration, movement of teeth or bone support, and restorative procedures. These modalities may be used alone or combined. The goal should always be to use the least invasive treatment while achieving the patient’s objectives (Fig. 17).

In summary, the third step is to ensure that the new occlusion is stable and functional. Re-establish IC by using the least invasive treatment that allows achievement of the patient’s objectives.

**Analogue and digital occlusal recordings of existing intercuspation and centric relation: Clinical protocols**

Historically, occlusal recordings were performed using wax wafers, wax rims on base plates and bite registration pastes, such as polyvinylsiloxane. With the introduction of contactless 3D impressions using intra-oral scanners, new techniques for occlusal recording have emerged.

The classic analogue technique requires a recording medium (waxes, polyvinylsiloxane) to be interposed between the arches. The interposition of any material in between the teeth or arches is an obstacle that the patient may avoid or try to accommodate for, thereby skewing the recording. The record itself may distort during trans-

---

**Fig. 13:** Intercuspation requiring opening of the vertical dimension for restorative space. **Fig. 14:** Significant wear requiring occlusal coverage and altering of occlusion. **Fig. 15:** Occlusion with the mandible in centric relation and a significant open bite. **Fig. 16:** Occlusion with intercuspation but a non-functional mandibular position.
portation to the laboratory. The laboratory step of fitting the occlusal record on to the stone casts and mounting the assembly in the articulator is also prone to significant errors.

In contrast, digital recording has several advantages regarding efficiency and accuracy. The recording takes place without an interposed medium. The uploading of the digital casts in the software to the IC or CR position happens without the need for positioning of physical stone casts by an operator (technician). This ensures an accurate and efficient mounting in the virtual articulator. The direct digital occlusal recording is based on the intra-oral scanner software matching the digital casts of the arches to the inter-arch scan obtained from the side view of the arches (Fig. 18). The only noted disadvantage of the direct digital recording relates to the additional cost of acquiring an intra-oral scanner and the learning curve associated with operating one.

Occlusal recordings of existing intercuspation
When the dentist decides to maintain the existing bite, that is, to work with what is there, the focus should be on ensuring that there is no unwanted change in the recording and transmission to the laboratory. Analogue recordings of existing IC can be performed using polyvinylsiloxane registration pastes or waxes (Fig. 19). Dental laboratories usually digitise the analogue records and fabricate the restorations digitally. The process of digitisation can introduce imprecisions, owing to the difficulty of the laboratory articulating the models in the precise position. Digital recordings of existing IC can be performed using intra-oral scanners. The scanner is placed in the buccal corridor and records the

---

Fig. 17: Treatment modalities to recreate intercuspation in the new mandibular position.

Fig. 18: TRIOS 3 software (3Shape) matching digital casts of arches to side view inter-arch scan (in light blue). Fig. 19: Occlusal record limited to the prepared tooth area (when existing intercuspation is not altered).
relative position of the maxillary and mandibular teeth (Figs. 20a & b).

Occlusal recordings of non-existent intercuspation/centric relation
The technique for finding and recording CR described in this section can be used in different clinical situations, such as one full arch of fixed partial dentures, or for occlusal devices. It also incorporates the recording at the desired VDO. The process of finding CR is done conventionally using an anterior device, such as a leaf gauge or a composite resin device. There are devices that attempt to find the CR digitally, but these are not the subject of this paper.

The described technique uses an anterior obstacle. The anterior obstacle is a valuable tool that stabilises the mandible, allows the clinician to choose the desired VDO and facilitates the inter-arch recording with analogue or digital methods. The anterior obstacle technique appears simpler and less prone to errors than similar techniques are because the mandible is more stable when supported by an anterior obstacle.

The recommended technique for finding the CR position in a clinical situation with all teeth in one arch prepared for restorations:
- Create a composite resin device (stop) on an anterior tooth (Fig. 21) at an approximate VDO to allow restorative space.
- Ask the patient to move the mandible forward and backwards two to three times. That will relax the lateral pterygoid muscles and allow the elevator muscles to position the condyles in a physiological position on the eminences.
- Adjust the composite resin device, using articulating paper, for a smooth mandibular movement. Also, adjust the height until the desired VDO is reached—evaluate the anterior space first, then the posterior space, and then adjust the prepared teeth if needed to gain the appropriate restorative space.
- After the adjustments, ask the patient to maintain the backward position. That can be considered CR.

The technique for recording the CR position can be performed using analogue (Figs. 22 & 23) or digital methods (Figs. 24–27).

**Conclusion**

Occlusion can be seen as a combination of IC and MP. Most of the time, dentists can restore in the existing IC. In those cases, the process is straightforward: the occlusal record is of the given bite (existing occlusion). When the IC is absent or has to be altered, the dentist should position the condyles in an orthopaedically stable position (CR). The authors recommend finding the CR using an anterior obstacle and loading of the elevator muscles. At the same time, the desired VDO can be established. Subsequently, one may record that position with analogue or direct digital methods. In the authors’ opinion, digital methods have several advantages, including their accuracy, ease of technique and ease of evaluation, and the capability of mounting in a virtual articulator without any other intervention.

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

**about**

**Dr Michael Radu** is an adjunct assistant professor in the Department of Prosthodontics at the College of Dental Medicine of the Nova Southeastern University in Fort Lauderdale in Florida in the US and maintains a private practice in Boca Raton in Florida.

**Dr Daniel Radu** works in private practice in Boca Raton.

**Dr Florin Lazarescu** maintains a private practice in Bucharest in Romania.

**contact**

**Dr Michael Radu**
1865 NW Boca Raton Blvd
Boca Raton, FL 33432
USA
IT'S SIMPLE TO FIND YOUR ZEN

MIS GLOBAL CONFERENCE
May 14-17, 2020
Marrakech, Morocco

PEACE OF MIND WITH PERSONALIZED DIGITAL DENTISTRY. MAKE IT SIMPLE

The MGUIDE system features user-friendly software to ensure accurate planning and an open design template that allows for a greater field-of-view and irrigation for easier implant placement. Learn more about the MGUIDE and MIS at: www.mis-implants.com
Digital face-bow transfer technique using the dentofacial analyser for dental aesthetics and 2D, 3D smile design: A clinical report

Drs Christian Brenes, Larry Jurgutis & Courtney S. Babba, USA

Introduction

Digital workflows are becoming more popular and are in demand among clinicians and laboratory technicians owing to the increased incorporation of CAD/CAM tools into the daily practice. Digitisation of records and data through cone beam computed tomography (CBCT) scans, intra-oral scans and model manipulation contributes to better communication processes for diagnostics, treatment planning, designing and manufacturing in dentistry.

In past decades, clinicians and laboratory technicians have used analogue articulators to simulate hinge and eccentric movements of the mandible, allowing for the fabrication of wax-ups and final restorations; the evaluation of occlusal function is fundamental to any dental treatment.\(^1\)\(^2\) Face-bows were developed as a complement to different articulator systems to orient the maxillary arch to the centre of rotation of the condyles in three planes of space and transfer the position to the articulator; similar movements can be reproduced for occlusal evaluation and diagnosis once the models have been properly mounted.\(^3\)\(^4\)

In recent years, the incorporation of CAD/CAM technology has provided for more efficient protocols by automating processes and reducing manual labor. Intra-oral scanners can digitise dental arches and register maxillomandibular relationships.\(^5\)\(^6\) Currently, many CAD/CAM systems include a virtual articulator simulatory module as a tool to simulate mandibular movements, which can be adjusted by using numerical values to represent condylar inclination, Bennett angle, vertical dimension, etc. The equivalent of analogue mounted maxillary and mandibular casts still applies in the digital workflow for a proper evaluation; however, a major

---

**Fig. 1:** Digital model imported into exocad dental software; the red lines illustrate the dental midline and occlusal plane estimated from tooth position without reference points.

**Fig. 2:** Patient holding the Kois Dento-Facial Analyzer System; the middle rod corresponds to the facial midline and the Fox plane is parallel to the interpupillary line.

**Fig. 3:** Index tray with bite registration material.

**Fig. 4:** Occlusal stand with index tray and dental model mounted.

---

16 | CAD/CAM 3 2019
The challenge has been to transfer the maxillary arch position without an analogue tool such as a face-bow. A digital model behaves similarly to a floating object in space: The 3D models are not accurately oriented in the x, y and z coordinates when they are digitally scanned, which makes identifying the facial midline and occlusal plane impossible without proper points of reference (Fig. 1). In complex aesthetic and full-mouth rehabilitation cases, it is crucial to identify the midline and plane of occlusion to recognise any potential canting and occlusal problems. Panadent introduced a simplified system for transferring mounted study casts to the analogue articulator, called the Koiz Dento-Facial Analyzer System, or Dento-Facial Analyzer (DFA). The Dento-Facial Analyzer system is a device created by Dr Koiz and sold by Panadent; the occlusal stand fits directly onto the magnetic mount of the Panadent articulator series; several companies have developed compatible occlusal stands to fit their articulators and similar systems. The device basically consists of a Fox plane with an adjustable middle rod (Fig. 2). An index tray is attached to the device to record the position of the maxillary arch using bite registration material and to transfer the patient’s occlusal plane and midline in the three planes of space to the analogue articulator with a magnetic plate that attaches to an occlusal stand (Figs. 3 & 4). This allows mounting of the casts at a fixed distance of 100 mm, which is based on Koiz’s research on average axis-incisal distance, which is substantiated by Bonwill’s equilateral triangle theory and Monson’s spherical theory. Different techniques have been proposed to transfer this information into the CAD software, but most are more time-consuming and complex, using full-volume CBCT data or 3D facial scanners and different software to generate data able to align the maxillary scan to the skull. Most affordable 3D facial scanners (under $5,000) do not generate high-quality meshes that can be used to directly align dental casts. The scans are able to capture colour and can confuse clinicians about the true quality of the underlying mesh; without the colour, the quality of the underlying mesh is typically distorted and does not represent the shape of the actual object (Fig. 5). Moreover, 3D facial scanners need to have reference markers to align the digital dental models to the facial scan, which makes the process more complicated than using an analogue face-bow.

The technique described in this article overcomes these problems because it can align digital casts to the virtual articulator by using a bite scan in conjunction with the DFA. The face-bow transfer technique is described as follows:

1. Properly take a dentofacial record using the Koiz DFA, aligning the middle rod to the midline of the patient and capturing the occlusal plane orientation with the Fox plane. Several materials, such as polyvinylsiloxane bite registration material, wax or impression compound, can be used on the plastic index tray.

2. Scan the maxillary and mandibular arches with an intra-oral scanner along with the bite record. The intra-oral scan used in this case was PlanScan (Planmeca), but any...
intra-oral scan or laboratory scan will work for its implementation (Figs. 6 & 7).

3. Scan one bite record to align maxillary and mandibular arches and scan an additional bite record using the previous record captured with the plastic index tray on the maxillary cast. Since the plastic index tray was used as a record to capture the midline and plane of occlusion with the DFA, the external middle rod and the Fox plane are not needed for the bite record scan. The anterior middle notch in the index tray corresponds to the facial midline and the base of the tray corresponds to the occlusal plane (Fig. 8).

4. Align all models and bite records in the software.

5. Export all STL models and import to the design software or use it within the CAD software if the digital system has a CAD module integrated to start designing the anterior restorations or digital wax-up.

6. If the CAD software has an articulator module available, the bite record can also be used; in this case, the exocad articulator module was used (exocad). Click the boxes that display the horizontal and vertical planes of the articulator. Align the corresponding planes: midline notch of the index tray to the vertical plane of the articulator; and base of the index tray to the horizontal occlusal plane of the articulator (Figs. 9 & 10).

In addition to the basic alignment, the clinician has two different ways to correlate the anterior–posterior distance of the digital model with the virtual articulator. The first option is available if the clinician already has a full-face skull CBCT (wide field of view, approximately 20 × 18 cm, standard resolution). The distance from the centre of rotation of the condyles to the central incisors can be measured and reproduced in the articulator module (Fig. 11); the exocad DICOM viewer module can be used to measure the CBCT data and correlate the dental model scan of the maxillary arch. The second option is using the average axis–incisal distance reported by Kois’s research of 100–110 mm, which corresponds to the average anthropometric distance from the centre of rotation of the condyles to the incisal edge of the maxillary central incisors; that is the distance traditionally used with the Panadent articulator models PCF and PSH and the occlusal stand used to mount the plastic index tray. A 3D measurement ruler tool can be used in most CAD dental software to establish the distance and thus position the models.

This technique is beneficial in anterior aesthetic cases and helpful in 3D smile designs. The advantage of using a 2D, 3D integrated CAD design is that any request from the patient can be done instantly in the 3D design, eliminating the need for a conventional wax-up, which takes hours, and minimising the clinical time needed to obtain a cast, because the cast can be manufactured by means of a 3D printer or milling machine, making the protocol extremely efficient. Furthermore, using 2D images captured by pho-

Fig. 9: Frontal view of the model orientation based on the horizontal plane of the virtual articulator. Fig. 10: Lateral view of the model orientation based on the vertical plane of the virtual articulator. Fig. 11: Model orientation in the virtual articulator using the distance from the centre of rotation of the condyles to the central incisors as the distance for proper mounting.

Fig. 12: Preoperative smile photograph. Fig. 13: Preoperative intra-oral photograph.
tographic cameras or high-definition video cameras and superimposing them to 3D data is the quickest and simplest approach. A 3D facial scanner often cannot capture a smile in fractions of a second like a photograph can; instead, the patient has to hold the smile for several seconds, making it more difficult for clinicians to capture a true smile.

Another advantage to using a virtual wax-up is the possibility of using cross-sectional views to visualise and measure the addition of restorative material prior to starting an invasive procedure. This is an extremely useful educational tool for minimally invasive techniques that can improve the appearance of the smile and at the same time offer a better prognosis by preserving tooth structure.\textsuperscript{13, 14}

The purpose of this article is to describe the 2D, 3D smile design integration and its benefits in the provisionalisation stage after using the digital face-bow transfer technique.

**Clinical report**

A 62-year-old woman presented to the Comprehensive Care Clinic at the Dental College of Georgia at Augusta University, Augusta, Georgia, US, with the chief complaint of worn and stained anterior teeth (Figs. 12 & 13). The patient was a smoker and reportedly smoked a pack per week. During the first appointment, clinical and radiographic examinations were done for proper diagnosis and formulation of a treatment plan. The clinical examination revealed attrition on the anterior teeth and maxillary premolars, stable periodontal health with probing depths of $<3\, \text{mm}$, and no endodontic lesions or pathology. A thorough occlusal analysis was done, with no significant findings. Maximum intercuspal position was coincidental with centric relation, and no alteration of the vertical dimension was diagnosed. After evaluation of the patient records, a set of intra-oral and extra-oral preoperative photographs was taken, along with a DFA record, which includes a record of the midline and occlusal plane based on facial aesthetics (Fig. 14). Incisal edge position was determined first by adding composite to the left maxillary central incisor as a guide to establish the new length based on the evaluation of lips at rest and during smiling.\textsuperscript{15} The composite restoration is not bonded to tooth structure and is only used to determine the aesthetic incisal edge position during rest position, phonetics and smiling. Once the position is established the length is recorded for the future digital wax-up and the composite is removed. A prophylaxis was done during the appointment to treat some of the extrinsic staining present on the teeth.

With the diagnostic information acquired during the first appointment, the steps of aligning the models using the face-bow transfer technique with the DFA system were followed. A 2D image of the patient was imported and aligned using match points to develop a 3D functional virtual wax-up by adding restorative material to the maxillary anterior teeth and first premolars. A natural tooth library with square shaped teeth similar to the patient’s natural anatomy was selected to create the virtual diagnostic wax-up to reproduce shape and texture. The dental software used in this case (exocad) also has a tooth colour selection option to show a simulation of tooth shade, which facilitates the patient’s visual perception of the proposed treatment and improves treatment acceptance (Fig. 14). The design was evaluated functionally using the articulator module for excursive movements (Fig. 15).
The virtual 3D smile design was shown to the patient at the second visit. She was able to visualise the possible results of the aesthetic treatment and participate by giving feedback before any invasive procedures were initiated. No modifications were requested. The virtual wax-up was 3D printed (MoonRay S, SprintRay) and a putty jig was created on the model to generate a mock-up for the patient using bis-acryl (Integrity, Dentsply Sirona; Fig. 16) owing to its minimal shrinkage and excellent aesthetic results. The mock-up has two functions. The first is to serve as an aesthetic and functional prototype that enables the patient to visualise and experience the end result with a restorative material. Any modifications can be done at this stage because it is temporary and non-invasive. The second function is to work as a reduction guide once the patient has approved it; the reduction is created through the mock-up material and not through tooth structure (Fig. 17).

Minimally invasive preparation (0.5–0.8 mm facial reduction and 1.5 mm incisal/occlusal reduction) was done for the labial aesthetic veneers, allowing for enamel preservation (Figs. 18 & 19). A final impression was taken and the 3D virtual design was used as the preoperative digital model, since no modifications were done intra-orally after verification. Leucite glass-ceramic blocks (IPS Empress CAD, Ivoclar Vivadent) were milled for the final veneer restorations in-house using a milling machine (PlanMill 4.0, Planmeca; Figs. 20 & 21). Final characterisation was done after glazing.

At the delivery appointment, an aesthetic try-in was done prior to bonding the restorations. The patient approved the aesthetics, marginal fit was verified, and the teeth and restorations were etched and bonded (Variolink Esthetic, Ivoclar Vivadent). The patient was extremely satisfied with the treatment outcome (Figs. 22–25). An occlusal guard was provided as part of the treatment plan. At the one-year follow-up, the patient reported no complications.

**Discussion**

This article presents a simplified digital technique for transferring the face-bow information to the articulator. Transferring the position of the digital models in relation to the face is important to reproduce functional movements and have predictable aesthetic results. Previous techniques using CBCT units require that the patient be submitted
to unnecessary radiation to orient the models. In addition, other techniques using 3D facial scanners require expensive hardware; most clinicians cannot justify this expense only for orientation purposes, and both of these methods require more time and are more complex in nature. The face-bow transfer technique could also be used with edentulous patients by using occlusal rims as the reference points for the central incisors. The occlusal rim and the bite record with the plate would have to be scanned in order to register the meshes and align the edentulous models. However, this could be more technique-sensitive owing to the lack of stability of the bases.

While other bite forks can be used for the technique presented here, the authors highly recommend the DFA because of its ease of use. This technique is compatible with any virtual articulator, unlike analogue articulators that require brand-compatible stands. This creates a universal digital transfer technique that can be efficiently shared digitally with any other clinician or laboratory technician. While additional studies are needed to validate accuracy and reproducibility, this technique has the potential to greatly improve the workflow of digital dentistry. The process could be made even more efficient with the implementation of a direct align algorithm in dental software upgrades and with the incorporation of jaw tracking devices and tracking scans. This technique is extremely useful in 3D smile design cases or aesthetic cases that require the visualisation of facial landmarks such as the midline and plane of occlusion.

**Conclusion**

The digital face-bow transfer technique using the DFA system is a predictable, quick and easy method of scanning and aligning digital models to a virtual articulator without the need for expensive equipment.

**Competing interests**

The authors declare that they have no competing interests.

**Acknowledgements**

The authors would like to thank the following companies: exocad, Planmeca, SprintRay, and Roland for the support provided for education and research; their help was of tremendous value.

Computer-aided, template-guided immediate implant placement and loading in the mandible

Drs Thomas Spielau, Uli Hauschild, Germany & Joannis Katsoulis, Switzerland

Background

Computer-aided implantology (CAI) was introduced more than 25 years ago with the aim of facilitating implant planning and avoiding intra-operative complications such as mandibular nerve damage, sinus perforation, fenestration and dehiscence. Based on a computed tomography (CT) scan and a digitised tooth set-up, the prosthetically ideal implant positions can be planned virtually with the help of guided surgery software, allowing for 3D visualisation prior to implant surgery. Furthermore, the possibility of transferring the virtually planned implant position to the real clinical situation is provided by a stereolithographically fabricated surgical template. While only few guided implant placement systems were available at the time, today, multiple CAI programmes are available on the market. Several in vitro, cadaver and clinical studies have reported on the accuracy of guided implant placement. Although the current state of software and hardware technology has improved, inaccuracies in implant placement may occur and these depend on different factors, such as the template support (bone, mucosa, teeth, implants), intrinsic factors of the surgical guide (tolerance in diameter between the drill and the guide sleeve, fabrication accuracy of the guide) and human-related factors during the workflow of virtual planning and guided surgery. The guided surgery approach is still a matter of controversy, even though the procedure may be performed in a safe and predictable way. However, a systematic and concise approach to performing the single steps in the treatment sequence may allow for more accurate implant positioning, as the type of guide and fixation have an important influence. Additionally, the use of multiple templates with different supports, that is teeth and implant support, combined in a sequenced order is believed to improve accuracy compared with a mucosa-supported approach alone.

While some patients wish to be informed in detail about the specific treatment steps, most want to know whether they would have to leave the dental office without teeth at some point of the treatment. In this context, immediate implant placement after tooth extraction and immediate implant loading with a fixed provisional restoration may help the patient, as the time after extraction and osseointegration is consolidated. In guided surgery protocols, minimally invasive placement and immediate loading have been possible treatment steps from the beginning. Postoperative morbidity after flapless surgery is significantly reduced compared with the traditional open approach, especially in edentulous patients. Later during the treatment, restorations fabricated with the help of computer-aided design/computer-aided manufacture (CAD/CAM) provide high-quality and aesthetic materials. Although CAI and CAD/CAM procedures have facilitated a straightforward workflow in the rehabilitation of edentulous patients, immediate implant placement and immediate loading protocols combined are complex and required a high level of organisation between the implantologist, the technician and the patient. The aim of the present case report was to illustrate the feasibility of a combined immediate implant placement and loading approach using CAI in the rehabilitation of a patient with a partially dentate mandible and who requested a comprehensive treatment and, specifically, one that would not leave her edentulous at any point.

Initial status and treatment concept

The partially dentate 74-year-old patient presented with masticatory problems due a removable partial den-
ture (RPD) with insufficient stability, in combination with chronic pain affecting the mandibular anterior teeth area. She asked for a comprehensive treatment and was not prepared to accept being edentulous at any stage of the treatment. The patient was a non-smoker and—with the help of antihypertensive (Candecor comp. 32 mg/12.5 mg, TAD Pharma) and anti-coagulant medication (quick 30, Marcoumar)—in good general health.

The dental status showed acceptable oral hygiene and some teeth with Grade III mobility (teeth #41, 31, 32, 18 and 28) and local periodontal problems, including horizontal bone loss (teeth #42, 41, 31, 32, 33, 18, 17, 27 and 28). Teeth #42 and 33 were healthy and not mobile. The alveolar crest in the lateral mandible area showed clinically a wide shape with thick keratinised mucosa. The initial panoramic radiograph revealed stable crestal bone.

The dental status showed acceptable oral hygiene and some teeth with Grade III mobility (teeth #41, 31, 32, 18 and 28) and local periodontal problems, including horizontal bone loss (teeth #42, 41, 31, 32, 33, 18, 17, 27 and 28). Teeth #42 and 33 were healthy and not mobile. The alveolar crest in the lateral mandible area showed clinically a wide shape with thick keratinised mucosa. The initial panoramic radiograph revealed stable crestal bone.

### Table 1: Material and software used for the planning and realisation of the treatment.

<table>
<thead>
<tr>
<th>Treatment step</th>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBCT</td>
<td>PaX-Uni3D</td>
<td>VATECH</td>
</tr>
<tr>
<td>Virtual implant planning</td>
<td>3Diagnosys</td>
<td>3DIEMME</td>
</tr>
<tr>
<td>Implants</td>
<td>ELEMENT RC (4.5 x 9.5 mm)</td>
<td>Thommen Medical</td>
</tr>
<tr>
<td>CAD</td>
<td>exocad</td>
<td>exocad</td>
</tr>
<tr>
<td>CAM</td>
<td>M1 Wet</td>
<td>Zirkonzahn</td>
</tr>
<tr>
<td>Provisional FDP</td>
<td>Prefabricated titanium abutments</td>
<td>Thommen Medical</td>
</tr>
<tr>
<td></td>
<td>CAD/CAM cobalt–chromium framework</td>
<td>Sintermetall (Zirkonzahn)</td>
</tr>
<tr>
<td></td>
<td>Composite veneering and teeth</td>
<td>SR Nexco Paste (Ivoclar Vivadent)</td>
</tr>
<tr>
<td>Final FDP</td>
<td>CAD/CAM cobalt–chromium framework</td>
<td>Sintermetall (Zirkonzahn)</td>
</tr>
<tr>
<td></td>
<td>Composite veneering and teeth</td>
<td>SR Nexco Paste (Ivoclar Vivadent)</td>
</tr>
</tbody>
</table>

Figs. 2a & b: Initial dental status: right side (a) and left side (b). Figs. 3a & b: Frontal (a) and occlusal view (b) of the study models after extraction of teeth #41, 31 and 32.
in the lateral mandibular area (Figs. 1–3). Thus, in the lower jaw, the single-tooth prognosis was fair for teeth #47, 42 and 33, and hopeless for teeth #41, 31 and 32.

During decision-making for the final treatment plan, various treatment options, including a removable dental prosthesis, were discussed with the patient. To fulfil the patient’s wish for a fixed restoration and to never be edentulous in any treatment phase and considering the prognosis of the remaining mandibular teeth, the decision was made to prepare a provisional fixed prosthesis with an immediate loading approach and to extract teeth #42 and 33 for prosthodontic reasons but to maintain tooth #47.

Digital implant planning (Table 1)

After extraction of the painful and extremely mobile teeth #41, 31 and 32 and adaptation of the existing RPD, a cone beam computed tomography scan (PaX-Uni3D, VATECH) with a 5 x 8 cm field of view, 85 kVp generator voltage, 5.5 mA generator current and 0.2 mm voxel size was performed to proceed with the detailed implant planning (Fig. 4). Based on the anatomical conditions and prosthetic planning (i.e. tooth set-up for the provisional RPD), six implants were virtually planned (3Diagnosys, 3DIEMME) in positions #46, 44, 42, 33, 35 and 36. As the implant positions #42 and 33 interfered with teeth #43 and 33, a two-step procedure with two surgical templates was planned for the guided implant placement (Figs. 5a & b). The templates were fabricated stereolithographically (DS3000 and XFAB, DWS) according to the virtual implant planning. Based on the same digital file (Figs. 6a–c), a provisional fixed dental prosthesis (FDP) was prepared preoperatively, allowing for an intra-oral adaptation between the abutments and the framework in order to achieve a passive fit (Figs. 7a–d).

Immediate implant placement

On the day of surgery, a single dose of antibiotic (2 g of amoxicillin and clavulanic acid) was administered pro-
phylactically one hour prior to surgery. This treatment continued for five days (1g of amoxicillin and clavulanic acid twice a day). Prior to the start of surgery, the patient rinsed with 0.2% chlorhexidine for one minute. Local anaesthesia was induced using a 4% articaine solution with 1:100,000 adrenaline.

The two-step approach entailed the flapless, guided insertion of four posterior implants (ELEMENT RC, 4.5 x 9.5 mm; Thommen Medical), using the first surgical template, which was tooth- and mucosa-supported (Fig. 8a). The template was then removed and teeth #42 and 33, which had supported the guide, were extracted. Thereafter, the second surgical template was positioned and stabilised on the four posterior implants with the help of specific abutments and the same anchor pins (Fig. 8b), thus allowing guided placement of implants (ELEMENT RC, 4.5 x 9.5 mm) in positions #42 and 33 immediately after the extractions. All the implants were inserted at a torque of 35 Ncm and had good primary stability.
Immediate loading

After removal of the second surgical template, the standard titanium abutments were mounted on to the implants at a torque of 15 Ncm (Fig. 9a). The gaps between the abutments and the FDP were filled with a dual-curing composite material and the screw-retained immediate provisional FDP delivered. The occlusion required only minor adaptations owing to the accurate digital preoperative planning (Fig. 9b). The postoperative panoramic radiograph showed the parallel axes of the six implants (Fig. 10).

Final fixed prosthesis

All six implants osseointegrated successfully without complications. After six months of the patient wearing the provisional FDP, a conventional impression was taken (screw-retained impression copings, open-tray technique, polyether material) to fabricate the final FDP on a new, precise cast (Fig. 11), which was then digitised with a laboratory scanner (Deluxe scanner, Open Technologies). The final framework was designed with straight connection to the implant platforms and with a cutback allowing for the veneering material (Figs. 12a & b). While the cobalt–chromium framework was fabricated using CAD/CAM technology (exocad, exocad; M1 Wet, Zirkonzahn), the veneering was performed manually, allowing for individual characterisation of the teeth (Figs. 13a–d). The models were fabricated with a laser stereolithography printer (XFAB) using an ABS-like polymer (Precisa RD096B, DWS). Healthy mucosal conditions were present at the delivery of the final CAD/CAM restoration, made from cobalt–chromium and composite veneering material (Figs. 14a–e). The accurately fitting FDP was attached with screws at 25 Ncm and the screw access area covered with composite material. The panoramic radiograph on the day of delivery showed optimal prosthetic and osseous conditions (Fig. 15). The patient followed a regular maintenance programme at the dental hygienist twice a year.

At the one-year follow-up appointment, healthy mucosal and stable crestal peri-implant conditions were ob-
served (Fig. 16). The patient was very pleased with the aesthetic and functional outcome. Thus, the performed treatment was successful, and it showed stable results without complications or the need for maintenance service after the first year.

Discussion

The use of CAI software in the preoperative virtual 3D implant planning allowed for guided and immediate implant placement, and proved to be especially beneficial in the mandibular full-arch case presented. While there are some studies that have investigated outcomes of immediately loaded implants placed in edentulous patients using computer-aided, template-guided surgery to support an FDP, only few case reports are available in the literature that describe the entire workflow, the patient’s state in detail and the usage of guided surgery templates with subsequent immediate loading. The considerably more complex combination of immediate implant placement and immediate loading required a high level of organisation between the implantologist and technician, minimising the required compliance of the patient. Pozzi et al. reported excellent results with CAD/CAM cross-arch zirconia bridges on immediately loaded implants placed with computer-aided, template-guided surgery. Several investigators have presented analyses of recent studies in this context, elaborating on the factors that influence accurate implant placement but also the comparable outcome of the restorations after guided implant placement. In the present case report, two CAD/CAM surgical templates were combined in this partially dentate patient, with extraction of teeth #42 and 33 and immediate implants performed in a sequenced order. The first scanner-based template was tooth- and mucosa-supported, enabling a higher template stability and thus more accurate guided osteotomies and implant placement. Four posterior implants were placed with this approach, allowing support of the second surgical template after extraction of teeth #42 and 33. The stability on these four points was high, as the implants in positions #42 and 33 showed a torque value of 35–40 Ncm each. The placement of the subsequent two anterior immediate implants was thus perfectly guided.

Different factors contributed to this insertion torque, such as the depth of the planned implant position in a more apical area than the extraction site, the minimally invasive tooth extraction, the macroscopic implant geometry and the osteotomy protocol with a smaller drilling diameter compared with the implant diameter (as proposed by the company), the accurate performance of the single steps in the pre- and intra-operative phases, and the bone density in the anterior mandibular area. The prefabricated provisional FDP was prepared to connect the abutments to the FDP intra-orally, which was easily performed, given the accurate implant positions. With this approach, the passive fit of the FDP was maximised, the clinical chairside efforts (in terms of abutment connection and occlusal adaptations) were minimal and the predictability was very high compared with the various limitations and problems reported in a recent review.

The preoperative communication between the dentist and the technician during the decision-making and planning phase was essential for concise timing in the clinic, ensuring the highest surgical and prosthetic performance accuracy in this particular case. Therefore, up-to-date software and hardware, as well as the knowledge of how to apply the specific products, were required. This
case report supports the need for minimally traumatic or flapless surgery, optimal implant positioning and immediate loading, as summarised in a recent review on randomised controlled trials.33

Conclusion

The present case report has emphasised the efficient workflow and the predictable outcome using CAI. The fabrication of an immediate provisional FDP and, subsequently, the final CAD/CAM restoration was facilitated by CAI, fulfilling the patient’s wish to being continuously restored throughout the complete treatment.

Editorial note: A list of references is available from the publisher. This article was first published online in BMC Oral Health on 11 April 2019.

Acknowledgements

Thommen Medical is acknowledged for its logistical and administrative help during the treatment.

Funding

No funding body was involved in the design of the study, in the collection, analysis or interpretation of data, or in the writing of the manuscript.

Competing interests

The authors declare that they have no competing interests related to this case report.

about

Dr Thomas Spielau specialises in implantology and oral surgery, and is in private practice.

Dr Uli Hauschild is the senior academic adviser in the Department of Postgraduate Education of the Faculty of Oral and Dental Medicine at Goethe University in Frankfurt am Main in Germany.

Dr Joannis Katsoulis is an associate professor in the Department of Reconstructive Dentistry and Gerodontology at the School of Dental Medicine of the University of Bern in Switzerland.

contact

Dr Thomas Spielau
Johannesstraße 7–9
474623 Kevelaer, Germany
info@ergozahn.de
Empowering People to Shape the Future

For over 30 years, Roland DG Corporation has manufactured intuitive and affordable technology products. Since 2016, DGSHAPE Corporation has continued that legacy of technological innovation. At DGSHAPE we design hardware and software solutions for professionals looking to grow their business and improve the lives of others. Our dental products, such as the DWX-42W, carry the DNA of Roland DG and our focus is on making tools that remove the barriers of innovation to let the great history makers of tomorrow shape a better future for us all.

For more information please visit www.dgshape.com
Introduction

Precision in implant placement is of utmost importance for achieving predictable aesthetics and successful restorations, especially in the anterior zone. The quest for accuracy has recently been aided by digital workflows and stereolithographic stents, which not only support planning the implant positioning by flapless procedures accurately but also make possible the prefabrication of a provisional restoration before the procedure. CAD/CAM technology helps reducing inadvertent time loss and manual errors of impression making, pouring casts and fabrication of prostheses.

The success rate of now routinely practised immediate implant placement and immediate loading exceeds 95 %, and this protocol has the added advantage of reducing the treatment duration and helping restore the aesthetics during the healing phase. During this period of osseointegration, it is imperative to assure soft loading and restrict micromotion on the implants. This is done successfully with softer materials like BioHPP (bredent medical), which is a ceramic-reinforced high-performance polymer. The modulus of elasticity is similar to that of human bone, thereby attenuating masticatory forces, unlike conventional materials, which could cause a direct load transfer to the underlying bone and sometimes with occlusal interferences even ceramic fractures and temporomandibular joint problems. Biocompatibility is the ability of a material to perform with an appropriate host response in a specific situation. It can also be defined as the ability of a restorative material to induce an appropriate and an advantageous host response during its intended clinical usage. BioHPP, owing to its virtue of biocompatibility, has a favourable soft-tissue response and, by virtue of its colour, is a material of choice for anterior restorations, as demonstrated by a recent animal study by Maté Sánchez de Val et al.

In the transitional phase of soft- and hard-tissue healing with immediate implantation in the anterior zone, the provisional crown should be aesthetic, as well as have superior strength. This is marvellously achieved with long-term provisional crowns fabricated with breCAM.multiCOM (bredent medical). It is manufactured from polymethyl methacrylate (PMMA) and has been offset with > 20 % ceramic fillers in order to increase strength. The multi-chromatic-layered CAD/CAM block of breCAM.multiCOM gives the dental prosthesis a natural colour gradient.

The success of the immediate implant placement protocol has been made predictable by the use of photodynamic therapy (soft laser disinfection) using HELBO...
HELBO therapy entails use of a blue photosensitiser, which diffuses in the bacterial biofilm. The dye molecules are activated using the TheraLite laser (660 nm), resulting in release of aggressive singlet oxygen molecules and thereby causing destruction of bacteria in the biofilm. This anti-infective therapy increases the certainty of immediate implant procedures in infected sockets. The following case report describes rehabilitation of ailing maxillary central incisors following a completely digital workflow.

Case presentation

A 45-year-old male patient presented reporting pain and discomfort of his maxillary central incisors. Clinically, the teeth (with metal–ceramic crowns) were mobile from the post build-up, and radiographic examination with a CBCT scan showed a periapical lesion associated with his maxillary central incisors (Fig. 1). The long-term prognosis of the ailing teeth was ascertained as poor.

Presurgical phase

A thorough 3D treatment planning was done using the preoperative CBCT scan and coDiagnostiX software (Dental Wings). Owing to the presence of sound, adequate apical and palatal bone, an immediate extraction and implant placement procedure was planned. Fabrication of a stereolithographic stent for fully guided placement of implants was completed. This entailed virtual extraction of the central incisors and superimposition on the scanned diagnostic cast (Fig. 2). Using the coDiagnostiX software, the implant position and size were planned. This information was shared with the laboratory to prefabricate the one-time final custom abutments using BioHPP SKY elegance prefabricated abutments (bredent medical). The designing of these was done in exocad, based on the cut-back of the digitally designed provisional crowns to be fabricated from breCAM.multiCOM (Figs. 3a–c). The subgingival collars of the abutments were customised to support the soft-tissue profile of the scored casts. Using the surgical stent, the implant analogues were inserted into the planned positions on the cast (Fig. 4) and the fit of the one-time final abut-
Ment and provisional crown was checked in the laboratory prior to surgery (Figs. 5a & b).

**Surgical phase**

The procedure was performed under local anaesthesia using the infiltration technique. Atraumatic extraction was done of the maxillary central incisors using periotomes and luxatomes (Fig. 6). Proceeding a thorough curettage, HELBO disinfection was performed intra-socket for reduction in the bacterial load (Fig. 7). The surgical guide was inserted in place, and with the predetermined sleeve sequence, the osteotomy site was gradually primed flapless (Fig. 8). The SKY implants (bredent medical) were inserted and a torque of > 35 Ncm was achieved. There was a dehiscence on the labial bone plate of the right central incisor alveolar socket, for which tunnelling was done beyond the defect and guided bone regeneration was performed by inserting a collagen membrane (angiopore, bredent medical) to prevent soft-tissue ingrowth during the period of osseointegration (Fig. 9). Since the jumping distance was more than 2 mm, the socket was grafted with a particulate cancellous bone augmentation material (0.25 cc; Rocky Mountain Tissue Bank).

The final customised BioHPP SKY elegance prefabricated abutments were torqued to 25 Ncm in the predetermined
positions (Fig. 10) and the screw access plugged with Teflon. The digitally prefabricated breCAM.multicom crowns were reline for an accurate marginal fit and soft-tissue support, and cemented on to the abutments using Premier Implant Cement (Premier Dental; Fig. 11).

After eight weeks, the high labial frenulum attachment, which was causing a pull on the inter-implant papilla, was eliminated by laser frenectomy (Fig. 12). Soft-tissue remodelling of the papilla was done by adjusting the contact point of the temporary crowns to within a 4 mm distance from the inter-crestal bone, to induce regeneration according to Tarnow’s principle (Fig. 13).\(^5\) Also, a lateral build-up of the crown contours helped squeeze the papilla downwards, closing the black triangular space between the crowns.

**Prosthetic phase**

At 12 weeks, the temporary crowns were detached from the abutments, the collar margins adjusted to an equi-gingival level and intra-oral abutment level, a digital scan (CS 3600, Carestream Dental) was performed and the STL file digitally transferred to the dental laboratory (Fig. 14). Using the DentalCAD software (exocad), the final crowns were designed and milled from IPS e.max (Ivoclar Vivadent) in the laboratory. As these were layered crowns, 3D models were printed for the laboratory procedure (Fig. 15). After a crown trial, the BioHPP SKY elegance abutments were coated with visio.link primer (bredent medical; cured for 90 seconds) and the crowns treated with hydrofluoric acid, washed and dried, and a universal bond applied. The crowns were cemented with dual-curing resin cement. Optimal aesthetics with a good emergence profile was achieved owing to the preservation of both the hard- and soft-tissue, and the patient was satisfied with the clinical outcome (Fig. 16).

**Discussion**

The digital workflow in implant dentistry has made optimal implant positioning possible with pre-planning and use of a surgical guide. Prefabricating final abutments and provisional crowns helps maintain the tissue profile, assuring an immediate restoration, as well as the aesthetic appearance, to the patient during the entire treatment period.

In the current case report, a stereolithographic stent was fabricated based on the CBCT scan for accurate implant placement. A systematic review concluded that guided placement has at least as good an implant survival rate as conventional protocols do.\(^6\) However, several unexpected procedure-linked adverse events during guided implant placement indicate that the clinical demands on the surgeon were no less than those during conventional placement. A flapless approach was possible because of the stent. A flapless approach prevents stripping of the periosteum, improving blood supply at the surgical site.

An immediate implant placement and loading protocol was followed in the current case. Anitua et al. concluded that immediate loading of implants inserted into fresh and infected extraction sockets is not a risk factor for implant survival.\(^8\) A current study of Prof. Arturo Novães, presented at EuroPerio in Amsterdam in the Netherlands, showed that, with the disinfection of the extraction alveolus with HELBO, better bone quantity and quality in the healing time could be achieved.\(^9\)

Gallucci et al., whose study results were presented at the fifth ITI Consensus Conference, stated that for the anterior region, immediate and early loading of single-implant crowns are predictable procedures in terms of implant survival and stability of the marginal bone.\(^10\) However, data regarding soft-tissue aspects is not conclusive enough to recommend immediate or early loading of single-implant crowns in aesthetically demanding sites as a routine procedure. Immediate loading in such sites should be approached with caution and by experienced clinicians.\(^10\)

The one abutment at one time concept is very beneficial for maintaining crestal bone levels in post-extractive sockets.\(^11\)
A recent meta-analysis found less bone loss for one abutment at one time over a longer follow-up period. BioHPP was the material of choice for the one-time abutment, as it ensures soft loading during the healing period by virtue of its biomechanical properties and has a superior gingival response. It also offers improved aesthetics in the anterior zone owing to its non-metallic, light, dentine-like colour. The provisional crowns were fabricated with breCAM.multiCOM owing to its strength and aesthetics. It is a PMMA integrated with > 20% ceramic fillers, and therefore, this restoration can last for up to two years. The multi-chromatic layering of breCAM.multiCOM gives the dental prosthesis a natural colour gradient.

A digital intra-oral scan was taken of the one-time abutments for fabrication of the final crowns. A study revealed that crowns based on intra-oral scans had a significantly better marginal fit and better interproximal contacts than crowns based on physical silicone impressions.

**Conclusion**

The digital workflow in implant dentistry constitutes a paradigm shift from traditional protocols, enabling accurate treatment planning and predictability. However, long-term controlled studies are required to obtain conclusive evidence for clinical superiority of digital workflows for immediate implant restorations compared with conventional techniques. The use of new-age biomaterials with greater biocompatibility helps to improve tissue response and provides better aesthetic predictability.

**Acknowledgements:** The author would like to thank DT Danesh Vazifdar from the Adaro Dental Laboratory in Mumbai in India for his support.

**about**

Dr Burzin Khan is a Mumbai-based dentist and published author. In 1990, he completed his MDS in Prosthodontics at the Government Dental College in Mumbai in India. He maintains his multi-speciality clinic Opus Dental Specialties. He is a mentor for the Mastership series programme on Implant Prosthodontics at Eduhub Mumbai. In addition, he is past President and one of the Founders of the Indian Academy of Osseointegration.

**contact**

Dr Burzin Khan, MDS  
Opus Dental Specialties  
17, Murban Rd, Azad Maidan, Fort  
Mumbai, Maharashtra, 400001, India  
Phone: +91 22 66340038-9  
opusdents@gmail.com
REGISTER FOR FREE!
DT Study Club – e-learning platform

Join the largest educational network in dentistry!

www.DTStudyClub.com
Immediate loading of a socket shield (partial extraction therapy) post-extraction implant with the final CAD/CAM crown

The ONE protocol for one-day natural aesthetics and preventing buccal collapse

Drs Filipe Lopes, Bernardo Mira Corrêa, Portugal & Maurice A. Salama, USA

Introduction
Immediate implant placement is a well-recognised and successful treatment option after tooth extraction.\(^1,2\) Success rates for both immediate and delayed implant techniques are comparable; however, the literature reports that one can expect buccal collapse of the original buccal volume and midfacial recession of at least 1 mm after immediate implant placement, possibly worse in thin gingival biotypes.\(^3\)

Low aesthetic areas are usually of little concern; however, recession and ridge collapse, even in these areas, can still be visible under certain social and smiling circumstances. Besides aesthetic problems, ridge collapse and recession may compromise long-term results, because of food impaction and hygiene difficulties for the patient. The socket shield (SS) technique provides a promising treatment adjunct to better manage the aesthetic and functional risks associated with tooth loss followed by replacement with an implant.

The subjacent principle to its use is to prepare the root of the tooth (or the remaining root) indicated for extraction, leaving the buccal/labial root section. The intention is to keep the root’s physiological relation to the buccal plate as intact as possible. The root fragment’s periodontal ligament (PDL), attachment fibres (depending on apico-coronal positioning of the grinding of the shield), vascularisation, root cementum, bundle bone and alveolar bone are intended to remain vital and undamaged in order to prevent the usual post-extraction socket remodelling, which is extensively reported in the literature. This might more effectively support the buccal/labial tissue, maintaining the root effect convexity visible adjacent to natural roots and so often lacking around restored implants.

Initial patient condition and clinical status
A healthy, non-smoking, 40-year-old male patient presented with a mandibular left first premolar with a fractured root. The root had previously been treated endodontically, three years before suffering a bone level transversal fracture (Figs. 1a & b). The patient had already received several implants to replace some of his lost teeth over the previous nine years. The missing mandibular premolar could be easily seen and was one of his complaints. The patient had moderate aesthetic expectations, high functional demands and little time to come to the appointments.

Diagnostic and radiographic evaluation
After analysing the computed tomography (CT) scan on BTI Scan II software (BTI Biotechnology Institute; Fig. 1c), the root was not considered to have the minimum criteria for retaining a crown, or a post and core and crown. As the bone availability, bone density and remaining buccal bone were considered to be ideal, implant therapy was immediately considered.

This CT scan was taken three years before the root fractured. As there was no infection related to the root and sulcus probing, all around the remaining root and all the way down to bone contact showed no socket alteration—a Type I socket was diagnosed—it was decided not to irradiate the patient further. This CT scan data, supported by the clinical examination, was considered reliable, despite the three years that had passed.
Treatment plan and options
The patient was presented with the two options for replacement of his tooth:
- conventional implant therapy, like that which he had already received several times, consisting of immediate post-extraction implant placement either with or without provisional immediate restoration of the implant;
- partial extraction therapy (PET) utilising the buccal root fragment that would be deliberately left on the socket to try to further preserve anatomy and avoid the usual bone remodelling expected after tooth extraction, followed by immediate loading with the final CAD/CAM restoration.

The patient understood the options and chose the second option, expressing no opposition to the procedure.

Clinical procedure
After local anaesthesia, the root was sectioned mesiodistally. A long-shank root resection bur (Root Membrane Kit) on a high-speed handpiece was used under abundant irrigation (Fig. 2). After ensuring that the two fragments of the root, lingual and buccal, had been separated, periodontal elevators were inserted between the lingual bone and the remaining lingual fragment, slowly severing the PDL until its removal was accomplished. Extreme caution was used in order not to touch or loosen the remaining buccal fragment, which was intended to be left in the socket. The remaining buccal root fragment was then reduced coronally to bone level, using a long-shank round bur of 3 mm in diameter (Root Membrane Kit). The buccal shield was thinned to about an overall thickness of 1.5 mm. Its reduction was accomplished in such a way that the remaining root fragment would have a slight concavity facing the socket and the implant. The last drill used was a cylindrical long-shank red-stripe drill that allowed the polishing and smoothening of the surface of the root fragment (Komet Dental). With a periodontal probe, the lingual bone wall of the socket was checked for integrity. The remaining SS fragment was also checked for mobility. Thorough curettage of the remaining lingual, distal and mesial walls of the socket was performed.

The site for implant placement was prepared through the socket, according to the manufacturer’s instructions. A low-rotation (120 rpm) protocol was utilised with no irrigation, except for the first sharp bur of the sequence, which was used with higher rotation (800 rpm). The sequencing of the drills was done in a very precise and careful manner in order to avoid contact with the remaining SS fragment.

A 5 x 15 mm BTI interna plus implant (internal connection) was placed lingually to the SS, taking as refer-
ence for 3D positioning the adjacent tooth and implant crowns. The platform of the implant was placed 1 mm below the level of the buccal bone crest and the SS (Fig. 3). A BTI UNIT Transepithelial abutment was used to extend the implant’s platform 0.5 mm subgingivally (Fig. 4).

The gap distance inside the socket between the implant and the SS was filled solely with plasma rich in growth factor (Endoret, BTI Biotechnology Institute; Fig. 5). A final zirconia crown was fabricated and placed 24 hours after surgery. It was entirely designed and fabricated using the Zirkonzahn CAD/CAM system (Figs. 6–8).

Healing was uneventful, with no signs of infection or other complications at the one-week, two-week and one-month follow-up visits. The patient was very satisfied with the fast, comfortable, aesthetic and functional outcomes achieved.

At the one-year follow-up visit, the soft-tissue contours adjacent to the implant restoration and the buccal bone volume and convexity still resembled those adjacent to the natural teeth. Bone levels around the implant appeared stable during radiographic evaluation (Fig. 9). No perceptible loss occurred. The artificial crown had an emergence profile mimetic of that of a natural tooth. At the two-year follow-up visit, the tissue contours looked stable and appeared even to have improved when compared with the one-year follow-up visit (Fig. 10).

The two-year follow-up postoperative cone beam computed tomography (CBCT) scan (Figs. 11 & 12), as well as the clinical photographs, illustrated the bone level, the buccal bone volume achieved and maintained over the period. Also, it was possible to see that the gap distance, radiographically, appeared to have been filled with bone. It was surprising also to see that bone level was well above the implant–abutment junction, maybe in response to a very efficient maintenance of a zero micro-gap at the junction owing to this BioBlock (BTI Biotechnology Institute) one abutment, one time concept, providing a virtual one-piece implant.

Discussion

Prior to the SS technique, every time a tooth was to be replaced by a dental implant, the treatment options were as follows:
- post-extraction immediate implant placement with an immediate provisional restoration, filling or not filling the gap distance and rebuilding or not rebuilding the facial tissue to the implant, either with bone or soft tissue;
- a delayed approach with or without additional augmentative surgical procedure(s), depending on whether there was a compromised ridge defect after tooth loss.

While there are several techniques, well supported by the literature, to effectively manage ridge defects (be it with guided bone regeneration or with soft-tissue management), this same literature also shows that this augmentation can only partially compensate for the tissue loss. A certain amount of 3D shrinkage is always to be anticipated with healing. The submergence of tooth roots was first introduced to better preserve the alveolar ridge volume beneath removable complete dentures, preventing part of the bone loss subsequent to tooth extraction, maximising the available support area and, in some cases, creating an aesthetic (similar to natural) emergence profile in the aesthetic area. Successful tissue regeneration around submerged tooth roots was reported by Malmgren et al. more than three decades ago. Submerging the roots of hopeless teeth, for pontic site development, has been shown to be a valid and useful treatment in order to prevent the aesthetic damage that could result from the tissue collapse that generally follows a tooth extraction, as Salama et al. reported when developing pontic sites beneath fixed partial dentures.

In the SS technique, as described by Hürzeler, the root or tooth is ground down to 1 mm above the crest in order to preserve the supra-crestal fibres with epithelial and

Figs. 11–12b: The two-year follow-up post-op CBCT scan.
connective tissue attachment. Maintaining a fragment of the root ensures preservation of all the delicate tissue associated with it: the PDL, bundle bone, buccofacial plate and overlying keratinised mucosa, avoiding the typical remodelling subsequent to tooth extraction. Bäumer et al. produced the first human histological evidence demonstrating that it was possible to retain the attachment of the remaining SS to the buccal plate via a physiological PDL, free of any inflammatory response and with no osteoclastic remodelling activity. A sound junctional epithelium was also seen. The authors reported good preservation of the buccofacial tissue, but with an average of 1 mm of horizontal loss after final restoration. Chen et al. reported 0.72 mm of buccal resorption using a similar procedure. Very few case reports currently exist and the case reported here, with immediate loading with the final restoration, to the authors’ knowledge, is the first.

Conclusion

An increasing amount of evidence is being produced on the efficacy and safety of utilising PET/SS in conjunction with immediate implant placement to avoid the tissue collapse that always follows implant therapy. However, caution is advised both in case selection and in performance of the procedure, as it is a very technique-sensitive one.

In the case report, the authors have highlighted the biological benefits of combining technology and biology:

- PET by keeping an SS fragment of the root and its corresponding PDL, preventing in that way most of the tissue remodelling and collapse always expected in these kinds of clinical situations;
- the one abutment, one time protocol, by immediately extending the implant neck and creating, through the BioBlock concept (stable zero micro-gap at the implant-abutment junction), a virtual one-piece implant; the use of an abutment with a controlled nano surface roughness prone to soft-tissue adherence;
- digital CAD/CAM technology that allows for precise design and emergence profile planning, as well as fabrication of zirconia restorations, further enhancing soft-tissue response around dental implant restorations.

This case report is the first, to the authors’ knowledge, to demonstrate two-year follow-up successful preservation of post-extraction socket tissue combining PET/SS, one abutment, one time (UNIT abutment) and immediate loading (with occlusal loading) through a digital workflow using a CAD/CAM Zirkonzahn crown (Fig. 13).

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

Dr Filipe Lopes obtained his DDS and DMD from the University of Porto in Portugal. From 2000 to 2007, he was a clinical lecturer in the postgraduate programme in oral rehabilitation at the Faculty of Dental Medicine of the University of Porto. He currently lectures in the BTI Biotechnology Institute’s advanced oral implantology courses. Dr Lopes is CEO of the Centro Português de Medicina Dentária—Portugal Implant Dental Center, the Centro de Ortodontia Damon Portugal and the Centro de Medicina Dentária de Braga. He works in a practice that focuses on orthodontics, oral rehabilitation and implantology exclusively.

Dr Bernardo Mira Corrêa obtained his DDS and DMD from the University of Porto in Portugal. He currently lectures in the BTI’s advanced oral implantology courses. He is CEO of the Clínica Mira Corrêa, an implantology and oral rehabilitation centre in Oporto.

Dr Maurice A. Salama completed his undergraduate studies at the State University of New York at Binghamton in the US in 1985, where he received his BS in Biology. He received his DMD from the University of Pennsylvania’s School of Dental Medicine in the US, where he later received his dual specialty certification in orthodontics and periodontics, as well as implant training at the Brånemark Center at Penn. He was awarded the J. George Coslet, DDS, Memorial Scholarship and Richard Chase Scholarship at the University of Pennsylvania during his postdoctoral studies.
SIGN UP NOW!
The world’s dental e-newsletter

Stay informed on the latest news in dentistry!

www.dental-tribune.com
Dynamic real-time surgical navigation

Digital imaging, diagnostics and impressions, and the use of computer-aided design/computer-aided manufacture (CAD/CAM) for prosthesis fabrication and lasers for soft- and hard-tissue augmentation are altering the developmental framework in dentistry. Nowhere is this more prevalent than in the foundational pillar of endodontics.

The magnification and illumination properties of surgical operating microscopes enhance the accuracy of freehand navigation access cavity preparation and microsurgical osteotomy. This has engendered a transformational shift to conservative, more restricted endodontic access cavity preparation. This preserves coronal and radicular tooth structure by optimising the long-axis entry point, the drill angulation and the glide path to the terminus of the root canal space.

Limitations

In spite of these advances, there are limitations in endodontic clinical scenarios where canals sclerotically regress in a coronal-apical direction and surgical access is space restricted. While the clinician’s experience is a positive factor, altered vertical and lateral angulation of the long-axis orientation of the endodontic access cavity presents iatrogenic risk. In endodontic microsurgery, a small bone volume or a misdirected osteotomy can injure the inferior alveolar nerve or perforate the maxillary sinus and other critical anatomical structures.

The advent of cone beam computed tomography (CBCT—DICOM files) and 3D printing has transformed pretreatment planning. DICOM files are converted into stereolithographic...
files, which are used to create static navigation stents (CAD/CAM-fabricated). The stents direct the access cavity preparation and microsurgical orientation, thus avoiding removal of unnecessary tooth and bone structure (Figs. 1a & b).

Dynamic navigation offers new prospects for computer-guided endodontic protocols. Enhanced accuracy owing to real-time feedback diminishes the complex impact of access cavity preparation of calcified canals, retreatment and microsurgical procedures.9–11

Each navigation protocol has disadvantages. With freehand navigation used for dentoosseous access and surgery, clinical judgement is the pilot. Freehand navigation depends upon visualisation of the anatomical scenario from information provided by casts and radiographs. Significantly more time is required with a freehand navigation technique in contrast to a guided technique. Determining the canal path position is more complex.

Stereolithographic stents (static navigation) require a medium field of view CBCT scan. Polyvinylsiloxane im-

![Fig. 3: The screen is divided into (1) panoramic view, (2) 3D reconstruction, (3) axial view, and (4) buccolingual and (5) mesiodistal section views.](image1)

![Fig. 4a: The planned axis angulation and orientation of the virtual drill are exacting in targeting calcified canals. (Courtesy of Dr Bobby Nadeau)](image2)

![Fig. 4b: The red virtual pathway reflects an off-angle positioning. (Courtesy of Dr Bobby Nadeau)](image3)

![Fig. 4c: Piezotome planning. (Courtesy of Dr Bobby Nadeau)](image4)

![Fig. 5: The three landmarks chosen are not collinear, and the centre of the thin red cross-hair that appears is focused on the surface of the landmark.](image5)
pressions of the arch to be treated are poured and a
digital 3D scan of the stone model merged with the
patient’s DICOM files. The use of an intra-oral scanner
is preferable.

In the case of dynamic navigation, virtual planning of
the endodontic access preparation or the osteotomy can
be affected by the resolution of the CBCT scan. Flaws
in the process of fiducial integrated stent fabrication can
result in inaccurate image acquisition.

Innovation navigation

Dynamic navigation facilitates real-time computer guidance
technology using an imported CBCT data set. This is anal-
ogous to the use of GPS and satellite navigation. An inno-
vative computer-guided technology, Trace and Place (TaP),
has been developed by the Canadian company ClaroNav.
TaP obviates the need for a fiducial stent, with the resultant
increase in the accuracy of dentoosseous penetration.
An optical tracking device (Fig. 2) tracks a Jaw-Tracker,
the optical tracking tag connected to the patient’s jaw,
and a Drill-Tag, which is the optical tracking tag con-
ected to an instrument specific to the procedure. The tip
is superimposed on the CBCT scan, which is mapped to
the patient’s jaw.

The heightened level of accuracy of TaP technology en-
hances the facility of treatment for restricted access cavity
preparation and minimises the size of cortical window
osteotomies (high-speed; Piezotome, ACTEON). Ultrasonic
tips used for root end retro-preparation can also be tracked
by dynamic navigation software.

TaP workflow planning and trace registration

Estimates place the global population over 65 at 615 mil-
lion. Years of dentate and periodontal disease can impact
on the pulp, the periapex and the periradicular tissues.
With longevity will come increasing numbers of a mosaic
of endodontic procedures, as age and treatment induce
sclerotic changes in the pulp canal space. As such, the
use of dynamic navigation will prove to be of significance
in a myriad of endodontic treatment protocols.

Prior to the appointment

The first stage of TaP workflow is the importation of the
patient’s CBCT data set (as DICOM file) into the dynamic
navigation planning software to reveal the dentition. The
screen shows the streaming video, panoramic view, tar-
get view, depth indicator, and buccolingual and mesiodistal
section views (Fig. 3). The access point of entry, the axis
orientation/angulation and the depth of the access cavity
are planned. For microsurgical procedures, the Piezotome
pathway is based on the dimensions of the osseous pathol-
ogy surrounding the root apex (Figs. 4a–c). The planning
stage can be done at any time prior to the procedure, pro-
vided the CBCT scan is consistent with the current dentate
condition. As a preliminary step prior to the trace regis-
tration, three to six trace starting points (landmarks) are
chosen and marked on visible and accessible teeth.
When the computer mouse is positioned over the 3D model, a 2D cross-sectional view appears. The red cross-hair sticks to the landmark, its centre on the surface (Fig. 5). The software advises the clinician if it suspects that the landmark is in an incorrect position.

**Trace registration**

The Jaw-Tracker (mandible or maxilla) or Head-Tracker (maxilla) is securely fastened to the jaw to be treated (Fig. 6). It should be noted that the Jaw-Tracker can be positioned at a distance from the rubber dam, unlike a Jaw-Tracker attached to a fiducial stent, which is more positionally restricted. Once the three landmarks have been determined, the optical tracking sensor tracks the Tracer-Tag/Tracer-Tool as it is brushed around the landmarks on the facial, lingual and occlusal surfaces in a manner similar to applying etching or bonding solutions. The software shows the number of points contacted as a percentage (Fig. 7).

**Calibration of the drill**

The Drill-Tag is attached to the handpiece, and the drill axis and drill tip are calibrated. The optical tracking sensor continuously tracks the Drill-Tag, and the software shows the location and position of the drill or Piezotome. The software will issue a warning if the Drill-Tag or the Jaw-Tracker is out of view of the camera (Figs. 8a & b).

**Dentoosseous real-time navigation**

The navigation screen is active when the system identifies the calibrated instrument as it approaches the patient’s jaw. The target view measures the distance between the instrument’s tip and central axis of the designated access penetration point, the glide path or the osteotomy. The central axis length of the planned procedure is represented by the centre of the static white target, and the tip of the drill is indicated by the moving black cross following the drill tip movement. The real-time direction of the drill is represented as a cone in the head of the handpiece (Figs. 9a & b).

During the drilling, the moving cross and cone are tracked. The cone will turn green when the instrument tip is within 0.5 mm and has an angulation of less than 3° to the planned glide path or osteotomy. When the drill tip reaches a distance of 1 mm from the apical or horizontal extent of the planned depth landmark, the depth indicator turns yellow.

**Conclusion**

Dynamic navigation is an additional value chain in digital workflow sequencing. Minimally invasive protocols are the trajectory of dentistry’s future. Dynamic navigation is proving to be both the pilot and co-pilot of this new milestone in patient-centric care. All innovation requires seminal exploration of both the incentives for and barriers against prior to acceptance of a new technology as a contributing protocol. Early adaptation is osmotic: general acceptance occurs by diffusion. Improvements in the resolution of computer screens, optical markers and the reference array will herald an unprecedented level of accuracy in endodontic procedures. Digital has replaced analogue as the societal norm. The transition in the dental profession is in process.

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

**about**

**Dr Kenneth Serota** obtained his DDS from the University of Toronto Faculty of Dentistry in Canada in 1973 and received his Certificate in Endodontics and Master of Medical Sciences from the Harvard–Forsyth Dental Center in Boston in Massachusetts in the US. Active in online education since 1998, he is the Founder of the ROOTS endodontic forum (started in 2000) and the NEXUS interdisciplinary forum. Dr Serota is an adjunct clinical instructor in the University of Toronto postdoctoral endodontics department. He has been a contributor to and author of clinical articles for the roots magazine since its launch in 2004.
Digital ecosystem: The future is not in five years, the future is now

Simone Matt, Switzerland

At a time when venerable institutions in numerous countries, such as the UK’s National Health Service, are already setting up their own digital ecosystems and when not only companies but also private households are increasingly becoming almost paperless, it is certainly not too early to take an interest in the digitisation of our own dental practices. Many practices are already equipped with digital devices that replace or complete some steps of the traditional dental procedure in the daily practice. However, what I would like to highlight in this article is the potential that those clinicians who are willing to fully engage in the digitisation of their practices and to create their own digital ecosystems can realise.

What is a digital ecosystem?

“Digital ecosystems are comprised of companies, people, data, processes and things that are connected by the shared use of digital platforms. These partnering ecosystems are created to enable collaboration and provide mutually beneficial results to all parties involved.” In the case of a dental practice, the involved parties may be the patient, the clinicians and the entire practice team, as well as external stakeholders, such as supplying companies and other healthcare or insurance providers.

What is needed to create a digital ecosystem?

Foremost in the realisation of such a system is the most undigital of all conceivable elements, namely the human being, or more precisely all team members of the practice in question. Of course, the implementation of a digital ecosystem will fail even with the most sophisticated technical equipment if not all persons involved in the practical operations understand and support the digital process.

Technically, in addition to the obvious requirements, such as sufficient and interconnected computer workstations and a fast Internet connection, the cornerstones of a digital ecosystem in the dental practice are a powerful intra-oral scanner and a 3D radiographic unit. Depending
on the specialty, these devices can be complemented by a high-quality digital camera, a milling machine and a 3D printer.

**What are the benefits of such a digital ecosystem?**

In general, correctly used digital devices produce more accurate results compared with conventional instruments and therefore indirectly provide a higher quality of care. In addition, they usually save treatment time and therefore costs, not only owing to the shorter chair time but also owing to the significantly fewer consumables required and, in many cases, the reduced space requirements. In some cases, digital procedures are also perceived as more pleasant by the patient.

But these tools only become really efficient when they can be networked with one another, so that a digital workflow becomes possible without any gaps. This networking already has its most obvious advantages in practice when, for example, the measured values of the intra-oral scan are superimposed with those of the 3D radiograph to form a very meaningful data set. The use of the collected digital data by the practice’s own 3D printers or CAD/CAM units, for example for temporary prosthetic work, is also evident and profitable.

**What about interaction with the outside world?**

With digital ecosystems, the greatest untapped potential, which is already technically exploitable today, probably lies in the connection to the world outside the dental practice. For example, artificial intelligence (AI) for simulating treatment outcomes can be highly efficient in motivating patients to comply with treatment started. And, of course, such simulation can be an important factor in enabling patients to see the benefits of treatments offered by the dentist in the first place—the decision-making process is certainly made easier. However, this works best with very realistic simulations which clearly stand out from the robotlike images that have been known for some time. Only simulations with the individual and high-quality patient data sets, as discussed above, allow the potential to be fully exploited.

In some cases, such as in orthodontics with the new DenToGo (Straumann), a comprehensive suite of AI-based software solutions for tablets and smartphones, not only is patient choice facilitated by prior simulation, but progress is monitored and documented throughout the treatment period. The patient’s mobile phone as an imaging device is included in the communication with the practice.

In a concrete example, DenToGo Vitals Check allows in a first step a fast and visually easy-to-understand patient assessment. During this in-practice process, the clinician can identify, together with his or her patient, the orthodontic treatment needs and possibilities. Another DenToGo feature, My Smile, then provides almost immediately a realistic photographic simulation of the individual patient’s aesthetic situation during and at the end of the envisioned treatment—this, of course, helps tremendously in the decision-making for or against a treatment.

![Fig. 3: DenToGo rounds up the digital ecosystem.](image-url)
During the actual treatment, DenToGo Monitoring allows close-meshed support by the dentist without the patient having to come to the practice frequently: the patient takes photographs of his or her progress and sends these to the practice, which then gives either individual feedback or feedback automatically generated by the software but still perfectly adapted to the patient’s situation and needs. After completion and still without mandatory in-practice visits, DenToGo Smile Guard ensures good post-treatment stability and even helps to prevent relapse through regular notifications sent by DenToGo to the patient.

In short, DenToGo allows the dentist to provide high-frequency follow-up while reducing the number of practice appointments required during the treatment period. The patient feels better cared for and the clinician still has more time for other appointments with higher added value.

### The DenToGo suite of Softwares

*AI providing added value to doctors and patients*

<table>
<thead>
<tr>
<th>Software</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTG VITALSCHECK</td>
<td>Instant assessment of the patient oral condition</td>
</tr>
<tr>
<td>DTG MYSMILE</td>
<td>Realistic simulation of the patient's smile during and after treatment</td>
</tr>
<tr>
<td>DTG MONITORING (2D/3D)</td>
<td>Remote monitoring of the patient’s treatment at the clinic</td>
</tr>
<tr>
<td>DTG SMILEGUARD</td>
<td>Remote monitoring of the patient’s post-treatment phase at the patient home</td>
</tr>
</tbody>
</table>

Fig. 5: Suite of Software—unique and comprehensive digital ecosystem to the dentist and patient.
Greater visibility brings added value to the dental practice
The routine use of the technical cornerstones of a digital ecosystem in the dental practice makes the step to efficient patient communication extremely easy. Successful treatments automatically documented in images, scans and radiographs can quickly be shown on social media or in-house channels, such as the waiting room TV, as proof of competence.

Thanks to such visibility, existing patients are motivated to undergo new or additional treatments and new patients are attracted to the practice.

Additional potential of a digital ecosystem

The documentation of the clinical conditions of each patient case, which is greatly facilitated by a digital ecosystem, can also offer further advantages. For example, replacement prostheses for damaged prosthetic work can be fabricated with minimal effort and very quickly—patient satisfaction is guaranteed in such cases. Even in less pleasant situations, such as disputes with insurance companies or even legal cases, complete and meaningful data sets can be of great value to the clinician.

Lastly, the digital ecosystem helps with what are probably the most obvious forms of exchange with external partners, such as the laboratory or dental technician or other non-dental medical professionals treating the same patient. Of course, in such applications, but also in general in the implementation of a digital ecosystem, the utmost care is taken with regard to data protection—open communication but with clear boundaries.

Reference

Fig. 6: DenToGo at IDS 2019.

about
Simone Matt graduated from the Vorarlberg University of Applied Sciences and the Johannes Kepler University in Linz, both in Austria. She holds a Master of Arts in Marketing and Communications.

In 2009, she began her professional career in the dental industry and has since acquired a broad background, particularly in strategic marketing and product management roles, in Austria, Singapore and Switzerland. Matt demonstrated her experience above all in leading the successful global launch of the new Straumann 3D printer, the CARES P series. Currently, she is Director of Solutions Management Orthodontics at Straumann.
DGSHAPE Corp. was formed in 2016 as a wholly owned subsidiary of Roland DG Corp. of Hamamatsu in Japan. Roland DG has been designing, engineering and manufacturing computer peripherals, such as pen plotters, vinyl cutters, engravers, wide-format inkjet printer/cutters and benchtop CNC milling machines since 1981. Starting in 2016, DGSHAPE assumed control of the design, engineering and manufacturing of all products, formerly in the Roland DG portfolio, that cater for the 3D, manufacturing and healthcare industries. Our products are assembled in Japan and distributed all over the world.

DGSHAPE is an independent company under the umbrella of the Roland DG group of companies. We feel that this is an important distinction. Roland DG will continue to engineer and manufacture digital printing products for the sign and graphics industries. These products will continue to be innovative, high quality and reliable. DGSHAPE, however, has something quite different in mind. The emphasis on product quality is not the only inspiration for our products and services. Here at DGSHAPE, it is not enough to bring a stellar product to market; we are also concerned with the purpose of the applications for which our products will be used. We are interested in the strategic intent of our current and future customers. At DGSHAPE, we share our parent company’s mantra of “Transforming your imagination into reality”. We also believe that we can take that notion one step further in our mission statement, “Empowering people to shape the future”.

At DGSHAPE, we make products for a variety of different industries, including healthcare, education, manufacturing and retail personalisation. Each of our products is designed with two basic ideas in mind: “make innovation, make life better”. If we envision a solution for a given market, we must first ask ourselves these two questions: is this product innovative and does it make life better?

Our dental portfolio includes products that help dental professionals restore people’s smiles. At first glance, this would seem like a simple treatment of a problem using digital technology. But, put that into perspective: by giving people their smiles back, the dental professionals and craftspeople that use our machines are giving patients back their confidence and their health, improving their future (Fig. 1).
DGSHAPE Corp., a wholly owned subsidiary of Roland DG Corp., makes its second appearance on the international stage with a booth at the World Dental Congress exhibition in San Francisco’s Moscone Center. The company continues to celebrate successful milestones in its brief two-year history, including the shipment of its 10,000th unit, updated branding and partnerships with CAD software manufacturers for clinical chairside workflows using DWX devices.

Speaking at the DGSHAPE booth, DGSHAPE Global Brand Manager Dana Curtis commented, “We launched our new DGSHAPE brand at IDS 2017, to establish the DGSHAPE company as the future of Roland DG dental and 3D products businesses. As DGSHAPE, we deliver the same excellence of build quality, reliability and technical innovation that we have always done, with the added benefit to our users that, now as a business focused purely on dental and 3D technologies, we are more agile and pioneering innovation in the dental space.

DGSHAPE continues rapid growth at World Dental Congress
DGSHAPE President Hisashi Bito said, “Roland DG released the first benchtop milling machine in 1987 with the PNC-3000 as part of the CAMM-3 line. Thirty years later, the company decided that these products, fuelled by successful new markets, such as the dental market, would benefit greatly from a unique emphasis and a dedicated team. The results are clear: in the consolidated financial results for 2018, DGSHAPE products show a 12.3% increase in revenue year on year. We feel our updated branding reflects our identity and success as an independent company.”

Curtis continued: “The addition of ‘A Roland Company’ to our branding reflects the relationship between DGSHAPE and our parent company, Roland DG. Our customers and stakeholders can see that DGSHAPE is more than a product and that we are exploring new business models and new market solutions.”

Over the last two years, the DGSHAPE business has grown at an impressive rate. At the 2019 International Dental Show, held in Cologne in Germany, DGSHAPE celebrated this success, with the 10,000th unit being shipped during the show. Curtis said, “It is easy for us to understand where this rapid growth is coming from when we talk to our customers and hear their success stories. While there are thousands of labs with a single DGSHAPE machine, we also come across many labs with multiple-unit installations. We love to see how scalable our technology is, and we are constantly looking for ways to add value for future growth.”

DGSHAPE is continuing its innovation in the dental space with the first liquid-cure digital denture milling solution—Time Reduction Kits—and the first asset performance management software for dental devices—DWINDEX.

www.dgshape.com

Formnext exhibition offers an overview of technological innovations

Additive manufacturing creating significant growth potential in the dental industry

Additive manufacturing has found its way into not only more and more dental practices but other areas of dentistry as well—including orthodontics and implantology. Three-dimensionally printed drill guides and bite splints, custom-made impression trays and dental models are just some of the applications. Using 3D printing to make crowns and bridges is another established technique.

Indeed, the dental industry was one of the first to recognise and leverage the benefits of additive manufacturing. Bridges and crowns have been 3D printed since the turn of the millennium. The quality of the systems, processes and materials involved has continued to improve in the interim, ushering in a significant increase in applications. As a result, the market’s growth has seldom dropped into single-digit figures. Additive manufacturing is now generating around US$260 million in annual revenue (2018) in the dental industry according to an extensive study done by the Chinese market research and consulting firm QY Research. This strong growth in the additive dental industry is expected to continue into the future—or even to accelerate. QY Research projects an increase in global revenue to US$930 million by 2025—a more than threefold increase within six years.

These developments are giving rise to even more attractive business opportunities for dentists, dental laboratories and other users. The certification of processes and products has improved not only manufacturing quality but the commercial possibilities in the industry as well. All things considered, additive manufacturing now has the potential to replace metal casting in the dental technology segment.

For users, knowledge of the entire production process is key. That includes everything from design, software and printers to process monitoring, post-processing and quality control. Formnext, the world’s premiere exhibition in additive manufacturing and other modern production technologies, offers an excellent overview of the current and future possibilities afforded by additive manufacturing. On 19 to 22 November 2019, leading international manufacturers will showcase the latest developments in Frankfurt am Main in Germany. These innovations will include a number of solutions specifically designed for the dental industry, such as small, high-precision 3D printers and corresponding materials for metal dental prostheses.
Premiering at IDS 2019, TRUE LOW DOSE is the latest X-Mind trium CBCT innovation from ACTEON, with up to 50% less radiation exposure* and no loss of image quality and accuracy. This is possible thanks to new algorithm** associated with an innovative mechanism that brings the X-ray sensor and source closer to the patient. This results in increased protection for the patient, while preserving the most reliable and accurate diagnosis possible for the practitioner. This innovation confirms ACTEON’s leadership in the design of less invasive and less traumatic dental imaging technologies.

X-ray radiation reductions of up to 50%*
The new algorithm developed by ACTEON allows image acquisition with significantly reduced exposure time, resulting in a lower dose to the patient. The algorithm applied to these lower-dose projections improves contrast and decreases noise, thus accurately revealing the anatomical structures. This unprecedented patient protection is achieved without compromising image quality.

Greater child protection through increasingly less invasive innovative technologies
The new specific acquisition mode for smaller patients, and children in particular, reduces their radiation exposure. The X-ray sensor and source slide closer to the patient. In close proximity to the head, the unit emits less radiation while achieving image quality equivalent to standard acquisition.***

Pioneer on true innovation on the worldwide dental imaging market, ACTEON is maintaining and expanding its position with its TRUE LOW DOSE solution: facilitating procedures for the practitioner through features that are less traumatic and more acceptable for the patient.

X-Mind trium
Finally a TRUE LOW DOSE 3D CBCT imaging system

Accurate diagnosis and planning for higher success rates
ACTEON’s CBCT integrates high performance, state-of-the-art tools to increase diagnostic reliability and improve patient care. With X-Mind trium and ACTEON Imaging Suite software, treatment becomes more efficient and safer, less traumatic and therefore less stressful. Bone density around the implant is assessed with a single click, allowing easier clinical decision-making. Its simplified implant planning programme generates complete reports in less than a minute.

X-Mind trium has a small field of view (Ø 40x40) and provides ultra-high-resolution images (75 μm), making it the new reference in endodontics. X-Mind trium adapts to the growing needs of dental offices by pairing 2D panoramic with 3D imaging and digital cephalometric analysis when necessary. Cephalometric radiography offers simpler patient positioning and the smallest physical footprint on the market. X-Mind trium is the ultimate Mac-compatible therapeutic tool that adapts to the practitioner’s working environment.

* Ratio based on DAP measurements from standard X-Mind trium settings: 90kV-8mA-300pps
** Coming soon
*** Patent pending

www.acteongroup.com
“DTX Studio suite really can be used on a daily basis”

The recent Nobel Biocare Global Symposium saw many of the world’s leading voices on implantology and digital dentistry gather in the Spanish capital of Madrid. At the event, Dental Tribune International spoke with Dr Pascal Kunz, Vice President of Digital Solutions at Nobel Biocare, about DTX Studio suite and the benefits it provides for both dental clinicians and patients.

What are the major differences between Nobel Biocare’s DTX Studio Clinic, DTX Studio Implant and DTX Studio Lab?

They are all part of one coherent and open software suite for dental diagnostics, leading into treatments, including follow-up. Essentially, DTX Studio Clinic is the new diagnostic software for all patients. Until now, our various operating companies utilised several stand-alone, narrower-scoped diagnostic solutions to power their imaging devices and to analyse their acquired data. Every intra-oral optical camera, intra-oral radiographic solution and extra-oral imaging device, including CBCT scanner, needed such software. However, DTX Studio Clinic not only powers our devices, but generates and maintains a central image archive in which all visual data from different modalities can be gathered and stored on patient level with tooth position intelligence. Through that, DTX Studio Clinic provides a dynamic, visual patient library with a very strong open input and output path that allows for the clinician to initiate and follow up with all his or her patients and treatments. He or she can also engage with and connect to treatment partners via the embedded personalised online platform, DTX Studio Go.

In contrast to DTX Studio Clinic, which is designed for use with every patient, DTX Studio Implant is designed purely for dental implant rehabilitation and the respective workflows. It provides clinicians with a market-leading ecosystem for implantology with SmartFusion, Smart-Setup—an artificial intelligence-based automatic tooth setup—and one-click actions to generate a report for freehand surgery, to create an automatically designed surgical guide or to export the plan directly to our
dynamic navigation system, X-Guide. Whatever method of treatment the clinician has opted for—freehand surgery, guided pilot drilling or navigation—DTX Studio offers all options and links closely with the dental lab technician to enable same-day cement-free provisionals and, of course, a wide variety of final restorations.

The target group of DTX Studio Lab is, quite clearly, the dental laboratory, and it allows for technicians to provide model and diagnostic desktop scans, work with intra-oral scanner files from various sources, modify the artificial tooth setup, produce locally or order directly from NobelProcera and, most importantly, interact closely with the clinician. The DTX Studio Lab customer benefits heavily from the large install base of the clinical software to serve his or her customers in the best and safest possible way.

It’s important to note that all three of these entities are connected by DTX Studio Go, a web platform that each member of the treatment team can access to organise orders, reach out to other clinicians and service providers, and much more.

“Different patients require different treatment modalities and different skill sets, and all information [...] should be available at any given time.”

Does DTX Studio suite provide any benefits for the patient?

From a diagnostic perspective, the patient’s visual information will always be up-to-date even if no specific treatment is planned. This allows the clinician to stay focused on the patient and not lose time organising or searching through his or her diagnostic files in various software.

Today, dentistry without digital data simply doesn’t exist anymore. Without radiographic and other digital patient-specific diagnostic information, clinicians do not know exactly what the current patient situation is, what has changed from the previous visit and what needs to be done to address issues. Uninformed and potentially wrong decisions are costly for the patient and the treatment provider, DTX Studio suite is designed to generate information and uncover facts to provide clarity for each individual patient’s needs. To put it simply, this is what the patient expects: to be treated as an individual and not an implant case.

What we’re aiming to provide is an open platform that allows the clinician to be deeply integrated into the workflow yet, at the same time, has so many entry and exit points that this workflow can be tailored to the clinician’s specific needs. Different patients require different treatment modalities and different skill sets, and all information to evaluate the current situation and history should be available at any given time.

What is the learning curve for those new to DTX Studio suite? Does the workflow have specific benefits for the more experienced dental clinician?

It is interesting because DTX Studio suite is relatively easy to learn at first, yet the more you learn about it, the more you learn just how many additional functionalities it possesses. For me, this type of software must be clearly relevant to the user’s existing work processes. DTX Studio suite really can be used on a daily basis, and much like everything in life, if you use it every day, you will get used to it very quickly and begin to explore its capabilities. DTX is built to allow for this to occur naturally and is much easier to operate and share information through than having multiple software options that don’t interact or integrate with one another.

Of course, we also offer online training courses, as well as hands-on training courses by leading clinicians at events such as the Global Symposium. In addition, Nobel Biocare and affiliated operating companies with their own dealer networks have many dedicated teams of local staff available to help answer any questions the clinician might have.
From 3 to 5 October, the dental manufacturer Dentsply Sirona will be hosting Dentsply Sirona World 2019 at the Mandalay Bay Resort and Casino in Las Vegas. This annual industry gathering is expected to bring together thousands of professionals from all areas of dentistry. Attendees will have the chance to learn about recent innovations and gain hands-on experience with some of them, such as the new intra-oral scanner Primescan. The renowned entertainment programme is set to feature the likes of comedy legend Jerry Seinfeld.

Dentsply Sirona’s comprehensive training programmes reach more than 431,000 dentists worldwide annually through approximately 12,000 courses. The company has employed that vast experience to plan the educational programme at Dentsply Sirona World 2019, providing a programme that general practitioners, specialists, laboratory technicians, hygienists and assistance teams will all benefit from. Nearly 100 speakers will share their expertise, including Dr Karyn M. Halpern, Dr Todd Ehrlich, Dr Sameer Puri, Jasmin Haley, Dr Tarun Agarwal and Shannon Pace Brinker. There will be opportunities for attendees to ask employees and early adopters questions about the company’s range of new developments and existing products.

Of course, Dentsply Sirona World 2019 would not be complete if it consisted solely of learning opportunities. The last time the event was held in Las Vegas, runners donned their favourite intergalactic gear for an alien-themed 3-mile morning run down the Las Vegas Strip to promote health and wellness. This year’s agenda includes a 5-km “Treasure Trot” fun run and yoga as health and wellness opportunities on both Friday and Saturday morning.

“Dentsply Sirona World stands out. The variety of topics is unique and there is hardly any area in the world of dentistry that we don’t address in depth,” said Eric Bruno, Dentsply Sirona’s Senior Vice President of the North American regional commercial organisation. “We know that people attending Dentsply Sirona World appreciate the easygoing atmosphere. That’s why so many dentists, dental technicians and dental assistants from all over the world are coming to Las Vegas to meet, share ideas and learn from each other. And, of course, to have a good time together,” he continued.

“Participants can look forward to an outstanding entertainment programme, which I would like to keep mostly under wraps for the moment although I will share that world-famous comedian Jerry Seinfeld will be performing,” said Ingo Zimmer, Dentsply Sirona’s Vice President of Marketing. “I think I can safely say that our programme will meet, if not exceed, expectations!”

Dentists can find more information about the event and register at www.dentsplysironaworld.com.
FIRST CLASS EDUCATION WITH LEADING EXPERTS

- Implantology
- Endodontics
- Esthetics
- Periodontics
- Orthodontics
- Prosthodontics
- Practice management

IMMEDIATE DENTOALVEOLAR RESTORATION
IDR IMMERSION COURSE PART 1

DENTAL COURSE FINDER

Choose your specialty:

- Endodontics
- Esthetics
- Periodontics
- Orthodontics
- Prosthodontics
- Practice management

Search for your next course on tribunecme.com

ADA CERP
Continuing Education Recognition Program

Tribune Group GmbH is an ADA CERP-recognized provider. ADA CERP is a service of the American Dental Association to assist dental professionals in identifying quality providers of continuing dental education. ADA CERP does not approve or endorse individual courses or instructors, nor does it imply acceptance of credit hours by boards of dentistry.
International events

The ADA FDI
World Dental Congress
4–8 September 2019
San Francisco, USA
www.world-dental-congress.org

AAOMS Annual Meeting
16–21 September 2019
Boston, USA
www.aaoms.org

CEDE
19–21 September 2019
Poznań, Poland
www.cede.pl

Dental-Expo
23–26 September 2019
Moscow, Russia
www.dental-expo.com

EAO Annual
Scientific Meeting
26–28 September 2019
Lisbon, Portugal
www.congress.eao.org

GNYDM
1–4 December 2019
New York, USA
www.gnydm.com

Pragodent
3–5 October 2019
Prague, Czech Republic
www.pragodent.eu

AAID Annual Conference
23–26 October 2019
Las Vegas, USA
www.aaid.com

11th Dental Facial Cosmetic
International Conference
8–9 November 2019
Dubai, UAE
www.cappmea.com/aesthetic-dentistry

Congrès ADF
26–30 November 2019
Paris, France
www.adfcongres.com/fr/
I would like to subscribe to:

- CAD/CAM 4 issues p.a. €46
- ceramic implants 2 issues p.a. €30
- Clinical Masters 1 issue p.a. €15
- cosmetic dentistry 1 issue p.a. €15
- implants 4 issues p.a. €46
- laser 4 issues p.a. €46
- ortho 2 issues p.a. €30
- prevention 2 issues p.a. €30
- roots 4 issues p.a. €46

Terms & conditions: Your subscription will be renewed automatically every year until a written cancellation is sent to Dental Tribune International GmbH, Holbeinstr. 29, 04229 Leipzig, Germany, six weeks prior to the renewal date. All prices include VAT, shipping and handling.
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?

Magda Wojtkiewicz
(Managing Editor)
m.wojtkiewicz@dental-tribune.com
Innovative solutions for dental applications
www.maestro3d.com

2 x 5.0 MEGAPIXEL
Plug & Play
Smart Impression Scanning
Accuracy less than 8 micron
Texture Superimposition

Study Models
Virtual Setup
Clear Aligner
Indirect Bonding
Digital implant workflow

Connect to the future

From data capturing, planning, guided surgery to the final restorative solution, with the digital implant workflow from Dentsply Sirona you have all the support you need to save time, grow your business and provide patients with the best possible care.

www.dentsplysirona.com
Straumann® CARES® Digital Solutions > Intraoral Scanner

Straumann® Virtuo Vivo™
Capture each note.

SCANNING IN REAL COLOR.
SMALL AND LIGHT HANDPIECE.
REMOVABLE & AUTO-CLAVABLE SLEEVES.

Contact your local Straumann representative now or visit www.straumann.com.