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Dear Reader,

Dentistry is on the move! Today’s patients expect to be treated with the latest technology and materials to maximise their dental experience. As clinicians, we owe it to our profession and to our patients to utilise the newest technologies according to best practices that will elevate our care without compromise. I have adopted this approach to dentistry by integrating chairside CAD/CAM dentistry (E4D Dentist System, D4D Technologies) and in-office CBCT (i-CAT, Imaging Sciences International) into my practice.

With the E4D system, I am able to control my indirect restorative dentistry, without having to eliminate the laboratory or the technician. I am able to more appropriately coordinate single tooth treatment chairside with IPS Empress CAD and IPS e.max CAD materials (Ivoclar Vivadent), as well as provide more comprehensive options to meet my patients’ needs. In today’s world, CAD/CAM dentistry has given us the ability to offer reliable, in-office, same-day and high-quality indirect restorations to our patients. With the laser scanning capability of E4D, I can scan in the mouth, off an impression or off a model, providing total flexibility in patient treatment. In addition, the ease of use of the software and flow of production make it easy to delegate procedures to properly trained dental assistants for beautiful and functional results.

Generally, the same applies to the benefits of utilising my i-CAT. I can offer my patients the latest in cone-beam technology for diagnosis and treatment planning without having to go elsewhere or make additional appointments. The future combined use of technologies utilising intra-oral scans and CBCT data provides a unique view of a virtual patient prior to completing any treatment. This will provide the clinician, office team, dental laboratories and especially the patient with a unique view of the treatment plan, eliminate surprises in implant placement and harmonise anticipated results when all have the same ‘view’ of the entire case, from start to finish. The goal is to experience true restorative-driven implant therapy.

D4D Technologies and the Imaging Sciences group, with the groups from Gendex (CB500) and Instrumentarium (Scanora), are developing a software solution that combines digital data from intra-oral scans with 3-D surgical data (CBCT) to provide complete control and make restorative-driven implant therapy a reality. Through the dynamic collaboration of these dental technology leaders, future dentistry will use these technologies in harmony. For the general dentist, the collaborative efforts of leading digital scanning companies and cone-beam manufacturers will enable the expansion of same-day restorative care to same-day surgical placement of implants using cone-beam guidance and the immediate placement of an in-office and CAD/CAM restoration.

My patients are 3-D and I believe my treatment should be as well. Practising in this manner offers great advantages in treatment options and predictability. Dentistry is on the move, so our patients don’t have to! Get on board with the latest in modern dentistry—you, your team, your practice and your patients deserve it.

Yours faithfully,

Dr Sharnell Muir
Kelowna Dental Centre
Kelowna, BC, Canada
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Case acceptance in complex-care dentistry

I enjoy seeing the articles in CAD/CAM in which clinicians recount their creation of magnificent works of art through digital restorative dentistry. In most of the case studies I’ve read, I am sure the patient fees reach well over US$15,000 or more.

Let me ask you this: what percentage of your patients whose fee is US$15,000 or more are ready to start care immediately after you present their treatment plan? I have directed this question to thousands of my dentist audience members over the last decade and the overwhelming response is “fewer than 5 per cent.” Is this because patients do not understand dentists’ treatment recommendations? Or is it that the fee does not fit into their budgets? Chances are that both these apply.

As dentists we are pretty good at helping patients understand us and our treatment recommendations. What we are not good at is understanding our patients and the manner in which our treatment recommendations must fit into their lives. If you have heard it once, you have heard it a thousand times: the key to case acceptance is patient education. Go to dental seminars, read journals, listen to consultants; most of it sounds the same—educate, educate, educate. Now let me ask you this: is it true? Is patient education the solution to case acceptance?

If it is, then why do many new patients who have been thoroughly examined, educated and offered comprehensive treatment plans leave your practice and never return for care? Is it that you did not educate them sufficiently? Or is it that in the challenge of case acceptance, patient education is not the only answer?

Let’s consider the new patient process and case presentation and learn when patient education works for us and when it chases patients out the door.

Inside-out versus outside-in

How do we get patient education to work for us? Let’s first make the distinction between an inside-out versus outside-in new patient process. The traditional new patient process is inside-out. It begins by studying the inside of the patient’s mouth—the examination, diagnosis and treatment plan. It is after this inside look that we educate the patient with regard to all his/her problems—how he/she got them and what we can do about them, for example case presentation. After case presentation, we quote our fees and discuss financial arrangements. It is only once we have gone through our inside process that we discover what is happening outside the patient’s mouth—his/her budget, work schedule, time and significant life issues.

The flow of conversation starts with inside-the-mouth conditions and ends with outside-the-mouth issues. I label this traditional way of managing the new patient the inside-out process (Fig. 1).

For patients with uncomplicated dental needs—fees of US$3,500 or less—the inside-out approach with appropriate patient education works well. Here’s why:

First, patients with minimal clinical needs are often unaware of them. Patients with conditions such as periodontal disease, asymptomatic periapical abscesses and incipient carious lesions must be made aware of them and educated regarding their consequences. Patient education is the driver of case acceptance when patients are unaware of their conditions.

Next, the inside-out process works well for patients with fees of US$3,500 or less because the outside-the-mouth issues—fees, time in treatment and life issues—are such that most patients can proceed with their treatment without undue hardships or inconvenience. Dental insurance reimbursements, patient payment plans such as...
CareCredit and credit cards usually soothe the sting of fees for US$3,500 or less. Fees at this level are not insurmountable and usually do not anger or embarrass patients out of your office. But what if you present complex dentistry for more than US$3,500?

Let's suppose your fee is US$10,000 and it involves multiple, long appointments and your patient would lose time from work? Do outside-the-mouth issues get in the way of case acceptance now? Yes, they do. Does patient education make the unaffordable affordable? No, it does not. How do I know? You have proven it, have you not?

It is with the patient whose fee is greater than US$3,500 that I recommend an outside-in approach. Employing an outside-in approach involves initiating your new patient procedures with conversations—telephone and the in-office new patient interview—that focus on understanding what is happening outside the patient’s mouth, such as significant life issues, budget and work obligations. Later in this article, I'll show you how.

After we have an understanding of outside-the-mouth issues, we do our examination. Then, during the post-examination conversation and case presentation, we link our treatment recommendations to the realities of their outside-the-mouth issues. Let me show you how.

The flow of conversation starts with outside-the-mouth issues and ends with inside-the-mouth treatment recommendations. I label this an outside-in process (Fig. 2). An excellent example of an outside-in process is the purchase of a home. Imagine you and your spouse decide to buy a new house. You go to a real estate agent and, just a few minutes into the conversation, you talk about price range, neighbourhood, schools, proximity to work, financing and down payment. These are all big picture, outside-the-home issues. Once you settled on the broad outside-the-home issues then, and only then, does it make sense to begin discussing the detailed inside-the-home issues, such as room size, carpet and tile selection, lighting, etc. Good estate agents discover what the suitability factors of home buying are (price, down payment, monthly payments, location, etc.) before they get into the inside details. In other words, the flow of conversation is outside-in.

Now imagine you and your spouse go to the estate agent, but this time she is a former dentist and uses the traditional inside-out process she used as a dentist. As soon as you sit down she begins educating you on the inside-the-house issues—the difference between cement slabs versus crawl space foundations and vinyl siding versus brick exteriors. She goes as far to recommend another appointment with her so she can show you how to keep your house clean before you buy one. She does all this before she has any idea of what you can afford and where you want to live. What would you think? You would think about finding another estate agent, would you not?

How many of your complex-care patients, after experiencing your inside-out process, find another dentist for the most likely reason that you spent a bunch of time educating them on inside-the-mouth details before you had any idea what was suitable for them? You educated them right out your door.

An outside-in process works best for complex-care patients. Here patient education is not the driver of case acceptance. This is why: first, patients with complex needs often come into your office with a specific complaint—embarrassment about their appearance, aggravation by their dentures or fear of losing their teeth. They do not need to be educated about their chief complaint. They may not be aware of all their conditions, but it is most likely that they have lived with the complaint that brought them into your office for a long time.

Next, many complex-care patients have heard the patient education lecture about plaque, pockets and sugar many times before. It’s old news and thus not a subject that distinguishes you. For many patients, patient education efforts bounce off like BB’s fired at icebergs. Expecting to influence them into a US$10,000 treatment plan that does not fit into their budget by showing them how to floss well is naïveté.
Let me be clear at this point: we are going to spend some time on the patient education process with complex-care patients, it is just not one of the first conversations we will have.

The first conversations we will have with complex-care patients are about discovering outside-the-mouth issues—just like the suitability conversation with the estate agent. The outside-the-mouth issues of budget, time, work schedule, health issues are what I call fit issues. These are the issues into which your treatment plan must fit. Become good at discussing fit issues and you will save an incredible amount of time, you will sell much more dentistry and you will no longer blow patients out of the water—and out of your practice.

_Fit versus change_

The earlier influencers in my dental career emphasized that a significant part of being a good dentist is to get patients to change. Change the way they clean their teeth, change what they eat and change the priorities in their life and put dental health at the top. It took me ten years and thousands of patients to realize that patients change when they are ready, not when I tell them to.

I learned to replace the concept of change with the concept of fit. Instead of telling patients they need to change to accommodate my treatment plan, I learned to accommodate my treatment plan to fit their life situation. Patients, especially the more mature, complex-care patients, have complex fit issues. These include finances, family hassles, work schedules, special current events, travel, stressors, health factors, significant emotional issues; in short, any issues dominating the patient’s energy and attention. When you present complex-care dentistry, it has to fit into the patient’s life.

Think about it. If you offer most patients a US$10,000 treatment plan, something in their life has to happen. People need to wait to receive their tax refund, wait for a child to graduate from college, become more settled in their new job, or take a much-needed vacation. Knowing the manner in which your complex-care treatment plans fit into the current or foreseeable circumstances of your patient’s life is a mandatory skill for practising complex-care dentistry. Without fit, there is no case acceptance, regardless of the level of dental IQ or your zeal for patient education.

_Discovering fit issues_

Your team often knows what is going on in the patient’s life. How do they know? They talk—they chit-chat with the patients and they make friends. Another purpose of chit-chat is to learn about those fit issues in your patient’s life impacting their treatment decision. When chit-chat is intentional, I call it fit-chat—an indirect way of discovering patient fit issues.

When you fit-chat, be curious and listen more than talk. Listen to the manner in which patients spend their time and what’s creating stress in their life—health, money and/or family issues. If they mention something you believe may influence a treatment decision, be curious, listen attentively and encourage them to talk more about it. Through indirect fit-chat, you’re going to discover what’s going on in patients’ lives.

Some patients do not fit-chat well. They are simply not talkers. I am that way. When I get my hair cut, the last thing I want is a chatty experience. When you have a complex-care patient who will not fit-chat, you can try a more direct approach to discovering fit issues.

Here is an example of a direct approach: “Kevin, I know from the line of work you are in that you are busy and travel quite a bit. I also know you are aggravated by food trapping around your lower partial denture. Let’s talk about your choices and how we can best fit your dentistry into what is going on in your life. Is now a good time to talk about this?”

Here is another example of a direct approach: “Kevin, most people like you are busy, on-the-go and have lots of irons in the fire. I need to know if any of these irons are affecting the amount of stress you are under, the amount of time you can spend...
here with us, or if there are financial issues I need to consider when planning your care. I want to reassure you that I am very good at helping patients fit their dentistry into what is going on in their life.

Whether you are using an indirect fit-chat or a direct approach to discovering fit issues, an absolute prerequisite to a comfortable conversation is for you to have a connected communication style. This means you hold good eye contact, listen carefully and patiently; you maintain a conversational tone of voice and your speaking rate is relaxed. Be sure to pause long enough to let what you are saying sink in.

If you attempt to use a direct approach to fit issues but have a disconnected style (do not look the patient in the eye, speak too quickly, do not listen attentively), your conversation may be perceived as being inappropriate, unprofessional and seeking to diagnose their pocketbook sneakily.

Advocacy

Advocacy is the experience of patients when they realise that you are guiding them towards and not selling them into dental health. To be an advocate is to be a guide. To guide patients into complex care effectively you need to take the fit circumstances of their life into account and help them find a way to fix their teeth in light of those circumstances. This may mean fixing their teeth now, later, or over time.

Here is something you say that propels the advocacy experience. It occurs after the examination, but before any detailed conversation about clinical findings. Here is where you link the fit issues you discovered to your clinical findings.

"Kevin, now that I have looked at your teeth, I know I can help you. We treat many patients like you with partial dentures that do not work well. I know I can help. What I do not know is whether this is the right time for you. You mentioned you travel a lot and your company is in the middle of a big reorganisation. Do you go ahead with your treatment now? Do we wait until later? Or do we do it over time? Help me understand how I can best fit your treatment into everything that is going on in your life."

This advocacy statement leads to a conversation about the patient's fit issues. This conversation reveals what treatment fits and what does not. You will find that this approach results in many complex-care patients doing their treatment over time, allowing them to stay within the limitations of their fit issues. This is a good thing. I would rather treat two patients for US$5,000 each than no patients for US$10,000. It also yields lifetime patients for you. Patients will exhibit fierce loyalty to you when they experience advocacy.

The decision to educate

The decision when to educate and when to advocate is situational. Figure 3 demonstrates that the impact of patient education on case acceptance is highest when the complexity of the care (and its associated fee) is minimal. Patient education is the driver of case acceptance when a patient's conditions and fees are minimal. However, when the complexity of care increases, the role of advocacy takes over. Advocacy is the driver of case acceptance when the patient's conditions are complex and fees are high. Copy Figure 3 and keep it in area where you will see it often. Then, right before you go into case presentation, look at it and ask yourself: does this patient need education or advocacy? Let the situation guide you. When you do, you will discover how to keep from educating your patients out the door.

about the author

Dr Paul Homoly is a world-class leader in dental education. As a comprehensive, restorative dentist and acclaimed educator for over 25 years, he is known for his innovative and practical approach to dentistry. Dr Homoly is now offering YES! On-Line as the solution for dentists and their teams to excel at case acceptance. This on-line, seven-module curriculum, which is supported by a matching set of DVDs, takes your dental team step-by-step through the essential dental team-patient conversations, and has proven successful for over 30 years.

Distinguished by his focus on outcomes, Dr Homoly is legendary for his ability to teach and lead in a practical and engaging manner. For more information, visit www.paulhomoly.com or call Homoly Communications at +1 800 294 9370.
Undoubtedly, digital volume tomography has significantly expanded the range of dental imaging diagnostics. Just as Paatero ushered in a new era of dental radiology at the end of the 1950s with the development of the orthopantomograph and the resulting introduction of panoramic view imaging, 3-D processes will, in turn, replace panoramic view imaging.

Although digital volume tomography has to date been mostly used for pre-implantological planning and in reconstructive surgery, now other dental disciplines are beginning to appreciate the value of this process. It is in orthodontics, endodontics, dental surgery and periodontics that digital volume tomography represents a significant improvement of the possibilities of imaging processes. Its significance in the current domain, pre-implantological diagnostics, can be assessed as even greater.

Available digital volume tomographs

Digital volume tomographs (DVTs) have been on the market for a good decade, and the number of suppliers of such devices has increased dramatically. When observing the device market, two clear trends are evident: the trend towards an all-in-one device (also called dual use) and the trend towards DVTs of various volumes.

All-in-one devices

In addition to offering 3-D diagnostics, the majority of DVTs available on the market also provide the option of producing panoramic view images (real images, not reconstructed from a data record) and sometimes even lateral cephalogram. These devices thus cover the entire range of dental large-scale diagnostics—in contrast with the first generation, which only offered the DVT option.

The DVTs of today’s generation are often similar in design and appearance to traditional DVTs. The position of the patient with these and other frame devices is typically standing or sitting, while the once dominant supine patient position of the first-generation device is passé, except for that required by one DVT manufacturer.

Various volumes

The first-generation devices featured very large volumes that required time-consuming reworking.

Authors

Dr Georg Bach, Christian Müller & Alexander Rottler, Germany
of the immense data record for problems beyond large and reconstructive surgery in order to be able to evaluate the relevant data and/or regions in a target-oriented manner. Today, numerous manufacturers offer devices with small and medium-sized volumes. Three types of devices are available:

- **small volume (4 x 5 cm)** for oral surgery and dental procedures;
- **medium-sized volume (8 x 10 cm and higher)** for oral surgery and reconstructive surgery; and
- **large volume (18 x 20 cm and higher)** for oral surgery and reconstructive surgery.

**Problems with small and medium-sized volume devices**

Small- and medium-sized volume devices are generally used for pre-implantological diagnostics, oral surgery, and orthodontic and endodontic procedures. The limited volume size requires careful device setting and patient

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case report 3-D diagnostics

positioning so that the relevant structure is accurately captured.

For new users and those who only take volume tomograms once in a while, this correct setting can pose difficulties, which was our motivation for developing a DVT phantom that can be used for training purposes and for direct preparation of an image with a patient.

The DVT phantom and its application

The DVT phantom is an X-ray phantom that depicts a medium-sized mandibular and maxillary dental arch with the teeth positioned in ideal denticulation.

The phantom, which consists of a mandible and maxilla, is mounted on the individual bite or positioning support of the respective device. Barium sulphate is added to the plastic teeth so that they are visible in the X-ray image. These teeth are made by the manufacturer especially for X-ray applications. The DVT platform is then mounted on the device with the original bite support instead of a patient. The device setting can be done in two different ways:

a) The desired volume is preset using the device programme and then manually fine-tuned.
b) The device is manually set directly upon the region to be captured with the aid of the light visors.

Thereafter, the set positioning is saved.

Using the DVT phantom for training and practice

With the aid of the DVT phantom and the above-mentioned setting techniques, new users, who are training to become dentists or dental technicians, can learn how to set the device for the regions to be examined, generate one or more individual images using the preview function and check whether the setting was correct. In the event of incorrect settings, a better image can immediately be generated. In this manner, there is a direct learning curve.

Using the DVT phantom for preparing a patient image

Time-consuming and tedious setting (aiming) of the DVT on a patient who is already in the device is likely to be uncomfortable for the patient. This is where presetting the device with the aid of the DVT phantom comes in handy. The desired region is captured with the aid of the DVT phantom and, if needed, is checked with the preview function. Then, the phantom is removed and the patient is positioned in the device. Generally, only one device setting for the patient's body size and small fine-tuning are required before the image is set.

How to obtain a DVT phantom

A DVT phantom can be produced in cooperation with practising dental technicians. The plastic teeth containing barium sulphate are available on the market and a phantom can be made in the manner described above. An easier option is to send a DVT positioning aid of your device to dtcmfreiburg@aol.com or through www.dtcmfreiburg.de. Master Dental Technician Christian Müller will then mount a prepared DVT phantom on your positioning aid. Industrially manufactured plastic teeth containing barium sulphate (SR Vivo Tac/SR Ortho Tac, Ivoclar Vivadent) will be used, which are then incorporated into a mandibular and maxillary model made of transparent plastic.

We hope that the fascinating field of 3-D diagnostics will establish itself quickly in dentistry and remain an imaging procedure that significantly expands upon the hitherto range of dental X-ray diagnostics in the long term.

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Galip Gürel, Dentist, Turkey.

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The treatment of toothless jaws—A case for CAD/CAM

Author: Dr Sven Rinke, Germany

**Fig. 1** Subjective and objective prosthetic success criteria.

Various prosthetic concepts have established themselves for the fitting of superstructures according to the number of inserted implants. Generally, there is either a fixed denture mounted on six to eight implants and borne by these only, or a removable denture with a reduced number of implants.

The selection of a suitable denture depends on subjective criteria—patient expectations, financial constraints—and on clinical aspects—anatomic criteria, technical and clinical reliability of implants and superstructure. Accordingly, the success of the prostheses depends on the following factors (Fig. 1):

- **Subjective criteria** (patient satisfaction and quality of life);
- **Objective criteria** (probability of survival); and
- **Necessary maintenance effort** during the lifetime of the denture.

**Criteria for the selection of the type of denture**

Fixed, as well as removable implant-prosthetic dentures in the toothless jaw, as opposed to the conventional full denture, have proven to significantly increase patients’ satisfaction and improve their ability to chew. Hence, the insertion of two to four implants can lead to a clear improvement of quality of life. Therefore, the removable implant-supported and implant-retained cover denture prosthesis is nowadays considered an effective therapy.

However, there was also evidence that, in particular, the choice of fitting elements in a removable denture, for example magnets, ball-heads, bridges and telescopes, has an influence on patient satisfaction. With respect to stability and retention power, as well as achievable patient satisfaction, a comparative cross-over study demonstrated that magnets are inferior to the fitting with ball-heads. A comparison of ball-head elements and overdenture attachments used for the fitting of an implant-retained cover denture prosthesis did not demonstrate any differences with regard to patient satisfaction. However, there proved to be a significant difference in the rate of technical complications.

Within an observation period of three years, prostheses fitted with ball-heads required 6.7 repairs, whereas the group of bridge-fitted prostheses required 0.8 repairs per patient only. Hence, overdenture attachments as fitting elements for removable superstructures guarantee high patient satisfaction. Owing to their low rate of technical complications, they require less maintenance than alternative fitting elements, which is an important criterion for the long-term success of the prosthesis.

High maintenance requirements demand more practice visits and take the time of both the patient and the care provider. Furthermore, if there are technical complications that have led to the failure of superstructure elements, an intervention by a dental technician might be necessary to reconstruct or replace individual components. This is also connected with additional costs in order to maintain function.

When evaluating overdenture attachment constructions as fitting means, the various types and forms available must be considered. On the one hand,
there are individually shaped bar attachments, and on the other hand, there is the classic round bar, which can be manufactured either by casting or by combination of pre-fabricated elements.

The overdenture attachment fitted on four implants is a classic fitting element for a purely implant-supported cover denture prosthesis in a toothless upper or lower jaw. A retrospective study with 51 patients compared individually shaped bar attachments and round bars for the fitting of cover denture prostheses. Twenty-six patients were equipped with round bars, while 25 patients received a superstructure with an individual bar attachment on four implants each. After a surveillance period of five years, the survival rate of the implants was 100%. Larger technical complications that required a renewal of the mounting elements occurred in the round bars only in the form of fractures in the extension areas. The fractures on the extensions of the overdenture attachments, which were exposed to high mechanical stress, were due either to porosities in the cast object or to inhomogeneities in the area of the points of attachment. Furthermore, it was determined that low-grade complications (activation of hanks) occurred three times as often in the round bars as in the bar attachments. Thus, two causes of defects can be deduced: firstly, defects due to faults in the manufacturing technique (casting and joining processes); and secondly, defects causatively connected with the design of the superstructure.

Two versions are described in the literature for the fitting of attachments in the toothless upper jaw: the fitting of attachments on four implants in the anterior segment and the fitting of two attachments on three to four implants on the lateral segments (mostly after a previous sinus floor augmentation). Additionally, for the application of attachments in the toothless upper jaw, data from clinical studies has been published. Both attachment concepts featured almost identical survival rates after five years: 98.4% for the attachments in the anterior segment and 97.4% for the attachments fitted on six to eight implants in the lateral segments of the upper jaw.

In particular, fitting by bar attachments appears to be a therapeutic means with guaranteed success of the fitting of purely implant-supported cover denture prostheses in the upper and lower jaw. It excels with a low rate of technical complications, as well as low maintenance requirements. Hence, bar attachments constitute clinically tested fitting elements for implant-retained and implant-fitted removable superstructures in the toothless upper and lower jaws. No clinical data for the fitting of removable superstructures in the toothless upper jaw for magnets and for ball-head attachments is available. Additionally, the application of so-called locators for the fitting of removable implant superstructures cannot be considered to be based on evidence, according to the currently available data. To date, no results of clinical studies have been presented for this fitting element.

Telescopes as fitting elements for removable superstructures are popular particularly in the German-speaking countries, as they are very hygienic and easy to expand. However, these advantages are offset by the high technical requirements and costs. Clinical studies on the suitability of double crowns as fitting elements in implant prostheses demonstrate that they are generally suitable and they point out the advantage of combining the natural teeth with implants for the fitting of a removable construction, as opposed to attachments.

Fig. 2, Fracture of a bar attachment construction manufactured by casting in the area of the extension.
Fig. 3, Casting of the implants in the pick-up technique with a high strength casting material.
Fig. 4, Tooth arrangement produced on the work model.
Fig. 5, Virtual construction of the bar attachment construction with distal attachments.
Optimising the manufacturing technology

Despite the high and well-documented survival rates of attachment constructions, the question arises as to whether the strategies can be further optimised in order to avoid defects attributable to the technique. The traditional way of manufacturing attachment constructions is by casting. However, the larger the cast object, the more difficulties arise in terms of porosity and warpage, which increase the risk of mechanical failure and impair the proper fit (Fig. 2).10

Relatively early on, the well-known casting problems led to the establishment of alternative techniques. The application of pre-fabricated implant components, which were then joined by means of soldering or laser welding, was one way to improve the fit. However, with large constructions in particular, this procedure has the disadvantage of very time-consuming manual post-processing. Furthermore, there is the risk that the mechanical ability to cope with pressure may be reduced in the area of the joining point.

From an economical point of view, it would make sense to use largely bio-compatible material of sufficient mechanical strength for manufacture, such as pure titanium or a Co-Cr alloy. However, the processing of such alternative materials does not provide a sufficiently exact fit with the current casting techniques. In vitro examinations of cast implant superstructures made of non-metallic materials showed gaps of 200 to 300 µm between the superstructure and the implant arrangement.11 Compared to this, cast structures made of noble metals featured median gap widths of 40 to 50 µm.12 The use of alternative materials therefore requires an alternative processing technology in order to achieve the necessary precision. In the ideal case, the superstructure is cut from a prefabricated solid material in order to safely exclude inhomogeneities.

With this in mind, the manufacture of superstructures with cutting technological means utilising the computerised numerical control (CNC) process began more than ten years ago. In vitro examinations using this CAM technology demonstrated that the precision achievable in such constructions, with median gap widths between 20 and 30 µm, is better than the accuracy of fit achieved with cast frames made of noble metals.12 Modern scanning and software technology allows expansion of this manufacturing principle to virtual construction. Hence, the already well-known process of CNC cutting is supplemented with the option of a purely virtual construction. Several manufacturers offer this technology, for example Compartis ISUS (DeguDent).

Case presentation

The manufacturing process of an attachment utilising the Compartis ISUS system is documented below. After exposure of the implants, the next appointment was devoted, as usual, to making a casting with impression material that has a high final hardness and hence guarantees a secure fixing of the casting posts (for example, Impregum, 3M ESPE; Monopren transfer, Kettenbach Dental; Fig. 3).

In the ideal case, the casting appointment would entail the determination of the jaw relations and a casting for the model of the opposing jaw. After that, the work model is manufactured with the help of a removable gingiva mask in the area of the implants. When the first check-bite is taken, a first provisional model can be mounted immediately. Based on this working material, a tooth arrangement is prepared from plastic. It is useful if the information about the colour and the shapes of the teeth is already available during this work step (Fig. 4).

The tooth arrangement can be tried on at the next appointment and corrected if needed. The exact jaw relations can thus be determined and sufficient information will be collected for the definitive tooth arrangement. At this appointment, the precision of the casting should also be checked with a transfer jig. For this jig, the posts on the work model can be blocked with plastic and a metal reinforcement.
The jig must then fit onto the implants in the mouth without causing tension or shifting around. For the exact determination of the accuracy of the casting fit, it is advisable to perform the Sheffield Test. A screw is mounted and fastened on the post on one side of the distal implant. When fastening the screw, the transfer jig must not lift off the other implants. Furthermore, there must not be any gaps. If the screw can be fastened without making the transfer jig move, it can be concluded that the impression has exactly copied the situation in the mouth. In case of a negative result, a transfer defect can be assumed. In this case, the transfer jig should be separated and all posts should be fastened with screws so that a new impression casting can be taken.

Once an exact impression has been secured and the tooth arrangement has been adjusted, the CAD/CAM manufacture of the superstructure can begin. First, the work model and the tooth arrangement are sent to a Compartis ISUS Planning Centre. There, the virtual construction of the attachment is made according to the specifications of the dentist(s) and dental technician(s). In the present case, a bar attachment construction made of titanium with distal attachments (Preci-Vertix, CEKA) was chosen.

The tooth arrangement determines the space available for the superstructure and alignment towards the chewing area. This information then constitutes the foundation for CAD of the superstructure, the CAD process. For this purpose, special scan posts are initially screwed onto the implants, in order to determine the position of the implants with a first scan. Then, a second scan is done with the wax arrangement, in order to determine the available space and the orientation of the superstructure.

Thereafter, the desired superstructure is designed with the help of special software. This constitutes the basis for the manufacture of the superstructure utilising the CNC process (Fig. 5).

Dental technicians and care providers will then receive the construction suggestion of the Compartis ISUS Planning Centre by e-mail with a request for release or for advice regarding changes. As soon as the release is obtained, the manufacture of the attachment begins. The Compartis ISUS system uses modern cutting machines and special cutting strategies and ensures perfect quality of the surfaces, rendering manual post-processing dispensable (Fig. 6).

The dental laboratory can now commence with the fabrication of the secondary construction. In the present case, a secondary structure was initially made by means of electroplating (Solaris, DeguDent) and the plastic matrix for the Preci-Vertix retaining elements was incorporated. Thereafter, a cast tertiary structure was made of a Co-Cr alloy and bonded with the galvanoplastic structure. The superstructure was completed using the existing tooth arrangement (Fig. 7). Several in vitro examinations have proven the excellent accuracy of fit in these CAD/CAM-manufactured constructions (Fig. 8). In a comparison of five different techniques for the manufacture of implant superstructures, the CAD/CAM structures demonstrated a median accuracy of fit of 25 µm, while cast structures had median gap widths of 78 µm.\textsuperscript{13}

However, the advantage of the CAD/CAM technology is not only the highly precise manufacture of superstructures made of pure titanium and Co-Cr alloys, but also its applicability to a broad range of indications. Starting from the scan data, virtual construction allows for a wide range of variations in terms of various forms of superstructures, from the simple round bar to retaining element attachments or to a bridge frame for fixed constructions. With a CAD/CAM system, it is also possible to virtually incorporate active holding elements such as extra-coronal retaining joints, bars and press buttons.

In summary, it can be said that CAD/CAM technology is also ideal for the processing of alternative materials on titanium and non-precious metal basis. It provides the following advantages:

- high mechanical resilience due to homogeneous pore-free materials;
- tension-free fit due to precise CNC-manufacturing technology; and
- suitability for a large width of indications due to individual CAD.

The integration of virtual design supplements the trusted manufacturing technology based on cutting and hence opens up possibilities for new indications for alternative materials in implant prosthetics.\textsuperscript{12}

Editorial note: A complete list of references is available from the publisher.
In the following case, the CEREC 3D system and its one appointment capabilities played an essential part in the treatment. The patient suffered from facial myalgia and could not handle a repeat visit for a second try in insert, owing to the potential stress it would cause. She had previously experienced involuntary facial episodes—the drill had been bitten on—causing more trauma.

The patient had broken tooth #31 at the gumline. The rest of the tooth had been removed some time ago, leaving a gap. All treatment options were explained to her. We offered her a same-day ceramic bridge and informed her that this would be entirely experimental, even though I have made many of these types of full contour bridges.

Dr Carl Boyko, Welcome Smile Dental (Calgary, Canada), and I created the bridge. Firstly, Dr Boyko measured the span of the area that needed to be bridged. Once measured, we discovered that the area could support an I-14 TriLuxe Forte (VITA), which would be used to manufacture the bridge.

Dr Boyko then prepared the tooth #41 and 32 abutments. Following, he created a temporary bridge that would be used by the CEREC system as a temporary reference. Simultaneously, we measured the shade of the surrounding teeth (Fig. 1).

The patient did not wish for her lower teeth to be straightened, and therefore our goal was to restore her original smile. She felt that this would be a more natural result and did not wish the aesthetics to be obvious when she smiled.

Once the temporary bridge had been put in place, the temporaries were coated with titanium-dioxide powder. This creates a reflective surface that allows the CEREC 3D Bluecam to capture the optical impressions of the preoperative (occlusion) images. Once the temporary reference images had been captured, the patient was asked to smile. This is to ensure that the microscope images capture the full smile for the final restoration. The patient was then instructed to close completely to provide a reference occlusal plane.

Once the patient’s smile was captured, the temporary reference images were transferred to the CEREC 3D system. The images were then used to create a full contour bridge. The bridge was then tried in and the final impressions were taken. Once the final impressions were taken, the bridge was then ordered.

The patient was then asked to return to the dental office to try in the final bridge. Once the patient was satisfied with the final bridge, the bridge was cemented.

Three-unit, full-contour ceramic bridge in one sitting

Author: Chris Leinweber, Canada
captured, the temporary was removed and titanium dioxide was sprayed onto the abutments once again. We then used the CEREC Bluecam to capture the abutments (Fig. 2).

The bridge we wanted to copy virtually overlapped the prepared model. The gold colour model underneath was the original prepared image and the grey image on top was the correlation model. It was evident that the model matched from the speckled look to the grey model, as it perfectly overlapped the prepared model. We need this kind of speckled look to occur because there is a 20° pitch and roll and yaw of the camera in order to match up the images. Although the CEREC software merges the images this does not mean that the images will correlate 100%. The correlation may thus be reduced even though we have a virtual model (Fig. 3).

When using the correlation design technique, one can draw the margin starting with any one of the abutments. Simply start to draw the margin close to the interproximal. As one draws around the preparation, do not close the loop on the preparation on which you started. Continue to draw the margin out onto the tissue, thus creating a second margin on the imaginary pontic area. Continue on to the next abutment, draw around the next abutment, then continue back onto the tissue to continue the lingual margin of the pontic. Finally, join the rest of the margin to the original abutment to close the loop. Once the loop has been completed, one can carry on to the next window. In this way, we fool the CEREC software into thinking this pontic loop is one crown (Fig. 4).

Figure 5 shows our completed bridge that was milled using the VITA Forte block, which is not a plain monochromatic block. The final result will have a natural gradient built into it when completed, as it is has four colour steps to it (Fig. 5).

In order to achieve the proper shading for our ceramic, I used Quick Match (Hankins Laboratories), which can be used to mimic the stump shade value of the abutments (Fig. 6). Next, I used the Ivoclar Stump Shade Guide to match the shade tab to the appropriate colour on the Quick Match syringe. I injected the fireable stump shade material into the bridge abutments. Once the Quick Match had been injected, I started applying the glaze. The glaze turned the ceramic into a window showing us the internal core value. This makes staining the ceramics an easy process once firing is completed. The process can be repeated should more stain be required (Fig. 7).

I personally find that using the Quick Match product not only creates the right stump shade value, but is also great to use when firing small abutments that will not fit a peg (Fig. 8).

The final result is a bridge that is virtually indistinguishable from the original. This was all completed in a two-hour visit and the patient was very pleased with the final result. In this particular scenario, I was not worried about the bridge failing because of the size of the connectors. I know that using a feldspathic ceramic is not the number one choice; however, the amount of load on the anterior will not be such that the bridge will fail (Fig. 9).
**Real-virtual modelling of CEREC temporary crowns: A new approach**

**Authors**_ Dr Mikhail Antonik, Dr Mikhail Murashov & Dr Natalya Muraviova, Russia

The creation of a functional occlusion is the goal of any prosthetic treatment and can be very difficult to achieve in cases of full-mouth rehabilitation, especially in the case of temporomandibular joint (TMJ) dysfunction. In these clinical situations, provisional restorations are an excellent diagnostic instrument. Aesthetics, phonetics and function, after evaluation and acceptance by the patient after try-in of the provisional restorations, should be accurately transferred to the final restorations to ensure the same clinical success.¹²

The aim of this study is to demonstrate the manner in which individual movement characteristics of a patient’s TMJ can be included in traditional CEREC temporary crown fabrication. New occlusal relations need to be created with respect to the individual characteristics, such as mandibular and hinge axis positions, Bennett and sagittal angles. The incorporation of occlusal plane formation principles is essential to improve and ease a patient’s adaptation to new occlusal relations, as well as to reduce the probability of TMJ dysfunction. However, CEREC software does not enable the inclusion of TMJ parameters.

Following, we describe a technique that enables the fabrication of temporary CEREC restorations with respect to a patient’s TMJ parameters.
Step I: Electronic axiography and lateral X-rays

Computer analysis of jaw movements with electronic axiography is useful for determining the joint parameters (Fig. 1). Using mechanical tracing, axiography enables the collection of data on a patient’s TMJ, such as curve and inclination of the condylar path, mouth opening, Bennett and sagittal angles, mandibular protrusion and course of the mediotrusive tracks. Lateral X-rays provide data on movement by including the condylar tracks (Figs. 2a & b).

Step II: Slavicek analysis

We used CADIAX (Gamma Dental) to analyse the X-rays in detail (Fig. 3). Here, the distances, spaces and tooth relations are of considerable importance. The vertical dimension and the special position of the occlusal plane, the Spee’s curve and the various occlusal tables of the laterals were determined. In the lateral X-ray, we paid particular attention to the occlusion tables of the molars, especially tooth #6.

Step III: Partial wax-up

A partial wax-up of the individual occlusal surface was modelled on the master casts with respect to the TMJ angles and occlusal pattern of sequential functional guidance occlusion with canine dominance (Figs. 4 & 5).

Step IV: Scanning

The partial wax-up was scanned and combined with the virtual images of the teeth stumps and virtual restorations from the CEREC software database. Thus, we were able to easily control the form, cusp position and inclination of the teeth with respect to individual TMJ movement characteristics and peculiarities of the facial skeleton. We used the diagnostic display with display options for virtual modelling using CEREC software (Fig. 6).

Step V: Milling

The temporary restorations were traditionally milled (Fig. 7).

Conclusion

The method of real-virtual modelling described in this article enables us to guide the anatomical form of restorations using wax reference points with respect to the dynamic TMJ parameters of the patient. The method is a combination of a partial wax-up in the articulator and virtual computer modelling. With CEREC software, we are able to create temporary restorations with respect to individual jaw movements.

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

about the authors

Dr Mikhail Antonik, Dr Mikhail Murashov and Dr Natalya Muraviova from the Moscow State University of Medicine and Dentistry in Russia can be contacted at mmurashov@yahoo.com.
Imagine a technology that brings the most detailed knowledge of the patient’s dental anatomy and greater treatment predictability right into the dental office. A good imagination is no longer necessary to achieve this goal. That technology, CBCT imaging, is not just a dental daydream but also a reality every day in many dental offices nationally and internationally. Three-dimensional technology is already redefining dental outcomes across a broad spectrum of treatment options, including implants, bone grafting, oral surgery, orthodontics and endodontics. The ability to capture a 3-D image of the mouth and to view it from all angles, together with the capability of rotating that 3-D mode and zooming in on details, can only result in more effective dental treatment.

With cone beam, all of the information can be coordinated for integration with other applications, such as guided implant placement software or CAD/CAM. Since the i-CAT and the GXCB-500 capture scans in DICOM format, clinicians can combine this high-resolution data with digital 3-D impression scan data to perform restorative-driven implant planning and take advantage of CAD/CAM milling (Fig. 1). Software navigates the clinician through the planning process using virtual implants. CAD/CAM yields a surgical guide that ensures the plan translates into precise placement of the actual implants and facilitates final implant restoration milling. Pairing these two technologies ultimately reduces the risk of poorly placed implants.

Dentists who have already implemented 3-D technology are seeing results, from more proficient diagnosis to more defined treatment planning and increased case acceptance. CAD/CAM spoke to Dr Steven Guttenberg, owner of i-CAT, and Dr John Flucke, owner of GXCB-500 HD, who share their experiences on how CBCT is helping to change the face of dentistry across a wide range of procedures.

Fig. 1. Proficient technology: Restorative-driven implant planning.
being looked upon with curiosity, but now it is becoming the standard of care for dental radiography. Education in the possibilities that 3-D imaging brings to the practice is invaluable.

While 2-D still has its place in the dental practice, many patients need more for optimal care. Change is not easy, but it is necessary to change, to move forward and to provide patient care in a better manner. Three-dimensional imaging is definitely a paradigm shift, letting dental professionals see the same information in an entirely different way. Nothing else really describes what is going on here.

What do you tell general practitioners who may feel intimidated by this technology?

Dr Flucke: That question is exactly the reason that I entitled my seminar Scrabble and Alphabet Soup—Bringing Simplicity to Cone-Beam Technology. There is a lot of hesitation on the part of some general dentists that cone beam is just for the realm of the specialist or the dental school. When faced with acronyms such as CBCT, cone-beam computerised tomography, or terms such as voxel, the 3-D equivalent of a pixel, they get intimidated by the mishmash of initials and unfamiliar words. They just want an X-ray.

After becoming educated about 3-D imaging, they realise that it is not as intimidating as they first expected. I am not an electrical engineer or radiologist; I am just a dentist who uses 3-D cone beam to improve patient care, and that is why it is important to hear about this technology from people like me. Far more important than the Scrabble and alphabet soup, imaging is all about providing the best possible outcome for the patient.

Can you share a case from your own practice?

Dr Flucke: There are so many cases, but this case in particular was very satisfying. A new patient arrived at my practice eight months after seeing her previous dentist, who she had seen for the past ten years. The patient had always been diligent, almost fanatical, about her dental health, but was two months overdue for a cleaning.

We took a CBCT scan and found an undetected cyst growing in the mandible almost to the point of causing a fracture of the mandible (Fig. 3). When we pointed this out, the patient responded, "Maybe that is why my lip goes numb sometimes, and I get these shooting pains in my jaw."

While the patient wondered why, even throughout her regular visits to the dentist this condition went undiagnosed, I recognised that the previous dentist was not really at fault. The dentist had been taking the necessary required radiographs over the years, 20 film 2-D surveys, but this patient needed more. Because of the various options in viewing 3-D technology, I sent the scan out to a radiologist and subsequently referred the patient to an oral surgeon. The CBCT showed that as the cyst grew, it was putting pressure on the nerve, causing the pain and numbness.

Four different outcomes were possible for this condition, and two could have either been life-altering or life-threatening. Fortunately, the situation turned out to be benign, necessitating some extractions and bone grafting. Afterward, the patient asked, "Why did I go somewhere else for ten years, and the dentist never saw this, when you found this after ten minutes?" It was all thanks to CBCT.

What is your main message to dentists contemplating implementation of CBCT?

Dr Flucke: I’m a general dentist. I use and believe in this technology. I have seen so many scans that have changed the course of treatment or provided the missing information for difficult diagnoses. By being a speaker at the International Congress on 3-D Dental Imaging, this is what I want people to know: Don’t be afraid to use 3-D imaging. Use it because it is the smart and the best thing to do. The end game is making the lives of our patients better and cone-beam 3-D imaging is the best way to do that.

Dr Guttenberg: To say it with George Bernard Shaw’s words: "Progress is impossible without change, and those who cannot change their minds cannot change anything."
Two-dimensional imaging modalities have been used in dentistry since the first intra-oral radiograph was taken in 1896. Significant progress in dental imaging techniques has since been made, including panoramic imaging and tomography, which enable reduced radiation and faster processing times. However, the imaging geometry has not changed with these commonly used intra-oral and panoramic technologies.

Cone-beam computed tomography (CBCT) is a new medical imaging technique that generates 3-D images at a lower cost and absorbed dose compared with conventional computed tomography (CT). This imaging technique is based on a cone-shaped X-ray beam centred on a 2-D detector that performs one rotation around the object, producing a series of 2-D images. These images are re-constructed in 3-D using a modification of the original cone-beam algorithm developed by Feldkamp et al. in 1984. Images of the craniofacial region are often collected with a higher resolution than those collected with a conventional CT. In addition, the new systems are more practical, as they come in smaller sizes.

Today, much attention is focused on the clinical applications—diagnosis, treatment and follow-up—of CBCT in the various dental disciplines. The goal of the following systemic review is to review the available clinical and scientific literature pertaining to different clinical application of CBCT in the dental practice.

Materials and methods

Clinical and scientific literature discussing CBCT imaging in dental clinical applications was reviewed. A MEDLINE (PubMed) search from 1 January 1998 to 15 July 2010 was conducted. Cone-beam computed tomography in dentistry was used as key phrase to extend the search to all the various dental disciplines. The search revealed 540 papers that were screened in detail. Owing to a lack of relevance to the subject, 406 papers were excluded. Thus, the systemic review consisted of 134 clinically relevant papers, which were analysed and categorised (Table I).

Analysis

Oral and maxillofacial surgery

CBCT enables the analysis of jaw pathology,3–11 the assessment of impacted teeth (Fig. 1), supernumerary teeth and their relation to vital structures,6,12–21 changes in the cortical and trabecular bone related to bisphosphonate-associated osteonecrosis of the jaw5,22–23 and the assessment of bone grafts.24 It is also helpful in analysing and assessing paranasal sinuses6,25 and obstructive sleep apnea.27–28

As the images are collected from many different 2-D slices, the system has proven its superiority in overcoming superimpositions and calculating surface distances.26–29 This advantage made it the technique of choice in mid-face fracture cases,30–31 orbital fracture assessment and management22 and for inter-operative visualisation of the facial bones after fracture.32–34 Since it is not a magnetic resonance technique, it is the best option for intra-operative navigation during procedures, including gun-shot wounds.35–36
CBCT is largely used in orthognathic surgery planning when facial orthomorphic surgery is indicated that requires detailed visualisation of the inter-occlusal relationship in order to augment the 3-D virtual skull model with a detailed dental surface. With the aid of advanced software, CBCT facilitates the visualisation of soft tissue to allow for control of post-treatment aesthetics, for example in cleft palate cases to evaluate lip and palate bony depressions.27–42

Research is underway to assess its ability to detect salivary gland defects.43 Honda et al.44 describe a clinical case in which the time needed to complete a tooth auto-transplant case was significantly shortened owing to the application of CBCT.

Endodontics

CBCT is a very useful tool in diagnosing apical lesions (Figs. 2a & b).21,45–56 A number of studies have demonstrated its ability to enable a differential diagnosis of apical lesions by measuring the density from the contrasted images of these lesions, in whether the lesion is an apical granuloma or an apical cyst (Figs. 3a & b).49,55–57 Cotton et al.46 used CBCT as a tool to assess whether the lesion was of endodontic or non-endodontic origin.

CBCT also demonstrated superiority to 2-D radiographs in detecting fractured roots. Vertical and horizontal root fracture detection is described in several clinical cases.21,46,55–59 It is also agreed that CBCT is superior to peri-apical radiographs in detecting these fractures, whether they are bucco-lingual or mesiodistal.60–61

In cases with inflammatory root resorption, lesions are detected much easier in early stages with CBCT compared to conventional 2-D X-ray.21,62 In other cases, such as external root resorption, external cervical and internal resorption, not only the presence of resorption was detected, but also the extent of it.21,46,54,58,63–64

CBCT can also be used to determine root morphology, the number of roots, canals and accessory canals, as well as to establishing the working length and angulations of roots and canals.21,25,46,55–56,58,65–67 It also is accurate in assessing root-canal fillings.47,51,56,58 Owing to its accuracy, it is very helpful in detecting the pulpal extensions in talon cusps68 and the position of fractured instruments.69

It is also a reliable tool for pre-surgical assessment of the proximity of the tooth to adjacent vital structures, size and extent of lesions, as well as the anatomy and morphology of roots with very accurate measurements.21,46,54,58,69–71

Table I

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<th>Specialty</th>
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Specialty Number of articles in 

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Endodontics 32 23.88
Implantology 22 16.42
Orthodontics 16 11.94
General dentistry 14 10.45
Temporomandibular joint disorder 8 5.97
Periodontics 5 3.73
Forensic dentistry 1 0.75

Fig. 3a & b _Apical cyst shown as orthopantomogram (a) and CBCT (b)._
Additionally, in cases in which teeth are assessed after trauma and in emergency cases, its application can be a useful aid in reaching a proper diagnosis and treatment approach.46,55,73–74

Recently, owing to its reliability and accuracy, CBCT has also been used to evaluate the canal preparation in different instrumentation techniques.25–76

**Implantology**

With increased demand for replacing missing teeth with dental implants, accurate measurements are needed to avoid damage to vital structures. This was achievable with conventional CT. However, with CBCT giving more accurate measurements at lower dosages, it is the preferred option in implant dentistry today (Figs. 4a & b).2,6,11,18,70,77–89

With new software that constructs surgical guides, damage is also reduced further.77,84,90–93 Heiland et al.94 describe a technique in which CBCT was used inter-operatively in two cases to navigate the implant insertion following microsurgical bone transfer.

CBCT enables the assessment of bone quality and bone quantity.18,26,70,80–93,85,88,95–97 This leads to reduced implant failure, as case selection can be based on much more reliable information. This advantage is also used for post-treatment evaluation and to assess the success of bone grafts (Figs. 5a–d).18,88

**Orthodontics**

Orthodontists can use CBCT images in orthodontic assessment and cephalometric analysis.5,70,84,98–99 Today, CBCT is already the tool of choice in the assessment of facial growth, age, airway function and disturbances in tooth eruption.100–103

CBCT is a reliable tool in the assessment of the proximity to vital structures that may interfere with orthodontic treatment.104–105 In cases in which mini-screw implants are placed to serve as a temporary anchorage, CBCT is useful for ensuring a safe insertion106–108 and to assess the bone density before, during and after treatment (Fig. 6).109–110

Having different views in one scan, such as frontal, right and left lateral, 45-degree views and sub-mental, also adds to the advantages of CBCT.10,124 As the images are self-corrected from the magnification to produce orthogonal images with 1:1 ratio, higher accuracy is ensured. CBCT is thus considered a better option for the clinician.113

**Temporomandibular joint disorder**

One of the major advantages of CBCT is its ability to define the true position of the condyle in the fossa, which often reveals possible dislocation of the disk in the joint, and the extent of translation of the condyle in the fossa.10,56,114 With its accuracy, measurements of the roof of the glenoid fossa can be done easily.115–116 Another advantage of some of the available devices is their ability to visualise soft tissue around the TMJ, which may reduce the need for magnetic resonance imaging in these cases.117

Owing to these advantages, CBCT is the imaging device of choice in cases of trauma, pain, dysfunction, fibro-osseous ankylosis and in detecting condylar cortical erosion and cysts.70,87,98–120 With the use of the 3-D features, the image-guided puncture technique, which is a treatment modality for TMJ disk adhesion, can safely be performed.121

**Periodontics**

CBCT can be used in assessing a detailed morphologic description of the bone because it has proved to be accurate with only minimal error.
The measurements proved to be as accurate as direct measurements with a periodontal probe. Additionally, it also aids in assessing furcation involvements. CBCT can be used to detect buccal and lingual defects, which was previously not possible with conventional 2-D radiographs. Additionally, owing to the high accuracy of CBCT measurements, intra-bony defects can accurately be measured and dehiscence, fenestration defects and periodontal cysts assessed. CBCT has also proved its superiority in evaluating the outcome of regenerative periodontal therapy.

General dentistry

Based on the available literature, CBCT is not justified for use in detecting occlusal caries, since the dose is much higher than conventional radiographs with no additional information gained. However, it proved to be useful in assessing proximal caries and its depth. Table II shows examples of typical doses of various dental radiological procedures in dental practice.

Forensic dentistry

Many dental age estimation methods, which are a key element in forensic science, are described in the literature. CBCT was established as a non-invasive method to estimate the age of a person based on the pulp–tooth ratio.

Discussion

CBCT scanners represent a great advance in dento-maxillofacial (DMF) imaging. This technology, introduced into dental use in the late 1990s, has advanced dentistry significantly. The number of CBCT-related papers published each year has increased tremendously in the last years. The above systematic review of the literature related to CBCT-imaging applications in dental practice was undertaken in order to summarise concisely the indications of this new image technique in different dental specialties.

Cone-beam computed tomography in dentistry was used as key phrase in this systematic review. Other terminology encountered in the literature, such as cone-beam volumetric scanning, volumetric computed tomography, dental CT, dental 3-D CT and cone-beam volumetric imaging, did not result in additional relevant papers.

The clinical applications for CBCT imaging in dentistry are increasing. The results of this review demonstrate that 134 papers were clinically relevant and that the most common clinical applications are in the field of oral and maxillofacial surgery, implant dentistry, and endodontics. CBCT has limited use in operative dentistry owing to the high radiation dose required in relation to its diagnostic value.

The literature on CBCT is promising and needs further research, especially with regard to its use in forensic dentistry, in order to explore more potentially beneficial indications in that area. No literature concerning direct CBCT indications in prosthodontics was found. However, several overlapping indications were found in other dental specialties contributing to the final standard of care in prosthodontic treatment. These indications include but are not limited to bone grafting, soft-tissue grafting, prosthetically driven implant placement, maxillofacial prosthodontics and temporomandibular joint disorder. CBCT images can also be of great value in special cases in which multiple teeth have to be assessed for restorability (Figs. 7a–e).

The latest CBCT units have a higher resolution, lower exposure, are less expensive and designed for use in dentistry. Additionally, the flat-panel detectors appear to be less prone to beam-hardening artefacts. There are, however, several important disadvantages as well, such as susceptibility to

Table II. Typical doses of various dental radiological procedures.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-oral (F speed, rectangular collimator)</td>
<td>0.001</td>
</tr>
<tr>
<td>Intra-oral (E speed, round collimator)</td>
<td>0.004</td>
</tr>
<tr>
<td>Full-mouth set (E speed, round collimator)</td>
<td>0.080</td>
</tr>
<tr>
<td>Lateral cephalogram (F speed, rare-earth screen)</td>
<td>0.002</td>
</tr>
<tr>
<td>Dental panoramic technique (F speed, rare-earth screen)</td>
<td>0.015</td>
</tr>
<tr>
<td>CBCT (both jaws)</td>
<td>0.068</td>
</tr>
<tr>
<td>Hospital CT scan (both jaws)</td>
<td>0.60</td>
</tr>
</tbody>
</table>
movement artefacts, low contrast resolution, limited capability to visualise internal soft tissues and, owing to distortion of Hounsfield Units, CBCT cannot be used for the estimation of bone density.

It is crucial that the ALARA principle (As Low As Reasonably Achievable) is respected during treatment, as far as the radiation dose of CBCT imaging is concerned. CBCT imaging will improve patient care, but users have to be trained to be able to interpret the scanned data thoroughly. Dentists should ask themselves whether these imaging modalities actually add to their diagnostic knowledge and raise the standard of dental care or whether they only place the patient at a higher risk. Continuous training, education and thorough research are thus absolutely essential.

One of the most clinically useful aspects of CBCT imaging is the highly sophisticated software that allows the huge volume of data collected to be broken down, processed or reconstructed. This makes data interpretation much more user friendly, if the appropriate technical and educational knowledge is available.

The increasing popularity of CBCT resulted in numerous CBCT-unit manufacturers, frequent presentations at conferences and an increase in published papers. This resulted in an uncontrolled and non-evidence based exchange of radiation dose values and attributed to the limited technical knowledge about medical imaging devices for new-user groups. As a result, the European Academy of DentoMaxilloFacial Radiology has developed the following basic principles on the use of CBCT in dentistry:

1. CBCT examinations must not be carried out unless a history and clinical examination have been performed.
2. CBCT examinations must be justified for each patient to demonstrate that the benefits outweigh the risks.
3. CBCT examinations should potentially add new information to aid the patient’s management.
4. CBCT should not be repeated on a patient ‘routinely’ without a new risk/benefit assessment having been performed.
5. When accepting referrals from other dentists for CBCT examinations, the referring dentist must supply sufficient clinical information (results of a history and examination) to allow the CBCT practitioner to perform the justification process.
6. CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional [traditional] radiography.
7. CBCT images must undergo a thorough clinical evaluation (radiological report) of the entire image dataset.
8. Where it is likely that evaluation of soft tissues will be required as part of the patient’s radiological assessment, the appropriate imaging should be conventional medical CT or MR, rather than CBCT.
9. CBCT equipment should offer a choice of volume sizes, and examinations must use the smallest that is compatible with the clinical situation, if this provides a lower radiation dose to the patient.
10. Where CBCT equipment offers a choice of resolution, the resolution compatible with an adequate diagnosis and the lowest achievable dose should be used.
11. A quality assurance programme must be established and implemented for each CBCT facility, including equipment, techniques and quality-control procedures.
12. Aids to accurate positioning (light-beam markers) must always be used.
13. All new installations of CBCT equipment should undergo a critical examination and detailed acceptance tests before use to ensure that radiation protection for staff, members of the public and patient are optimal.
14. CBCT equipment should undergo regular routine tests to ensure that radiation protection,
for both practice/facility users and patients, has not significantly deteriorated. 

15. For staff protection from CBCT equipment, the guidelines detailed in Section 6 of the European Commission document Radiation protection 136: European guidelines on radiation protection in dental radiology should be followed.

16. All those involved with CBCT must have received adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection.

17. Continuing education and training after qualification are required, particularly when new CBCT equipment or techniques are adopted.

18. Dentists responsible for CBCT facilities, who have not previously received ‘adequate theoretical and practical training’, should undergo a period of additional theoretical and practical training that has been validated by an academic institution (university or equivalent). Where national specialist qualifications in dento-maxillofacial radiology exist, the design and delivery of CBCT training programmes should involve a DMF radiologist.

19. For dento-alveolar CBCT images of the teeth, their supporting structures, the mandible and the maxilla up to the floor of the nose (for example, 8 cm x 8 cm or smaller fields of view), clinical evaluation (radiological report) should be done by a specially trained DMF radiologist or, where this is impracticable, an adequately trained general dental practitioner.

20. For non-dento-alveolar small fields of view (for example, temporal bone) and all craniofacial CBCT images (fields of view extending beyond the teeth, their supporting structures, the mandible, including the TMJ, and the maxilla up to the floor of the nose), clinical evaluation (radiological report) should be done by a specially trained DMF radiologist or by a clinical radiologist (medical radiologist).

**Conclusion**

CBCT is most frequently applied in oral and maxillofacial surgery, endodontics, implant dentistry and orthodontics. CBCT examination must not be carried out unless its medical necessity is proven and the benefits outweigh the risks. Furthermore, CBCT images must undergo a thorough clinical evaluation (radiological report) of the entire image dataset in order to maximise the benefits.

Future research should focus on accurate data with regard to the radiation dose of these units. CBCT units have small detector sizes and the field of view and scanned volumes are limited, which is the reason that CBCT units specific to orthodontic and orthognathic surgery are not yet available. Additional publications on CBCT indications in forensic dentistry and prosthodontics are also desirable.

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

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**Fig. 7d** Examinations done for teeth #7, 8, 9 and 10 were atraumatic and bone grafting was performed.

**Fig. 7e** Temporisation done and healing of the grafted sites for future implant placement is awaited.

**about the authors**

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**Dr Hadi M. Alamri and Dr Mazen A. Alshalhoob** are interns at Riyadh Col- leges of Dentistry and Pharmacy.
Nobody will deny that aesthetics play a crucial role in the restoration of anterior teeth, irrespective of whether the restorations are placed in male or female patients. As the final outcome is dependent on the skills of the clinician, the aesthetic differences may be tremendous even if state-of-the-art techniques and materials are utilised. For the anterior restorations in the case presented, I used IPS Empress CAD leucite glass-ceramic blocks. These blocks are offered in two different levels of translucency by the manufacturer. Additionally, a Multi block featuring multiple shades is available. As these blocks are industrially processed, restorations of consistent quality are achieved. The glass-ceramic material is easy to polish or reduce, which enables the milled restoration to be veneered subsequently. As a result, the final aesthetic outcome can be optimised in a simple fashion.

I usually work with the polychromatic IPS Empress CAD Multi blocks, as they feature a true-to-nature gradation of shades combined with optimum levels of brightness and translucency. Consequently, they blend in seamlessly with the natural oral environment. In addition, they demonstrate lifelike fluorescence.

Today, patients’ needs and expectations differ widely. They may include quick healing, but also long-term stability or enhanced aesthetics. The use of IPS Empress CAD Multi blocks in combination with the CEREC 3 (Sirona) chairside CAD/CAM system allows restorations to be fabricated that meet the needs of today’s patients. In the case presented, a restoration was fabricated with an IPS Empress CAD Multi block. A highly aesthetic result was achieved that left nothing to be desired.

Case study

A 32-year-old female patient presented to my office dissatisfied with the aesthetic appearance of her upper anterior teeth. The incisal edges showed an irregular contour and discoloration was present (Fig. 1). The initial examination revealed an inconsistent incisal line and dark discoloration visible during smiling. Tooth #12 had previously been restored with a crown, while tooth #22 had received a composite restoration (Fig. 2). Prior to the start of the treatment, a CRT test was conducted. The results indicated a low caries risk level and good oral hygiene. Therefore, the restorative treatment could be started immediately.

The restorative options available to the patient were discussed with her. Her priorities included the lightening of the discoloured teeth, as well as the creation of softer, more feminine tooth shapes and the creation of long-lasting restorations.
Based on her wishes, an anamnesis and a diagnostic analysis were conducted. In the next step, I set up a treatment plan that included teeth #11, 12, 21 and 22.

First, I fabricated a mock-up, which was to serve as a basis for the discussion with the patient. Her wish of having teeth with a more rounded shape and thus with a softer, more feminine appearance was taken into account during the fabrication of the mock-up. The teeth were prepared according to standard procedures (Fig. 3). A fibre-reinforced endodontic post and core was seated in tooth #12. This was done to prevent root fracture but still ensure an aesthetic restorative result. In tooth #11, caries was detected in the area of the mesial angle. Following removal of the carious tissue, the cavity was filled with composite resin. Tooth #21 received a full-crown preparation. A rounded shape was prepared to ensure even distribution of the force to which the restoration would be exposed. In tooth #22, composite material was applied in the area of the medial angle.

The CEREC software features a tool termed correlation mode. This mode enables users to take an optical impression. As the patient had a very clear idea of the future appearance of her teeth, I decided to use this mode to match my ideas with hers. Therefore, a silicone impression was taken after the teeth had been prepared and a model was poured (Fig. 4).

Based on the mock-up, which had been discussed with the patient earlier, a wax-up was created on the model and an optical impression was taken (Fig. 5). The recorded model served as a guide for the construction procedure, which was carried out using the quadrant mode.

In the fabrication of anterior restorations, it is advisable to check the size and dimension of the incisal build-up from the palatal aspect continuously by means of a silicone matrix. This significantly facilitates the modelling procedure. Moreover, by proceeding in this way it becomes apparent immediately if data has been lost during optical impression taking. A loss of information in the area of the incisal edge usually renders the construction of anterior restorations considerably more difficult. The precise recording of data is of utmost importance, especially if the patient requests a particular tooth shape (Fig. 6).

The 3.6 version of the CEREC 3D software has a milling preview feature, which allows users to ‘place’ the restoration in the virtual block as needed in accordance with the gradation of shades from cervical to incisal (Fig. 7). This enables the operator to make use of the opaque/translucent areas or the gradation pattern of the block in an optimal fashion. If several teeth are restored simultaneously, there are now various options to utilise the different areas efficiently. Consequently, it is even possible to fabricate restorations that do not require individual characterisation or cutting back.
The versatility and flexibility of the IPS Empress CAD Multi block is thus further enhanced. After the restoration had been milled, it was seated on the model. The restoration had an excellent fit. Owing to the gradation of opaque and translucent shades from the cervical to the incisal region, the restoration had a very natural appearance (Fig. 8).

In the case presented, the restorations were glazed but did not have to be characterised because of the IPS Empress CAD Multi block’s lifelike aesthetics. The reason that I glazed the restoration was not primarily to improve its aesthetic appearance, but to impart it with even higher strength. In the literature, glaze firing is generally referred to as a means of increasing the strength of IPS Empress CAD restorations. I would like to point out however that IPS Empress CAD restorations also possess sufficient strength to ensure successful, long-term results if they are merely polished. Following try-in, the restorations were adhesively cemented (Fig. 9).

Particularly in the cementation of veneers, strict adherence to the cementation protocol is crucial to ensuring long-lasting results. Normally, I use Variolink II luting composite, since it allows (thin) all-ceramic restorations to be reliably, durably and aesthetically cemented. In the case presented, I decided to use the universal luting composite Multilink Automix, as it is very easy to use and convenient. The restorations were reliably cemented in just two steps. The high bond strength and long-lasting adhesion that are achievable with this system have been confirmed by numerous studies conducted in recent years. In contrast with Variolink II, Multilink Automix is only available in three different shades (yellow, transparent and opaque). As the patient’s teeth did not show any severe discoloration, the choice of materials was sufficient in this case.

Figure 10 shows the restorations three years after completion of the treatment. The restorations still look attractive and the gingival tissue has a healthy colour. We are proceeding on the assumption that the dark triangle between the two front teeth will become smaller over time. The four teeth were restored with IPS Empress CAD Multi block in a very satisfactory fashion, and the patient was very pleased with the result.

**Summary**

In Japan, it is generally assumed that conventional, laboratory-based restorative procedures are superior to computer-assisted techniques. Some experts are of the opinion that CAD/CAM-based systems even pose a threat to the profession of laboratory technician as a whole. In my opinion, this is a huge misconception. On the contrary, CAD/CAM technology and the manual skills of laboratory technicians can be ideally combined to achieve optimal results. The flexible use of digital and analogue techniques helps to better fulfill patient needs and advances modern dentistry. This position is corroborated by the case presented in this article, which was restored by making full use of the possibilities offered by the CEREC system and the IPS Empress CAD Multi block. I will continue to provide my patients with high-quality restorations, also by using sophisticated procedures. These procedures ensure that durable results and thus a high level of patient satisfaction are achieved.
The highlight of NobelProcera is an easy-to-use optical scanner that provides high accuracy scanning of complex geometries. Combined with the scanner is a cutting edge user-friendly CAD software package featuring intuitive tools such as full anatomical tooth library and cutback functions. In future, the functionality will also include impression scanning. NobelProcera provides a comprehensive product and material range such as implant bars, shaded zirconia abutments and temporaries, with precision of fit, quick turn-around times and consistent and predictable results. All products are individually manufactured from materials that are certified for excellent strength and homogeneity and come with a 5-year warranty.* Nobel Biocare is the world leader in innovative and evidence-based dental solutions. For more information, visit our website. www.nobelbiocare.com

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Established in 1994, Art Dental Ltd., a fast developing dental laboratory, has more than 16 years of professional experience in all types of highly aesthetic dental restorations. New generation materials and modern layering techniques ensure the production of consistent and high quality restorations. In view of the latest trends in modern dentistry, the laboratory specialises in the production of restorations placed over implants, as well as large constructions, for example 16-unit bridges on implants with no other teeth available.

For the past two years, Art Dental has produced more than 500 constructions using ZrO₂, non-precious alloys and PMMA composite/temporary constructions in combination with the Tizian CAD/CAM system (Schütz Dental). The following cases aim to demonstrate the significant advantages of ZrO₂ in combination with Tizian CAD/CAM.

Case I (Figs. 1–15)

This 45-year-old female patient suffered from very serious periodontal problems. The treatment plan involved extraction of all maxillary teeth and subsequent placement of six implants. In order to find the ideal place for perfect osseointegration and to avoid sinus lift intervention, the
two implants in the area of the distal premolars were fixed at a 35° angle.

Two attachments were placed on teeth #12 and 22, which enabled direct restoration. Many aspects had to be taken into consideration in order to achieve an enhanced stability, excellent shape adaptation and lifelike aesthetic results. We decided that the permanent construction was to be done using ZrO₂ and Tizian CAD/CAM.

We began by loading the model and the bite scans into the modelling software, which detected the preparation line of each unit individually. Owing to the flexibility of the software, the preparation lines of the attachments and the 35° placed implants were easily detected. Additionally, the process was fast and easy with an excellent accuracy of fit. Such level of precision can be achieved manually only at a high time cost.

A unique type of insertion was performed in the next step in order to determine the best position for the construction in the blank and to avoid undercuts, so no further actions would have to be done manually. After milling and sintering, the bridge showed an excellent accuracy of fit. We reduced the thickness of the cement gap and the crown border parameters, removed undercuts and received perfect results (demonstrated by the green arrows over each crown in Figure 5).

The software proceeded by automatically loading the anatomical shapes. A large variety of software tools provided excellent, lifelike results with regard to the natural tooth structure, morphology,
symmetry and composition. In this case, which would have been a challenge for every CAD/CAM system on the market, the Tizian Creative RT design software demonstrated significant advantages during the shape-forming process, especially for the attachments and the distal implants.

We were able to call the antagonists every time we needed to during the entire modelling process. The software automatically arranged the occlusal and approximal contacts but these can also be adapted manually if necessary. After the construction had been adapted to the bite, we proceeded to shrink the crowns and pontics. With the entire palette of forming tools available for reshaping, we reduced as much as we needed to. The connectors were set quickly and easily, while one was able to choose between different shapes, move in all directions, and change height, weight and thickness.

Figures 9 to 15 show the final construction before and after being seated in the patient’s mouth.

_Case II_ (Figs. 16–24)

This 40-year-old female patient was not satisfied with the look of her smile. By restoring her teeth, we were able to change the way the patient felt about her appearance. We selected a 12-unit zirconium framework with ceramic cover, a highly aesthetic solution.

_Case III_ (Figs. 25–27)

For this 54-year-old female patient, we created two temporary constructions from advanced PMMA composite materials for teeth #15 to 25 and #35 to 45. The two bridges, which she was required to wear for three months, were then replaced by zirconium constructions. The two bridges were placed on implants. The modelling process followed was the same as described in the previous cases.

_Correction_

The Tizian CAD/CAM system enables rapid manufacture of highly accurate restorations, both permanent and temporary. With user-friendly software and a large variety of software tools, as well as a fast and easy scanning, modelling and milling process, the materials are processed quickly and accurately with results hardly distinguishable from natural teeth. This exceptional piece of technical equipment proved to provide reliable and consistent results and product quality, as well as excellent bio-compatibility of the materials. Additionally, compared to cast-metal techniques, considerably less time was needed, while accuracy of fit and precision increased.
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For more than a hundred years, dental laboratories have designed dental restorations the same way by using a lost-wax process in accordance with which the design is first modelled by hand in wax, then reviewed, refined, invested and finally burned out in the process of creating a mould that will be used for casting. Twenty-five years ago, early dental CAD/CAM solutions, such as Sirona’s CEREC system, applied technology proven in automotive and aerospace design to the design of zirconia substructures (or copings) for crowns, allowing part of the process to go digital. However, while copings are simple, thimble shapes and relatively straightforward to design digitally, other types of commonly prescribed removable restorations, such as partial dentures, are not, owing to their highly irregular and intricate shapes. In addition, dental laboratory technicians are skilled artisans—having honed their manual dexterity, artistic style and design techniques over many years—not tech savvy engineers. These factors make it extremely difficult for them to use traditional dental CAD/CAM systems to create complex, organic-shaped dental restorations.

Creating dental restorations is partly science and partly an art. Each individual’s mouth and tooth shape is uniquely his/her own, meaning that a dental restoration is an individualised work of art, sculpted from scratch in bite-sized form. Computers can greatly speed the design process and add precision, for example by eliminating steps such as the need for a refractory model, applying digital wax thicknesses consistently and automatically, and assuring fast design iterations or a remake, if needed. Furthermore, having digital clasp designs and mesh patterns at your fingertips also helps accelerate the design process.

Until recently, dental CAD/CAM systems were either surface or solid modellers, utilising the same parametric technology and the accompanying rigid, hierarchical workflow as CAD/CAM systems that are used for industrial design. These traditional dental CAD/CAM systems also require that the laboratory’s restoration designer use a 2-D computer mouse to manipulate the design, which prevents the designer from leveraging the dexterity and artisanship they have spent years perfecting. While the laboratory technician may be able to see the restoration on screen, with a mouse they cannot feel the contours of the teeth and tissues, or the thickness or smoothness of a restoration’s surface—pivotal feedback that allows them to design accurately and efficiently.

In 2008, SensAble introduced what some dental authorities have called a revolutionary 3-D touch-enabled solution for dental restoration design. The company’s SensAble Dental Lab System remains the only proven digital solution to support the design and production process for removable partial frameworks and has since been expanded to handle full contour crown and bridge work and, with additional software, veneers.

The system is based on voxel technology (think of voxels as 3-D pixels), which provides unparalleled speed and design flexibility. This 3-D modelling approach means that laboratory technicians can handle even the most challenging cases and can literally design any type of restoration they can imagine. If they can wax it, they can design it on the SensAble system. This ability to use one system to create multiple types of restorations allows dental laboratories to leverage their investment across more lines of business, an important option in challenging economic times.

With the SensAble system, dental laboratory technicians use a haptic device, which the company calls a 3D Virtual Touch stylus, instead of a mouse, allowing them to literally feel the evolving restoration that they are designing on screen as they carve and smooth digital wax. The result, according to numerous European dental laboratories, is business changing. When dental restoration designers are suddenly offered a way to design digitally in which they can still use their sense of touch in the design process, they can transition more easily to working in the digital domain.
and design restorations with unmatched speed, consistency and precision. Laboratories are reporting that they are able to create vastly more work with the same number of staff and in some cases compete for large-volume business, such as government-funded restorations, because the laboratory's cost structure has suddenly become more favourable.

Suddenly, the painstaking task of working in wax has been elevated to state-of-the-art design. Numerous laboratory owners stated that the appeal of haptics has helped them to attract, quickly train and retain younger computer-savvy technicians entering the dental laboratory field. Other laboratories have reported that because of haptics, they have been able to teach individuals who are not trained laboratory technicians to use the system correctly and productively, expanding the pool of people from which they can hire.

_What is haptics_

Haptics refers to sensing and manipulation through touch. The word haptics originated from the Greek words haptikos and hapthesthai, which means to grasp or to touch. Haptic devices enable computer users to touch and manipulate virtual objects by feel within a true 3-D space.

SensAble's founders pioneered the development of a type of haptics now called force feedback, where the computer receives the force exerted by a person's natural touch and then returns a resulting force to the user as he/she manipulates 3-D models on screen. What dental laboratory technicians experience is that when they move their hand, the movement sends haptic input—data about force and position—to the computer via the haptic device. The computer makes appropriate graphical changes to the 3-D model of the dental restoration on screen—sometimes called rendering—while it calculates and sends the correct amount of force feedback back to the user through the haptic device. An easy way to think about this type of haptics is to imagine the forces that you experience against your hand and arm when pushing open a heavy glass door.

_How touchability speeds dental restoration design_

Labo W. Hoet & Co., a full-service dental laboratory in Ghent, Belgium, which has been in business for more than 35 years, provides restorations to dentists in the Flemish part of Belgium, Brussels and other European countries. The family-run laboratory employs 24 people and has worked with the SensAble Dental Lab System for the past year. Initially, the firm purchased the solution for use with partials, but when its owners took a closer look at the crown and bridge software, they decided to expand the use of the SensAble system throughout its everyday workflow. At present, the laboratory has one person who scans full time in preparation for designing both partials and crown and bridge work. Another laboratory technician designs full time. With this approach, Labo Hoet is able to manufacture nearly all of its crown and bridge restorations digitally. For several years, Labo Hoet owner Jan van Ooteghem was convinced about utilising digital solutions in the crown and bridge division, but had not found a CAD/CAM system for partials that actually worked. Labo Hoet had viewed a number of software packages but none produced a satisfying result.

When the laboratory saw partials created using the SensAble system, it was convinced that it was possible to use this as the main solution in its partials division. Initially, the firm thought the haptic device—which the team calls “the designing pen”—was just a gimmick to be different. But the technicians soon realised that the device really made a difference. Now, technicians can feel in three dimensions and, for partials, this is a particular benefit since their curves, multiple thicknesses and individual nature vary greatly from patient to patient. The haptic device has actually become “a third hand for the designer”.

Labo Hoet reports that the SensAble system saves the laboratory at least 30 % of the time it would take to create a partial manually. In general, the partials software has made it possible for Labo Hoet to boost its productivity, making more partials with the same number of technicians. Furthermore, the final restorations are much more consistent, accurate and detailed. With the software’s true 3-D capabilities, technicians can save time by not having to switch views all the time or having the software render another section. The haptic device allows the designer to feel into an area of the restoration—behind the corner of a restoration—in a way that is better than if they were only able to see it. Using the SensAble Dental Lab System, Labo Hoet is able to design partials quickly, more consistently, and as a combined result the restorations are much easier to finish once cast. Various conventional steps in the partial design and manufacturing process have disappeared, such as making the refractory model, resulting in additional time and cost savings from materials that are no longer used.
Although they originally used separate systems for fixed and removable restorations, Labo Hoet’s team found it was easier to use the same scanner and the same kind of design software for both partials and crowns and bridges instead of using multiple systems. Very important in this workflow is 3D Systems’ rapid prototyping printer. The laboratory already used this before they purchased the SensAble system, but with designing partials digitally, it became even more useful. The laboratory enjoys having the printer in-house, but for smaller laboratories, it is also possible to outsource the printing. Labo Hoet reports that the printed resin patterns are very easy to cast with and the results fit perfectly.

Additionally, the ongoing software upgrades provided by SensAble continue to expedite the design process, giving the laboratory more time to focus on design details. “Every software update that we have received from SensAble is a pleasant surprise,” van Ooteghem said. “The possibilities of the software are virtually limitless. I think the most important limitation is our own imagination. Everyday partials, partials with backing plates, full contour teeth, etc.—it is all possible. If we look back one year, it is hard to imagine the manual labour we had to do to make a partial. Just thinking about that has made it all worthwhile for us,” he continued.

SOCA Networks, France

SOCA Networks, located in Bordeaux and Paris, France, has been using SensAble’s Dental Lab System for nearly two years to create partials, crowns and bridges and veneers. This network of dental laboratories is one of France’s largest producers of restorations under contract to the French health-care system, and produces thousands of restorations per year. The network also serves as a primary production centre for the design and production of Remedent GlamSmile porcelain veneers.

While 70% of its business comes from France—and the bulk of that from government-reimbursed restorations—SOCA produces crown and bridge work, partials and veneers for clients across four continents, including work for Europe, the US and Canada, Australia, the UAE, Russia and Brazil. SOCA Networks operates production facilities in both France and Vietnam.

SOCA initially purchased SensAble’s system to accommodate its high-volume veneers business for Remedent, but gradually began using the software for partials in late 2009 and for manufacturing crowns and bridges in February 2010. Using SensAble’s system, SOCA designs approximately 100 partials, about 100 to 120 crown and bridge restorations and between 200 to 300 veneers per day.

Nicolas Thibert, an executive at SOCA Networks, reports that the accuracy and quality of SensAble-produced parts are definitely better than the two other dental CAD/CAM solutions he had previously tried out and require less time to create. Because SOCA has multiple locations, it can leverage talent in one office for partials or crown and bridge work and then transfer the SensAble-created files via FTP over its IT network. In addition to time-savings, SOCA believes the SensAble system has helped the firm automate small steps in the production process to decrease human error. For example, the SensAble system can automatically store individual dentist specifications and ensure there is an order number or a patient number on all parts.

SOCA also uses SensAble-created files for press-ables, an increasingly popular type of fixed restoration, and even has a few dentists who upload intra-oral scans to SOCA’s network, so that designers can automatically access the file and route it to the SensAble design stations.

_Dental parts are art—designing them correctly requires touch_

As humans we rely heavily on our sense of touch, sometimes without even realising it. Additionally, there will always be individual style and artisanship in the making of dental restorations. By giving dental laboratory technicians a touch-enabled CAD/CAM solution that allows them to maintain design control and create restorations the way they know they need to be made—together with voxel technology for speed and design flexibility—SensAble’s system helps European dental laboratories to transition to a digital workflow easily; increase productivity, accuracy and consistency; and capture new business all at the same time.

_about the author_

Bob Steingart, President of SensAble Dental Products, has over 25 years of experience in successfully transforming innovative technologies into commercial solutions. He has held executive positions in business development, product management and marketing at Avid Technologies, EMC, Lotus Development, Sitara Networks and Kurzweil Applied Intelligence. He holds an MBA from Harvard Business School, and a BSEE and MSEE from MIT. He can be contacted at bsteingart@sensable.com or by contacting SensAble at www.sensabledental.com.
White Peaks Dental Systems

*White Peaks Dental Systems*, a German manufacturer, specialising in the production of dental zirconium blanks, uses raw materials from Tosoh (Japan) exclusively, a world leader in dental zirconium technology. White Peaks’ blanks are certified to the highest standards (CE, FDA and DIN ISO 13485). The Copran ZR zirconium blanks are compatible with almost all CAD/CAM milling and manual systems. A large variety of blanks of high strengths and translucency, as well as pre-coloured blanks in shades A1 and A3 leave nothing to be desired.

White Peaks offers a variety of related products, such as zirconium colouring liquids in 16 classic shades, intensive shades for full contour shading, Cr-Co, titanium, CE PMMA blanks, PMMA and wax blanks for casting techniques, extremely long-lasting milling burs, and scan spray.

Calidia 4x and Calidia 5x, the new 4- and 5-axis CAD/CAM milling systems, are specially designed for use in dental practices. With a weight of approximately 650 kg, the systems are sufficiently small to fit into the average laboratory, but sufficiently heavy to perform at high milling speed. They offer the highest accuracy and are capable of milling zirconium, Cr-Co, titanium, lithium disilicate and feldspathic ceramic blocks. The open systems, like all materials and components offered by White Peaks, are obligation and royalty free.

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For additional information on our furnaces, scanners, equipment and materials, please visit www.white-peaks-dental.com.

### _contact_ CAD/CAM

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Congress on 3-D dentistry again exceeds goals in education

Authors: Imaging Sciences International & Gendex Dental Systems, USA

The 4th International Congress on 3-D Dental Imaging, sponsored by Imaging Sciences International and Gendex Dental Systems, held this year in La Jolla, California, offered attendees and the dental media an ideal setting in which to learn about 3-D technology. Experienced dental clinicians and professionals shared their considerable knowledge of 3-D’s past, use today, and development in the future. Attendees were provided with a wealth of information from speakers and vendors to assist them in their practical application of the quickly expanding technology.

The two-day congress utilised lectures, panel discussions, breakout sessions, and live demonstrations to allow for full participation and interaction amongst those gathered at the event. “There was definitely a myriad of course topics here, including detailed clinical information,” commented attendee Dr Christopher Phelps of Charlotte, USA. “And for those of us who already have the technology, it was helpful to have courses that focus on non-clinical aspects, as well, such as marketing and both Medical and Dental Insurance reimbursement.”

A new speaker at this year’s congress, Dr John Graham focused on clinical findings not apparent using 2-D radiology and keeping pace when it comes to dentistry’s evolving standard of care involving CBCT. “The dentists that attended the congress were looking to learn more about a technology that can help them advance patient care. I believe that they came away with a greater understanding of this and more,” he remarked.

Returning speaker and moderator, Dr Scott D. Ganz presented on the new sense of confidence to diagnose, plan, communicate and execute dental implant reconstruction and related procedures, such as bone grafting, that cone-beam data offers to clinicians. As Dr Ganz states, “It’s not the scan, it’s the plan!”

Dr Sharnell Muir spoke on the use of CBCT in conjunction with CAD/CAM applications which, in part, covered the process of in-office milling of surgical guides and restorations. “Dr Muir’s presentation gets right to the heart of how dynamic 3-D technology is—the ability to plan restorations and implants and make use of CAD/CAM applications to place and restore them is how patient-driven dentistry is accomplished,” said Mark Hillebrandt, Director of Product Management for ISI and Gendex. “She very effectively illustrated the power of CBCT–CAD/CAM integration.”

Also in attendance, Henrik Roos, President of Imaging Sciences and Gendex, noted that the attendees were very eager to learn about the benefits of 3-D technology. “We are proud to sponsor this comprehensive educational event that offers dentists the information they seek—how to better treat their patients and how to expand services in their practices,” he stated. The companies also announced that the next 5th International Congress on 3-D Dental Imaging will be held in Dallas, USA, at the Gaylord Texan Resort and Convention Center from 4 to 5 November 2011.

Imaging Sciences International and Gendex’s dedication to education is exemplified in their collaboration in delivering quality courses on 3-D imaging. Events include webinars, interactive regional meetings and local training sessions provided by knowledgeable dental professionals. Visit www.i-CAT3D.com for a complete course listing and registration information.

Editorial note: Selected presentations were recorded and are offered online, as C.E. accredited webinars. For programme details and registration, please see www.dtsstudyclub.com.
CEREC 25th Anniversary Celebration — A milestone event in dentistry

Author: Sirona Dental Systems, Inc., USA

Sirona Dental Systems’ CEREC 25th Anniversary Celebration (CEREC 25), which was held from 26 to 28 August 2010, may be over, but it will not be soon forgotten, according to the majority of the more than 3,000 attendees and more than a dozen keynote speakers, who participated in the milestone event, celebrating the 25th anniversary of the CEREC CAD/CAM system.

Several lectures offered information on a number of Sirona advancements. Dr Jay Reznick, a progressive oral surgeon, whose lecture was entitled CEREC–GALILEOS integration: A surgeon’s perspective, explained why the integration of CEREC CAD/CAM information into GALILEOS Implant Planning Software enables dental implant planning and surgical techniques that are far superior to traditional 2-D imaging and “freehand” placement of dental implants. The result is a less-invasive surgical procedure, awareness of anatomical challenges ahead of time, increased precision of implant placement, reduced surgical time and enhanced patient recovery.

In his lecture CEREC Connect and digital impressioning, Dr Michael Skramstad illustrated using the CEREC AC and CEREC Connect software to advantage and combining CEREC chairside techniques with CEREC Connect to maximise the use of digital technology and communication with the laboratory, for the fabrication of everything from simple single units and implants to complex anterior cases.

Sirona’s Internet-based service that caters exclusively for Sirona inLab and inEos Blue users is now under the management of laboratory industry veteran Bob Vasile. The range of materials and indications was expanded to include full-contour restorations and veneers made from Ivoclar Vivadent’s IPS e.max CAD lithium disilicate and VITA’s new RealLife material.

Dental and dental laboratory professionals networked with dental industry icons who conducted illuminating continuing education (CE) programmes that included clinical techniques, hands-on workshops, and dynamic lectures on practice management, marketing and hygiene. One of the many session highlights included Prof Werner Mörmann’s lecture The Evolution of the CEREC System. Who better to give such a presentation but the original developer of the CEREC system? Prof Mörmann explained CEREC’s humble beginnings as a small, mobile CAD/CAM unit integrating a computer with a monitor and keyboard, trackball, foot pedal, and an optoelectronic 3-D mouth-scanning camera, and its evolution into the CEREC AC unit with Bluecam and CEREC Connect, which now represents the industry’s most advanced CAD/CAM technology for the dentist and dental technician.

The Introduction of the Sirona Speakers’ Academy was another noteworthy highlight. This speaker-training programme provides both new and experienced speakers with coaching and strategies for delivering more distinctive and compelling presentations. Graduates of the Speakers’ Academy become preferred speakers within the Sirona community and gain access to the latest information regarding trends, market data, and product introductions within the category of digital restorative dentistry and imaging, thereby ensuring their presentation content is as accurate and current as possible. “The CEREC 25th Anniversary Celebration was the launch for many new programmes and services because we wanted our attendees to be on the inside track throughout this exciting and important event,” explained Michael Augins, President of Sirona USA.

CEREC 25 also featured three days of non-stop activities, in which participants could earn up to 18 CE credits while enjoying CAD/CAM-focused workshops, premium entertainment, and plenty of memorable celebrations at the luxurious accommodation provided by Caesar’s Palace. Sirona and guests closed CEREC 25 in true Vegas style at the sophisticated WHITE PARTY, which took place at the popular PURE Nightclub. Most attendees agreed that the WHITE PARTY was the hottest dental event of the decade.

“This may have been the most memorable and exciting three days of my career,” exclaimed Michael Augins. “The high level of continuing education programmes, networking opportunities and entertainment activity was a worthy tribute to the technology that changed the face of dentistry. This milestone event not only celebrated the first 25 years of CEREC CAD/CAM, it kicked off the next 25 years of Sirona innovation.”

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Touchdown for digital dentistry: CADapalooza ’10 scores!

Author: D4D Technologies LLC, USA

CADapalooza ’10 certainly lived up to its reputation and delivered an exceptional programme this summer in Dallas, Texas! Hundreds of dental professionals attended the three-day event held at the Gaylord Texan Resort and Convention Center, Cowboys Stadium and D4D Technologies’ world headquarters to see the future of dentistry firsthand.

The event began with a Millin’ Around welcome reception in the scenic Main Atrium at the Gaylord Texan Resort, where registered attendees, manufacturers and sponsors gathered for an evening of camaraderie and celebration. On Friday, attendees were shuttled to the new, US$1.4 bn Cowboys Stadium for a full-day lecture programme, covering such topics as current state-of-the-art systems and materials, and the incredible capabilities of leading edge integrated dental technologies that are under development. Special video messages from profession leaders Dr Gordon Christensen and Dr Pete Dawson were played for the crowd on the HD screens at the Main Club Level, where attendees were also treated to a live patient demonstration by CAD/CAMbassador Sherri White, featuring E4D’s DentaLogic software’s newest features.

Other notable presenters included Dr Paul Child, Jr., CEO of CR Foundation, sharing his perspective on CAD/CAM systems currently on the market; Dr Colin Norman of 3M ESPE; Dr Santine Anderson of THE DENTAL ADVISOR; Dr Don Deems, The Dentist’s Coach; Lee Culp; Dr Curtis Jansen and D4D Software Engineer Rakesh Lal introducing the revolutionary E4D Compass software; Dr George Tyowsky of Ivoclar Vivadent; as well as Dr David Reznik and Rick Willeford, providing a fresh perspective of the business side of dentistry.

Midway through the day, lunch was served and attendees were invited to step in front of an HD camera to have their video image projected onto the massive 55-meter JumboTron. Photos were captured as souvenirs to commemorate their experience on the world’s largest HD screen. After the break, the D4D Marketing team prepared a series of amusing viral videos that the crowd could watch on either the JumboTron or back at the Club Level. Following the laughter, lectures continued as the E4D DentaLogic and E4D Compass software demonstrations remained on the JumboTron.

The programme closed that afternoon and all participants were led up seven storeys for an evening reception at the Dr Pepper Star Bar overlooking the football field. Guests were greeted with hors d’oeuvres and cocktails as they arrived, and all had the opportunity to tour the 3,000,000 sq. ft. stadium, including a behind-the-scenes look at the Cowboys’ and Cheerleaders’ locker rooms, as well as a free-for-all run of the field itself. Many took photos in the Cowboys star at the centre of the field, while others took the opportunity to go all the way and run for a touchdown!

On the final day, all participants participated in the Build-a-Crown and Advanced Design workshops at D4D Technologies’ world headquarters in the Dallas suburb of Richardson, Texas. Bringing models of their own, they attended workshops at pre-arranged times to sit with CAD/CAMbassadors to see their own crown being scanned, designed and then milled right before their eyes in a matter of minutes! Ivoclar Vivadent, Premier Dental and 3M ESPE’s technical specialists were on hand to ensure each crown was left with proper aesthetic control—with stain and glaze, characterisation, crystallisation and polishing centres.

“The support of our partners is unparalleled, having Henry Schein Dental, Ivoclar Vivadent, Premier Dental, Imaging Sciences International and 3M ESPE all pulling in the same direction has made this a tremendous success and paved the way for the future of digital dentistry,” said Dr Gary Severance, Vice-President of Marketing and Clinical Affairs at D4D Technologies. Presenters were also on-hand at the Advanced Design workshops to highlight upcoming software releases and revealed the Top 10 Steps to Restoration Design, taking their restorations from ordinary to extraordinary, led by Lee Culp. Over 200 restorations were completed and given to the participants and every attendee was able to experience the Experience of what E4D can do for them, their practice and especially their patients.

If you attended this year’s event, we sincerely thank you for your participation and we hope you found the experience as rewarding as we did. Be sure not to miss next year’s event, as it promises to exceed even the greatest expectations for the future of dentistry!
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The new challenge in dentistry

Author: Dr Dobrina Mollova, Dubai

For the fourth time, Dubai hosted the CAD/CAM & Computerized Dentistry International Conference organised by the Emirates Dental Association and the Center for Advanced Professional Practices. The annual conference was a great success, achieving record attendance and further establishing its reputation as the industry’s leading CAD/CAM scientific conference.

Dr Amin Hussain Al Amiri, CEO for Medical Practice and Licence and Chairperson of the UAE Supreme National Blood Transfusion Committee, and Dr Afaf Sayed Ja’afar, Acting Director of the Continuing Medical Education (CME) Department, opened the conference and expressed their gratitude for the support of the development of new technologies in dentistry and their appreciation of the excellent opportunity this conference offered with regard to CME in the region.

With 480 participants from 17 different countries and with different specialties, the attendance was exceptional. The two-day conference was chaired by Dr Munir Silwadi, scientific coordinator, and Dr Dina Debaybo, Nicolas & Asp University College of Postgraduate Dentistry. The plenary presentations by internationally renowned speakers from Germany, France, Lebanon, the UK, Egypt and the KSA presented the latest in the field. A wide range of topics was covered, for example tooth preparation for CAD/CAM technology, post, core and final restorations, proper cementation and objectives, as well as computerised implantology and orthodontics. Dentists and dental technicians from both governmental and private sectors enjoyed the high level of the scientific programme. Guest speaker Dr Khaled Abouseada from Egypt commented: “Thank you not only for inviting me as a speaker to this conference but thank you for your great efforts, which were amazing and the first reason for the success of this conference.”

Guests from the Moscow State University and the University of Belgrade gave poster presentations on the use of CAD/CAM for different treatments.

This year, a new feature, a two-hour open discussion forum with the theme Zirconia—The Truth, was introduced to the conference programme. International experts used the opportunity to present their points of view on the topic and agreed that Zirconias are NOT all the same. The panel members—researchers, experienced clinicians, top industry players and academics from universities in Sharjah, Ajman, Boston, Moscow and Belgrade—offered a substantial amount of information and enabled attendees to discuss the topic and share their experiences and ideas.

Leading manufacturers, like Sirona, 3M ESPE, Ivoclar Vivadent, DeguDent, VITA, Amann Girrbach, Hint-ELs and GSK, generously sponsored the event to contribute to the development of these advanced technologies in the discipline. They exhibited their latest products and technologies, and reported an all-time high in terms of participant interest. Additionally, the Breakfast with the Sponsors event, which was held every morning, offered an excellent networking opportunity. This exclusive access also offered sponsors the opportunity to share experiences with colleagues, make new contacts and strengthen existing relationships. Many sponsors expressed their appreciation that this event had been arranged.
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