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This year’s most important event in the dental industry—the International Dental Show (IDS) in Cologne is behind us. IDS once again succeeded in showcasing the highest level of innovation in dentistry, and IDS 2013 was all about digital dentistry.

CAD/CAM procedures now not only offer improvements in preventative care, treatments, and laboratory procedures so important for dental professionals, but also give patients a virtually unprecedented opportunity to see the desired treatment outcome, and experience the benefits of engineering expertise and medical advancement directly.

Backward planning, as it is called, is increasingly becoming integrated into dental procedures and dental laboratory processes. The more complex the medical procedures it is used with, the greater the benefits it offers will be. Dental implants are a good example because the treatment outcome depends greatly on consultation. Dentists and dental technicians can now work with data from 2-D and 3-D radiographs captured using CBCT and facial scanners, as well as with data obtained from classic or digital dental impressions. This allows the creation of precise digital surgical guides, for example, that ensure dental implants will be placed in exactly the right position and at precisely the right angle. Any crowns or bridges subsequently seated will be in the optimal position too. In addition, the emergence profile can be designed to have as natural an appearance as possible.

This issue of CAD/CAM discusses some of these new procedures, and I hope that these articles will aid you in applying these methods in your practice to improve your work to your patients’ benefit in particular.

Yours sincerely,

Magdalena Wojtkiewicz
Managing Editor
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COMMITTED TO SIMPLY DOING MORE FOR DENTAL PROFESSIONALS
The human body contains over 200 different types of cells, which are organised into tissues and organs that perform all the tasks required to maintain the viability of the system, including reproduction. In healthy adult tissues, the cell population size is the result of a fine balance between cell proliferation, differentiation, and death. Following tissue injury, cell proliferation begins to repair the damage. In order to achieve this, quiescent cells (dormant cells) in the tissue become proliferative, or stem cells are activated and differentiate into the appropriate cell type needed to repair the damaged tissue. Research into stem cells seeks to understand tissue maintenance and repair in adulthood and the derivation of the significant number of cell types from human embryos.

It has long been observed that tissues can differentiate into a wide variety of cells, and in the case of blood, skin and the gastric lining the differentiated cells possess a short half-life and are incapable of renewing themselves. This has led to the idea that some tissues may be maintained by stem cells, which are defined as cells with enormous renewal capacity (self-replication) and the ability to generate daughter cells with the capacity of differentiation. Such cells, also known as adult stem cells, will only produce the appropriate cell lines for the tissues in which they reside (Fig. 1).
Not only can stem cells be isolated from both adult and embryo tissues; they can also be kept in cultures as undifferentiated cells. Embryo stem cells have the ability to produce all the differentiated cells of an adult. Their potential can therefore be extended beyond the conventional mesodermal lineage to include differentiation into liver, kidney, muscle, skin, cardiac, and nerve cells (Fig. 2).

The recognition of stem cell potential unearthed a new age in medicine: the age of regenerative medicine. It has made it possible to consider the regeneration of damaged tissue or an organ that would otherwise be lost. Because the use of embryo stem cells raises ethical issues for obvious reasons, most scientific studies focus on the applications of adult stem cells. Adult stem cells are not considered as versatile as embryo stem cells because they are widely regarded as multipotent, that is, capable of giving rise to certain types of specific cells/tissues only, whereas the embryo stem cells can differentiate into any types of cells/tissues. Advances in scientific research have determined that some tissues have greater diffi-

combined with a bone marrow concentrate.

**Fig. 10a** A histological image of the site grafted with bank bone combined with bone marrow. Note the presence of considerable amounts of mineralised tissue.

**Fig. 10b** A histological image of the site grafted with bank bone not combined with bone marrow. Note the presence of low amounts of mineralised tissue.
special science & practice

In dentistry, pulp from primary teeth has been thoroughly investigated as a potential source of stem cells with promising results. However, the regeneration of an entire tooth, known as third dentition, is a highly complex process, which despite some promising results with animals remains very far from clinical applicability. The opposite has been observed in the area of jawbone regeneration, where there is a higher level of scientific evidence for its clinical applications. Currently, adult stem cells have been harvested from bone marrow and fat, among other tissues.

Bone marrow is haematopoietic, that is, capable of producing all the blood cells. Since the 1950s, when Nobel Prize winner Dr E. Donnall Thomas demonstrated the viability of bone marrow transplants in patients with leukaemia, many lives have been saved using this approach for a variety of immunological and haematopoietic illnesses. However, the bone marrow contains more than just haematopoietic stem cells (which give rise to red and white blood cells, as well as platelets, for example); it is also home to mesenchymal stem cells (which will become bone, muscle and fat tissues, for instance; Fig. 3).

Bone marrow harvesting is carried out under local anaesthesia using an aspiration needle through the iliac (pelvic) bone. Other than requiring a competent doctor to perform such a task, it is not regarded as an excessively invasive or complex procedure. It is also not associated with high levels of discomfort either intra or post-operatively (Figs. 4a & b).

Bone reconstruction is a challenge in dentistry (also in orthopaedics and oncology) because rebuilding bony defects caused by trauma, infections, tumours or dental extractions requires bone grafting. The lack of bone in the jaws may impede the placement of dental implants, thus adversely affecting patients’ quality of life. In order to remedy bone scarcity, a bone graft is conventionally harvested from the chin region or the angle of the mandible. If the amount required is too large, bone from the skull, legs or pelvis may be used. Unlike the process for harvesting bone marrow, the process involved in obtaining larger bone grafts is often associated with high levels of discomfort and, occasionally, inevitable post-operative sequelae (Figs. 5a–e).

The problems related to bone grafting have encouraged the use of bone substitutes (synthetic materials and bone from human or bovine donors, for example). However, such materials show inferior results compared with autologous bone grafts (from the patient himself/herself), since they lack autologous proteins. Therefore, in critical bony defects, that is, those requiring specific therapy to recover their original contour, a novel concept to avoid autologous grafting, involving the use of bone-sparing material combined with stem cells from the same patient, has been gaining ground as a more modern philosophy of treatment.

Fig. 11a Bone marrow.
Fig. 11b Bone marrow transfer into a conic tube in a sterile environment (laminar flow).
Fig. 11c Bone marrow homogenisation in a buffer solution (laminar flow).
Fig. 11d Bone marrow combined with Ficoll (to aid cell separation).
Fig. 11e Pipette collection of the interface containing the mononuclear cells (where the stem cells are present).
Fig. 11f Second centrifuge spin.
sequently, to the detriment of traditional bone grafting (with all its inherent problems), this novel method of combining stem cells with mineralised materials uses a viable graft with cells from the patient himself/herself without the need for surgical bone harvesting.

Until recently, no studies had compared the different methods available for using bone marrow stem cells for bone reconstruction. In the following paragraphs, I shall summarise a study conducted by our research team, which entailed the creation of critical bony defects in rabbits and subsequently applying each of the four main stem cell methods used globally in order to compare their effectiveness in terms of bone healing:

- fresh bone marrow (without any kind of processing);
- a bone marrow stem cell concentrate;
- a bone marrow stem cell culture; and
- a fat stem cell culture (Figs. 6 & 7).

In a fifth group of animals, no cell therapy method (control group) was used. The best bone regeneration results were found in the groups in which a bone marrow stem cell concentrate and a bone marrow stem cell culture were used, and the control group showed the worst results. Consequently, it was suggested that stem cells from bone marrow would be more suitable than those from fat tissue for bone reconstruction (Fig. 9). It is clear that the level of mineralised tissue is significantly higher in those areas where stem cells were applied (Figs. 10a & b).

Evidently, although bone marrow stem cell techniques for bone reconstruction are very close to routine clinical use, much caution must be exercised before indicating such a procedure. This procedure requires an appropriately trained surgical and laboratory team, as well as the availability of the necessary resources (Figs. 11a–h, taken during laboratory manipulation of marrow stem cells at São Leopoldo Mandic dental school in Brazil).'

Fig. 11g. The pellet containing the bone marrow mononuclear cells after the second centrifuge spin.
Fig. 11h. A bovine bone graft combined with a bone marrow stem cell concentrate.
All images courtesy of Células Tronco em Implantodontia.


**about the author**

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Dentistry has come a long way since our colleagues were forced to use foot powered drills and mix amalgam from its bare components. Modern day dental equipment and materials are at the cutting edge of medical and dental innovation, and it's trade shows such as the International Dental Show (IDS) where the developments of the future are announced. Modern dentists no longer have merely a straight probe and a dental drill at their disposal. We now have scans, 3-D images, growth factors and an almost unlimited choice of materials available to use.

In writing this piece, I made a tough decision to focus on what I believe to be key areas of dental innovation. It is in these areas of imaging, CAD/CAM technology and growth factors that I believe are going to be important in the dental surgery of the future.

Computer-aided design/computer-aided manufacturing has had a presence in dentistry for nearly 20 years. However, it is only in the last ten years that developments have really made a difference in the reliability, ease of use and functionality of these devices. We now have CAD/CAM machines (e.g., CEREC, iTero, Lava) that can scan an entire arch, design and fabricate all-ceramic restorations in the practice. The popularity of chairside CAD/CAM units has never been greater. The materials that we are able to use in conjunction with CAD/CAM scanners have gone from monolithic, one shade blocks to multi-layered, all-ceramic, lithium-disilicate constructions that can be sintered and finalised in as little as 15 minutes.

The appearance of these restorations, although still needing a well-trained (and artistic) dentist, could be said to be on par with certain lab-based fabrications whilst maintaining the advantages of being a chairside single visit restoration. CAD/CAM technology is now almost universally used in the fabrication of dental implant abutments and bars, reducing construction times, designs and fit. Dentists are now beginning to use chairside CAD/CAM
devices to restore dental implants without the need for any impressions.

**CBCT 3-D scanners and CAD/CAM integration**

Cone beam computed tomography (CBCT) scans are now commonplace in dentistry, particularly in implant dentistry where Grondahl (2007) found that 40 per cent of all CBCT scans were taken for implant treatment. Where 3-D scans were reaching a shortfall was in actually relaying the information obtained into the mouth during the surgical procedure. One recent innovation has been to overlay scans of the patient’s own teeth and soft tissues onto the CBCT scan data. This gives an accurate representation of the hard and soft tissues and their relationship to each other. For example, an implant can be planned in the implant software with the angulation of the implant taking into account the ideal position of the final crown, which can also be shown in the CBCT scan.

In order to do this previously, the dentist would have to make a study model and then wax up the ideal final restoration contour, ensuring some barium sulfate within the wax in order for it to show up in the scan. This was both costly and time consuming. Recent developments have allowed one to take an intra-oral scan using a suitable device, such as a CEREC or iTero machine, and overlay this with the CBCT scan. No models, no wax ups; the procedure is almost instant and can be done with the patient in the chair. As a patient education tool, this visual format is invaluable, allowing patients to fully understand the proposed work and its execution.

Taking this one step further, guided implant surgery now allows us to not only plan implant placement using ideal restoratively driven protocols, but actually allows us to make a guided surgical stent, made in-house or by a lab, and place the implant through the stent. Studies have found that this is an accurate treatment modality that can be reliably executed. Flapless surgery with immediate temporisation has the ability to revolutionise the patient journey and help us to meet their expectations.

**Facial scanners**

A small but rapidly developing area of digital dentistry is facial scanners. These are in their infancy at the moment, with a lot of companies still trying to iron out the bugs in the machines. Their potential applications in the field of plastic surgery, facial aesthetics, orthodontics, implant surgery and orthognathic surgery are endless.

I have been fortunate to see a prototype facial scanner from Sirona and even managed to have my face scanned (Figs. 1 & 2). The detail achievable with these units is impressive. Once this information is combined with 3-D scans, teeth scans and jaw articulation, a fully working and movable representation of the patient’s head can be compiled on the computer screen. Allowing for treatment planning and assessment to be carried out without any need to see the patient. One application of this may be in developing countries, where various experts from around the world can examine complicated facial reconstruction cases without them actually seeing the patient. As already mentioned, the opportunities for patient education are huge, and with procedures such as plastic surgery and orthognathic surgery being so difficult to properly consent for, facial scanners will greatly aid clinicians.

**Growth factors**

Available for a long time in medicine and dentistry, growth factors have been the reserve of PhD students and professors until recently. The resurgence of the usage of platelet rich plasma (PRP) has come about with added research showing that using PRP can greatly improve osteoblast proliferation (Parmar 2009) and accelerate soft-tissue healing. Companies are now offering clinical courses for dentists to make, produce and use PRP in their own surgeries within 15–30 minutes. The main advantage of PRP is that it’s free; is obtained from the patients’ own blood, thus removing the risk of rejection; and can be made in vast quantities. As more research is published, coupled with simpler production kits, PRP use will increase in all aspects of invasive dental surgery.

The above is just a short description of what is being developed for the future. Dentistry has never been so intertwined with technology. The next 10 years will prove to be exciting and I eagerly await to hear, see and use the new technologies that are being developed today.
**Straumann’s coPeriodontiX: 3-D digital bone measurement using cross-sectional CBCT image data in periodontal issues**

**Authors:** Drs Jonathan Fleiner, Andres Stricker & Dirk Schulze, Germany

**_coPeriodontiX (Straumann)_** is the first software to offer the 3-D evaluation of periodontal bone status using cross-sectional CBCT image data. The aim is the measurement of bone progression prior to, during, and after treatment, as well as monitoring to measure the effectiveness of regenerative treatment. X-ray images have always proven a valuable tool in periodontal diagnostics. Usually 2-D imaging processes, such as bitewing images, intra-oral images of single teeth, or panoramic tomograms, are used for this purpose. All these processes are able to provide important diagnostic pointers, but none of them are without fundamental limitations, even at a high quality. It is against this background that cone-beam computed tomography (CBCT) has gained increasing importance over the past few years and is now firmly entrenched in certain areas of modern dentistry. In today’s periodontology, CBCT allows for precise answers to a number of diagnostic issues relating to structural bone changes in the dentoalveolar area. High-resolution and overlap-free imaging of teeth and bone structures, as well as their pathological deterioration, play a major role in diagnostics.

**_Principle of radiological bone measurement_**

As there have been no satisfactory software-based solutions existed to date for standardized use in the periodontological evaluation of cross-sectional data (obtained using CBCT or CT), software was developed in collaboration with Straumann under the name of coPeriodontiX and is now presented for the first time in its current version (8.0) for daily clinical use. The principle of standardised evaluation follows the X-ray six-point measuring principle in analogy to clinical assessment. By positioning a digital 3-D coordinate system centrally on the tooth to be measured, the software automatically generates transverse cross-sections of the tooth (Figs. 1a & b). Using settable, defined landmarks, the distance...
along the axis of the tooth is measured automatically at six measuring points circumferentially around the tooth (vestibular and oral, with mesial, central and distal measurements in each case) to give a 360-degree evaluation of crestal bone status. The dentino-enamel junction and crestal alveolar bone serve as reference landmarks (Figs. 2a & b). In the case of multiple-rooted teeth, any possible pathological furcation involvement can be clearly evaluated using a special 360-degree panoramic view and by metrically measuring the degree of furcation involvement (Fig. 3). All findings can be presented individually in graphic or table format as desired (Figs. 4a & b).

**Imaging processes in dentistry: 2-D versus 3-D**

The main disadvantage of conventional 2-D image processing is the 2-D display of 3-D anatomical structures. Important morphological aspects and their pathological changes to the tooth-supporting alveolar ridge can only be detected at advanced stages of deterioration, or perhaps not at all, owing to overlapping images. The amount of bone available can only be determined with a certain degree of accuracy in the approximal spaces. The detection and quantitative determination of double- to triple-walled bone defects is often a diagnostic challenge, even in the case of high-quality X-ray images. In this context, coPeriodontiX is intended to be a valuable tool that allows precise and standardised evaluation of 3-D cross-sectional images as part of periodontal diagnostics in addition to the indispensable clinical exploration. The focus is the measurement of available bone mass prior to, during, and after treatment, as well as monitoring following the regenerative treatment of vertical periodontal defects and furcation involvement, for example.

**Limitations of CBCT**

**Artefacts**

A major problem with all cross-sectional imaging methods is the generation of image artefacts. Typically, high-density structural elements in the object investigated (e.g. metallic restorations, root pins, implants, osteosynthesis plates) lead to obliterating and hardening artefacts in beam direction. Under certain circumstances, these may impair the diagnostic assessment of directly adjacent structures (e.g. approximal spaces, peri-implant region), and may in part even mimic pathological structures.

**Effective radiation dose**

The radiation dose for patients undergoing dental CBCT largely depends on the CBCT system, the type of detector used, and the exposition parameters of the X-ray itself. As a rule, image-intensifier systems produce a slightly lower dose than flat-panel detector systems do. The effective dose, in terms of risk management, can be reduced considerably by selecting an image volume adjusted to the area of exploration. Scientific studies have shown that the dose of CBCT may well be similar to the magnitude of intra-oral film status for a single tooth (with up to 14 individual images) and that CBCT may offer considerably higher information content in direct comparison. Nonetheless, strict indications according to the ALARA (as low as reasonably achievable) principle should be adhered to under all circumstances when employing CBCT to minimise the exploration risk for the patient.

**Imaging accuracy and precision**

When defining the precision and measuring accuracy for periodontal diagnostics, a certain degree of deviation between the clinical situation and the resulting radiological information is inevitable but can be regarded as...
Regarding the reliability of radiological measurements, initial study results showed an overall measuring imprecision of two to three times the voxel size, regardless of the prior knowledge of dental radiology of the users involved. Depending on the number of roots, measuring accuracies of between 0.26 and 0.34 mm have been recorded for single-rooted teeth, and between 0.27 and 0.55 mm for multiple-rooted teeth. The effect of the individual user did not prove to be significant. In principle, these values permit the conclusion that a basic accuracy at this level, compared with measuring imprecision during clinical diagnosis of the patient, can well be considered consistent and regarded as being acceptable from a clinical point of view.

**Conclusion**

Especially for complex issues, the use of CBCT can be viewed as a valuable diagnostic tool in modern periodontology applying the ALARA principle. The undistorted and non-overlapping 3-D imaging of the tooth-supporting alveolar ridge by methods such as CBCT has significant potential in periodontal diagnostics—under the precondition of robust scientific evidence. In this context, the coPeriodontiX software described in this article is the first to offer support to users in the detection of dental, periodontal, and ossary deterioration, particularly in highly complex cases, and coPeriodontiX may be an interesting option for surgical restoration (Straumann Emdogain, BoneCeramic, MembraGel). Finally, it should be mentioned explicitly that the software described in this article does not replace clinical diagnosis, but should rather be viewed as a useful radiological means of support. This includes the option of portraying the soft tissue of the intra-oral gingival profile using surface scan data obtained with iTero for example (Align Technology; Fig. 5). A number of further clinical studies are being conducted using numerous diagnostic parameters to examine the technical features of current CBCT systems (e.g. image resolution, image quality, creation of artefacts) and to exploit the diagnostic potential of CBCT fully, especially for its use in periodontal diagnostics.

*Editorial note: A complete list of references is available from the publisher.*
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Time proven clinical success of the SHORT™ implant

Authors: Prof. Dr Mauro Marincola, MDS Angelo Paolo Perpetuini, Dr Stefano Carelli, Prof. G. Lombardo, Italy & Dr Vincent Morgan, USA

Introduction

In 1892, Julius Wolff, a German surgeon, published his seminal observation that bone changes its external shape and internal, cancellous architecture in response to stresses acting on it (Wolff's law of bone modelling and remodelling). Therefore, it is a significant engineering challenge to design a short implant that biocompatibly transfers occlusal forces from its prosthetic restoration to the surrounding bone. It requires the understanding and application of many basic biological, mechanical, and metallurgical principles. It is paramount that the entire design of a SHORT™ implant optimises the effectiveness of each of its features within the implant’s available surface area and length. Clinical success cannot be met by any single implant design feature such as surface area, but rather requires the appropriate integration of all of its features.

Since an implant’s design dictates its clinical and mechanical capabilities, it is scientifically approved that bone healing around a plateau-designed implant is different than the appositional bone (the bone that is formed by osteoblasts after cell mediated interfacial remodelling) around threaded implants. The plateaued, tapered and root-formed implant body provides for 30% more surface area than comparably-sized threaded implants. But more importantly, the plateaus provide for an intramembranous-like and faster bone formation (20–50 microns per day), resulting in a unique Haversian bone with clinical capabilities different from the slower forming (1–3 microns per day) of appositional bone around threaded implants. Additionally, the plateaus provide for the transfer of compressive forces to the bone throughout the entire implant.

Description

We analysed the most time-proven short implant on the market that was called the Driskol Precision Implant in the early 1980s, than Stryker and the Bicon Dental Implant from 1993 (Boston, USA).

The Bicon implant has a bacterially-sealed 1.5 degree locking taper (galling or cold welding) connection between the abutment and implant, with the ability for 360 degrees of universal abutment positioning. Having a bacterially-sealed connection eliminates the bacterial flux associated with clinical odours and tastes and reduces inflammation and bone loss consistently.

Another unique characteristic is the sloping shoulder that facilitates the appropriate transfer of occlusal loads to the bone when positioned below the bony crest. But more practically, the sloping shoulder facilitates aesthetic implant restorations,
for it provides space for the interdental papillae with bony support even when an implant is contiguous to another implant or tooth. The sloping shoulder design has been, since 1985, the basis of a sensible biological width and the origin of platform switching.

The 360 degrees of universal abutment positioning provides for the extraoral cementation of crowns; the use of the cementless and screwless Integrated Abutment Crown (IAC™), the intraoral bonding of fixed bridges, which eliminates the need for cutting, indexing and soldering of bridge frameworks, multiple and easy removal of abutments over time; and the slight aesthetic rotational adjustments during and prior to the seating of a restoration.

Clinical long-term results

In the following long-term case description we can observe the stability of the crestal bone around the sloping shoulder of the plateau implant. Clinically, the soft tissue contour around the Integrated Abutment Crowns indicates a healthy and stable epithelial tissue.

The single-tooth implant is a viable alternative for single tooth replacement. Single-tooth replacement with endosseous implants has shown satisfactory clinical performance in different jaw locations.

Minimal or no crestal bone resorption is considered to be an indicator of the long-term success of implant restorations. Mean crestal bone loss ranging from 0.12 mm to 0.20 has been reported one year after the insertion of single-tooth implant restorations. After the first year, an additional 0.01 mm to 0.11 mm of annual crestal bone loss has been reported on single-tooth implant restorations. Some implants demonstrate no crestal bone loss and/or crestal bone gain after insertion of definitive restorations.

Crestal bone gain has been documented on immediate and early loaded implants with a chemically modified surface after one year of follow up. A six-year prospective study reported that 43.8% of splinted Morse taper implants experienced some bone gain. Crestal bone gain has been documented around immediately loaded Bicon implants. The factors that lead to periimplant bone gain in different implant designs have not been investigated. It would be beneficial for the dental practitioner to understand what factors are associated with crestal bone gain on single-tooth implants after crown insertion. Radiographic long-term control also as a clinical observation of the soft tissue structures surrounding the abutment emergence profile can

Figs. 1–12. Radiographic long-term control helps maintain the implant’s bone/soft tissue stability.
provide the clinician with a better understanding of an implant's bone/soft tissue stability (Figs. 1–12).

The ideal scenario in modern implant dentistry would be the implant replacement for every missing single tooth (Figs. 13 & 14). The single tooth replacement guarantees good aesthetics, consequently to the fact that a single crown that follows all criteria of a natural-looking soft tissue emergence profile can support the soft tissue in order to recreate papillae anatomy.

Another important aspect of single crown restorations on implants is that the patient can follow a better oral hygiene compared to bridgeworks. Nevertheless, bridgeworks are commonly used as alternatives to single tooth replacement. The reasons are multifactorial, with the cost-benefit factor at first place (Figs. 15 & 16). Another significant facet is the atrophic bone situation of the patient, were complicated and expensive bone graft procedures are needed before even thinking of placing single implants.

Alternatively to sophisticated and expensive bridgeworks (Figs. 17 & 18), cost-effective and simple prosthetic techniques were developed in the last years. One of these techniques, the Fixed on SHORT™, allows to provide the patients with bone atrophies or partial bone deficiencies with a fixed, metal free prosthetic that can be supported by four to six short implants (Figs. 19–22).

**Conclusion**

In this short and synthetic article, the authors like to show the variety of treatment options when implants and prosthetic materials are used with the criteria of long-term crestal bone preservation, recreation and long-term stabilisation of the biological width around the implant/crown and the use of short- and ultra-short implants in all clinical situations. The proper selection of an ultra-short or short implant depends strictly on the implant design which dictates the implant's function.

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

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Figs. 17 & 18. Complex bridgeworks.
Figs. 19–22. Fixed-on-SHORT™ technique for fixed, metal free prosthetics.
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Until very recently, my patients would have considered undergoing complete treatment including a ceramic crown or a bridge in one visit science fiction. The science of CAD/CAM technology has progressed at a staggering pace, enabling me to treat a case that represents a new level in the field.

This case report demonstrates a procedure that allows the treatment of a patient who has lost a tooth or had one extracted. In one visit, he or she can receive an implant using a while-you-wait, made-on-demand implant guide. Furthermore, modelling of the individual abutment or placing of a solid titanium abutment with a temporary crown, or a permanent ceramic crown, based on the indication and diagnosis, can be performed in the same visit.

The implant guide that is produced while the patient waits (CEREC Guide, Sirona) speeds up the entire process incredibly, owing to a precisely mapped location in a 3-D CBCT scan using GALAXIS and GALILEOS Implant (both Sirona) visualisation.
Moreover, it also enables implantation using the flapless technique. Immediate fabrication and use of the implant guide is even more important in immediate implant placement after extraction of multi-rooted teeth, for which free-hand implantation is extremely difficult (or near impossible).

In addition to CEREC Guide, we can order and use the CLASSICGUIDE (SICAT), made on the basis of a conventional impression, or OPTIGUIDE (SICAT), a stent that is manufactured without bite plates and impressions, requiring only a digital scan of the patient’s mouth with CERECAC (Sirona) and a CBCT scan of the patient’s jaws (using GALILEOS or ORTHOPHOS XG 3D). Of all three guides that could be used, that is, a pilot drill, sleeve in sleeve or completely guided stents, only CEREC Guide can be produced in office immediately. CEREC Guide was used in the following clinical case report.

Clinical case report

A 55-year-old male patient refused orthodontic treatment to move tooth 13 into proper position while making space for a replacement of tooth 12. The patient had been chewing on primary tooth 53, which was extracted about 14 days before implantation. Figure 1 shows the gap after extracting tooth 53. Tooth 12 was missing and tooth 13 had moved mesially into the space (Fig. 2). Overall, the patient was healthy and had no hereditary disease.

In this case, we began the treatment by taking a conventional impression of the jaw in which we were considering placing an implant to replace a missing tooth. We used quick-setting plaster well suited to fabricating the stone model (Fig. 3). We placed a reference body in the location of planned implantation on the stone model to determine the correct size (three sizes are available: small, medium and large).
The reference body should about against the adjacent teeth and fill the gap with the largest possible area but it should not become lodged between the adjacent teeth during placement. Once we had determined the optimal size, we wet the stone model with water and applied thermoplastic stent material softened with warm water to cover one to two adjacent teeth on each side ideally. The properly heated stent compound appears to be glassy/transparent, which by its transparency also indicates plasticity interval. Once the colour changes to opaque, setting has begun. While the stent compound was still warm and adapted to the stone model, we inserted the reference body (medium in this case; Fig. 4). When the thermoplastic is still clear, it is possible to observe and review how the reference body relates to the edentulous space. Corrections can still be made until the material becomes opaque. Undercuts on the stone model can be blocked out before using, for example, a composite compound (not wax) to allow easier detachment of the thermoplastic stent material with the reference body from the model. Personally, I do not block out undercuts to ensure the most accurate mounting. Even in the ensuing test in the patient’s mouth, one must hear the characteristic click sound.

Once satisfied with the placement and retention of the stent with the reference body in the patient’s mouth, we captured a CBCT scan of the patient using GALILEOS or ORTHOPHOS XG 3D. One needs to ensure that the large fiducial-containing portion of the reference body faces orally as depicted in Figure 4 and not buccally in ORTHOPHOS XG 3D, as there may be a tendency to cut this portion off in its 8 cm x 8 cm field of view. While waiting for the image to load on the PC, we scan the implant space layout on the model using an intra-oral scanner (CEREC AC) and software modelling of the proposed crown follows, in terms of suitable shape, size and location in the future implant position.

Once the CBCT scan has loaded, we open the GALAXIS software and begin the planning. The first step is to insert the exported CEREC crown proposal in *.ssi format because this is the only CEREC crown proposal format that GALAXIS software can read (Fig. 5). The exact placement of the proposed CAD/CAM crown in the CBCT scan will allow precise...
read-out of borders between hard and soft tissue (Figs. 6–8) and the digital implant placement under the crown in such a way that the future connection of the implant and crown using an abutment is prosthetically possible (Fig. 9). After the digital implant had been imported into GALAXIS, the need to use CEREC Guide (or another guided-surgery technique) became apparent in this case owing to a dramatic conical apical narrowing of the roots of the adjacent teeth 14 and 13 in the intended implant space (Fig. 10). Owing to the lack of space between these roots, we chose a 3.3/8 mm implant (SwishPlus, Implant Direct). After digital implant placement, we select to continue and edit the sleeve system. After selecting this option, a new dialog box marked “reference body” appears. On this screen, we mark the fiducial points using the lever underneath the image and move the lever until the fiducials appear to be as round and clear as possible. Finally, we double click on the three most clear fiducial points and the software will then automatically search for and determine the remaining fiducials (Fig. 11). Next, we confirm that the fiducials have been found and the reference body appears on the 2-D and 3-D images (Fig. 12). In order to better visualise the interaction of the drill path and drill body with the implant, the final drill path and pilot drill path must be turned on in the 2-D views (Fig. 13). The reference body must fit exactly within the drill path in order to be milled.

The most important part of CEREC Guide production is setting the D2 value. The D2 value, also known as the drill stop length, is the distance from the apex of the implant to the top of the guide. If we measure the length of the drill from its cutting tip to the drill stop, the D2 value will be that length minus 1 mm, which is the thickness of the implant guide handle. In our case, for the 8 mm implant used, this value was 23 mm (the 24 mm drill minus the 1 mm handle). The D1 value changes with the D2 value automatically (Fig. 14).

In order to continue, we export this arrangement data back to the CEREC AC unit as a *.cmg or *.dxd file. After opening the correct file in CEREC Software 4.xx, the drill body proposal will appear in the milling preview (Fig. 15). Now we can place the appropriate block size (in our case this was “M”) into the milling unit (MCXL on inLab MC XL, Sirona) and select “mill”.
Milling time is approximately 12 to 16 minutes (Fig. 16). We break the drill body out of the block and remove the sprue carefully.

Next, we remove the reference body from the thermoplastic stent and, using a scalper or bur at a very low speed, cut away a thin layer of the thermoplastic material from the bottom of the guide to allow the drill to pass through the guide. When snapping the drill body into the thermoplastic stent, it is important to ensure that the drill body is inserted with the correct vestibulo-oral orientation (Fig. 17).

Sirona produces specific guide handles for each block size (again in small, medium and large) and for several implant guide kits. In our case, we used the guide handles for Straumann for the next step because these handles are compatible with the Implant Direct implant used.

Surgery
We begin with anesthetising the tissue around the work area and placing the cleaned and disinfected CEREC Guide in the mouth, followed by the fit evaluation. The guide should feel secure and not move over the teeth. As we performed the flapless technique, we began by punching the tissue with the appropriate puncher (Fig. 18). We then removed the guide and easily separated and removed the punched tissue (Fig. 19). We placed the CEREC Guide back into position and continued with subsequent drills and guide handles.

Using the guide kit for Straumann (Sirona CEREC Guide Drill Key Set ST), we started with the M 2.2 handle and 2.2 mm pilot drill (Fig. 20), followed by the M 2.8 handle and 2.8 mm drill (Fig. 21). Finally, we removed the CEREC Guide and inserted the 3.3/8 mm SwishPlus implant without the guide, that is, free hand (Fig. 22).

Temporary
We screwed a solid abutment (Implant Direct; Fig. 23) into the inner part of the implant, and covered the screw-hole with Teflon. This was immediately followed with an intra-oral scan. As scanning powder cannot be used for an unhealed soft-tissue margin, we used the new powder-free CEREC Omnicam camera. Next, we proceeded through the steps of CEREC Software 4.xx (Fig. 24) to mill the temporary crown from a LAVA Ultimate block (3M ESPE; Figs. 25 & 26). While it is acknowledged that dentistry is not Formula One, the patient was very satisfied with a total treatment time of 115 minutes.

Conclusion
This case report has demonstrated the workflow and manufacture of CEREC guides. Anyone interested in this procedure and its processes is invited to visit our training centre in the Czech Republic, where one can view patient surgeries live and participate in a practical demonstration course. For further details and course schedules, please visit www.gototraining.cz._

Important note: If immediate casting of a plaster model is not possible at your practice, it is possible to utilise a hydro-plastic stent material with a reference body of the correct size together with intra-oral scanning of the mouth to be placed directly in the mouth without a stone model.

_Contact_

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Fabrication of a customised implant abutment using CAD/CAM: A solution specific to each clinical case

Author: Dr Thierry Lachkar, France

The multiplicity and sophistication of the offering in the field of prosthetic elements in implantology allow the practitioner to make a choice appropriate to the clinical particularities of each case. If the practitioner chooses a standard implant abutment, the dental technician will have to make adjustments, which implies considerable losses in precision and time. Moreover, with such abutments it is difficult to create an anatomical emergence profile because it cannot be modified and the base of the abutment cannot be changed. This observation is equally applicable to the angulation, which might even be selected by default.

A customised abutment created with CAD/CAM is the most accurate and simplest solution for an optimal result. The abutment is individually designed in order to ensure the homothety of the thickness of the materials and therefore the overall strength of the prosthesis. The dental technician has in this case maximum freedom in terms of design in order to create an abutment with the optimum emergence profile and angulation. In this manner, the abutment is specifically designed and fabricated for each patient.

Titanium has been established in dental implantology as the reference material owing to its biomechanical properties and its biocompatibility. Today, we are able to benefit from over 40 years of clinical and experimental experience in implantology. Customised abutments can be fabricated from titanium, zirconia or hybrid materials, such as a combination of titanium and zirconia, which in certain clinical circumstances improves the aesthetics of the visible areas while respecting the requirements of biocompatibility and biomechanics.

Seating a four-unit bridge on three anatomical implant abutments

Clinical case

A 40-year-old male patient presented for treatment. He had no particular medical conditions or any contra-indications concerning the placement of implants. In 2009, the patient had undergone a sinus lift (an increase in the maxillary bone volume and the displacement of the sinus membrane to ensure implant success by increasing the height of the available bone) at a hospital prior to the placement of implants to replace teeth 15–17. The post-operative sequelae (pain, oedemas, etc.) resulted...
in the patient being entirely opposed to another intervention of this kind on the opposite side of the mouth.

During an appointment in October 2011, I was able to persuade the patient to accept implant treatment. I suggested first removing the three-unit bridge on teeth 23–25 and then extracting the roots of teeth 23 and 25, as well as seating of a denture on the day of the extraction, followed by placement of three implants in regions 23–25, the extraction of tooth 26, and seating of a four-unit bridge as the final prosthetic solution.

As the height of the available bone around tooth 26 was insufficient, I would not place an implant in that area but a tooth extension (a sinus lift would otherwise have been essential). The treatment plan was accepted by the patient two weeks later, and teeth 23 and 25 were extracted at the end of the month.

The patient was seen on 10 January 2012 for implant placement: two implants (NobelReplace RP, Nobel Biocare) with a diameter of 4.3 mm and a length of 13 mm for regions 23 and 24, and one implant (NobelReplace WP) with a diameter of 5 mm and a length of 10 mm for region 25. Tooth 26 was extracted on the same day without placement of an implant as already mentioned.

In May 2012, implant-level impressions were taken (open-tray impression technique), and the patient’s occlusion was recorded using silicone and a bite tray. Owing to the constraints related to the angulation of the implants in regions 24 and 25, I opted for titanium abutments. The angle of the implant in region 23 allowed for the insertion of a titanium–zirconia abutment for good gingival grip and a better aesthetic result.

Ten days later, two titanium abutments (AnA T, Laboratoire Dentaire Crown Ceram) and one titanium–zirconia abutment (AnA T2, Laboratoire Dentaire Crown Ceram) were screwed onto the implants at a torque of 35 N, and sealed with Figs. 2 & 3. CAD/CAM at the laboratory for design of the abutments.

Fig. 4. CAD/CAM at the laboratory showing the framework according to the abutments.

Fig. 5. X-ray control of the abutments placed.

Fig. 6. Panoramic X-ray view and 3-D simulation of the implants.
case report  customised implant abutments

composite. An adjustment check of the contact points and of the occlusion was performed, followed by cementation of a ceramic bridge with a zirconia framework. A follow-up visit took place three days later.

Technique

For this case, it was possible to use abutments made from different materials according to the angulation of the implant: titanium for the pronounced angulations, and a combination of titanium and zirconia for the angulation with no particular constraints. It would have been equally possible to use a titanium abutment for the implant in region 23 but I opted for the titanium–zirconia abutment to obtain a better aesthetic result in the anterior region: brightness, translucency and no visible metal margin.

Customised CAD/CAM prosthetic elements and abutments respect the dental anatomy and allow extremely precise seating of a bridge on implants. Periodontal maintenance is therefore easier owing to easy access with a toothbrush because of the predetermined interdental spaces.

The simplicity of the process saves a considerable amount of time: no adjustments are necessary, the bridge is seated immediately, the occlusion is usually ideal, and greater accuracy can be achieved. In addition, only two appointments are necessary: one for impression taking and another for seating of the bridge.

_Dental technician’s perspective_

When the laboratory (Laboratoire Dentaire Crown Ceram) received this case, we were asked to create three customised anatomical abutments with a titanium interface for an individual and more precise fit, respecting the requirements of biocompatibility and biomechanics, and a coronary part in zirconia for a better aesthetic result.

Once the moulds had been cast, we determined that the considerable angulation of the implants in regions 24 and 25 and their shallow position in the tissue posed difficulties regarding the design of titanium–zirconia abutments. However, Dr Lachkar explained to us that in this case (i.e. the patient’s reluctance to undergo pre-implant surgery) he was forced to place the implants in the bone available and not necessarily in the ideal situation according to a prosthetic plan.

In this case, the titanium interface would have considerably exceeded the buccal surface and it would therefore have been necessary to reduce it. The bonding surface would therefore have been limited, which would have resulted in a great loss of mechanical resistance. We thus decided to use a titanium abutment manufactured from a single block and specially made to allow for such substantial angulations for teeth 24 and 25. For tooth 23, the implant angle allowed for a titanium–zirconia abutment, which was preferred to a titanium abutment for a better aesthetic result._

_Figs. 7 & 8_  The abutments in situ. Note the slight blanching of the gingival mucous membrane, indicating good subgingival adaptation.  
_Figs. 9 & 10_  Final result.

_Dr Thierry Lachkar_  
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Improving aesthetics in CAD/CAM dentistry – anatomic shell technique

Authors_ Drs Nelson RFA Silva & Paulo Kano, Brazil, Dr Eric Van Dooren, Belgium, Dr Cristiano Xavier, Brazil, Dr Jonathan L. Ferencz, USA, Emerson Lacerda, Brazil

Abstract
Challenges in aesthetic dentistry frequently involve achieving natural and lifelike surface textures and ensuring the predictability of the final aesthetic results.

This article presents the anatomic shell technique (AST), which uses flowable composite resin shells as temporary veneers to guide the fabrication of the final restorations and to predict the aesthetic and morphological outcomes using CAD/CAM technology.

Introduction
Lack of predictability regarding the final aesthetic outcome of CAD/CAM restorations is one of the major concerns among dental professionals, particularly in complex cases involving reconstruction using multiple units. Unfortunately, there is limited literature available on this topic. This article presents a technique in which light-cured flowable composite resin shells are used as temporary veneers prior to the final restoration to predict the aesthetic and morphological outcomes using CAD/CAM technology. A clinical case is used to describe and illustrate the clinical steps.

One of the challenges in aesthetic dentistry is achieving natural and lifelike surface textures. Surface texture directly influences the colour value and saturation and the zones of light reflection and absorption. An anterior restoration that does not exhibit a surface texture and lustre that is comparable to the adjacent natural teeth will immediately appear to be out of place, particularly when the surface of the surrounding dentition is complex or heavily textured. The natural tooth surface is composed of horizontal and vertical concavities.
and convexities that vary in complexity and intensity from tooth to tooth. The ability to observe and replicate the surface texture and lustre to create an anterior restoration that is indistinguishable from adjacent natural teeth typically requires a highly skilled laboratory technician. However, if one could mimic the surface texture of adjacent natural tooth surfaces and use a milling machine to reproduce it, one could provide a very good aesthetic restoration without the need for a highly skilled laboratory technician. The goal of this article is to describe a novel approach that attempts to reproduce the complexities and nuances observed in the surface texture and lustre of natural teeth utilising the AST technique for CAD/CAM restorations.

**Case description**

The treatment described involved a 43-year-old patient seen at the clinic with the chief complaint of dark staining of his teeth from antibiotic therapy (particularly tooth 21; Figs. 1a–d). The patient stated that his appearance affected his ability to socialise and smile. The patient expressed an interest in having his teeth treated to improve both his appearance and his occlusion.

The clinical investigation showed a very dark root due to endodontic treatment, with compromised remaining coronal structure. The endodontic treatment was accepted and a fibre post was cemented using a dual-cure resin cement (Multilink Automix, Ivoclar Vivadent) according to the manufacturer’s instructions, followed by temporary. Tooth 11 also exhibited an abfraction lesion.

At this point, it was decided to address the patient’s aesthetic goals with porcelain veneers. To achieve a rapid aesthetic transformation, the treatment plan involved using digital dental technology together with a novel concept in which composite resin temporary veneers (composite resin shells) were utilised prior to the placement of the final restorations to predict the final aesthetic outcome and to provide lifelike texture.

**Materials**

IPS Empress CAD Multi (leucite-reinforced glass-ceramic blocks; Ivoclar Vivadent) in shade A2 was selected for the final restorations. No impressions were taken.

Figs. 2a & b, Image of the Hajto model showing the surface texture of the anterior teeth (a). Image of composite shells under polarised light. Note the opalescence of the composite shells when the photograph was taken under polarised light (b).

Figs. 3a–f, Anatomic resin shell being positioned (a), polished (b) and luted (c) without etching and utilising a flowable composite. The texture obtained mimics the original texture of the Hajto model shown in Figure 2 (d–f).
or diagnostic casts were used during the treatment planning and clinical procedures. The entire aesthetic treatment plan relied upon imaging (including photographs), prefabricated Hajto models and dental digital technology (CEREC AC with Bluecam, Sirona—CEREC Software 4.0).

**Description of the anatomic shell technique**

The digital smile design protocol was used to determine the aesthetic needs of the patient. The patient, with the dentist’s assistance, selected the shapes of the teeth that best suited him using digital photographs of natural smiles from a computer smile library.

After determining the ideal shapes and sizes from the digital smile design database, Hajto models were selected based on the previously determined tooth dimensions of the patient. Subsequently, a silicone index (Virtual, Ivoclar Vivadent) was produced from the labial surface of the anterior teeth of the Hajto model that best matched the patient (Figs. 2a & b). Hajto models are replicas of the ideal natural anterior dentition of males and females, with examples of different tooth shapes, sizes and surface textures.

**Composite resin shells**

A light-cured flowable composite resin (Tetric EvoFlow Ivoclar Vivadent) was then carefully placed into the index to produce very thin composite shells that duplicated the shape of the model teeth. After complete polymerisation, the composite shells were gently placed intra-orally on the labial surfaces of the teeth and adjusted to obtain the best possible fit (Fig. 3a).

Once the best anatomic resin shell position was obtained, the shells were polished and luted without acid etching using flowable composite (Tetric EvoFlow, Ivoclar Vivadent) (Fig. 3d–f).

The clinician together with the patient evaluated the aesthetic outcome with the polished composite shells in place (Fig. 3d–f). Digital photographs were taken to analyse the symmetry between the teeth and the patient’s face. Following the digital imaging analyses, small adjustments were performed at the interproximal embrasures. After completion of the aesthetic modifications and polishing steps, the patient was asked to give permission to proceed with treatment for his new smile (Fig. 4).

**Digital imaging**

In order to facilitate the digital image capturing process, CEREC Optispray powder (Sirona; Fig. 5) was applied in the patient’s mouth to coat the teeth restored with the composite resin shells. An intra-oral scanner (CEREC Bluecam) was then used to create a 3-D digital model of the full mouth with the temporary composite resin shells.
In this procedure, the composite shells help to predict the shape and the final aesthetic outcome of the milling process. They also serve as a guide to establish the amount of reduction necessary during tooth preparation. After the scanning process, therefore, the teeth were prepared using the composite resin shells as a reference to determine the amount of tooth reduction.

A digital impression was taken (CEREC Bluecam) after the preparations had been completed. The digital image acquired after preparation was merged and correlated with the digital image taken with the anatomic composite shell in place to generate the proper shape of the permanent veneers to be fabricated (Figs. 6a–e). The milling process was then initiated using a CEREC III milling unit equipped with CEREC Software 4.0.

After the milling process, the veneers were removed from the milling unit and visually inspected for potential flaws. The veneers were then tried-in, polished with 0.6µm diamond paste and subsequently placed with Variolink Veneer Medium Value 0 (Ivoclar Vivadent) using the adhesive technique according to the manufacturer’s instructions (Figs. 7a–c). In order to mask the dark shade of the tooth substrate, a staining agent (IPS Empress Universal Stains, Ivoclar Vivadent) was applied internally to each veneer prior to cementation.

**Conclusion**

The concept of chairside CAD/CAM restoration differs from conventional dentistry in that the restoration is typically luted or bonded in place on the same day, whereas conventional dental prostheses of larger size, such as crowns, involve the placement of temporaries for several weeks while a dental laboratory produces the restoration. As the CAD/CAM restoration is bonded on the same day, the principles applied in predicting the final outcomes present unique challenges compared with conventional clinical procedures for any aesthetic treatment. The clinical case described here presented some limitations, as can be seen in the slight bulkiness of the final restorations and the straighter incisal edges of the two central incisors (Figs. 7a–c) compared with the composite shells (Figs. 3d–f). These differences were attributed to a software limitation, as no other anatomical/morphological modification was performed after the milling process had been completed. However, the final outcome using monochromatic blocks was acceptable and the clinical sequence presented here using AST shows a very simple and innovative way to predict the final outcome of an aesthetic treatment and suggests that CAD/CAM technology is a very attractive concept when one understands the materials science, machine capability and the limitations involved.}

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

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Today’s new digital technologies allow us to produce even challenging dental restorations in a creative, highly precise and time-efficient manner. So, why should we work with the old methods when Schütz Dental provides us with the means to produce therapy splints with an excellent fit via CAD/CAM technology? These splints offer exceptional material characteristics and are economical to produce (Fig. 1).

The production of therapy splints using Schütz Dental products does not necessitate complex new systems and techniques. Rather, it follows the established procedures of CAD/CAM.
restoration techniques. A situation model is first produced. Next, impurities such as bubbles are removed from the occlusal area. Subsequently, the model is adjusted regarding the relation between the skull and temporomandibular joint with the help of a facebow.

The upper and lower jaws are each digitised with a complete 3-D scan after a patient case has been created in the workflow file. Afterwards, both models are adjusted to each other in the scan fixator and scanned. A precise match of the models is achieved with help of this scan fixator. The fixator also helps to provide an exact adjustment to the relation between the skull and temporomandibular joint in the virtual articulator. This completes the scanning procedure.

The models are then opened in the Tizian Creativ RT CAD software (Schütz Dental). First, the insertion vector of the splint is preset. In this case (Fig. 3), it is done for the lower jaw. Here, the user presets the parameters that determine the later fit (tight or loose).

Next, the fully adjustable virtual articulator is positioned (Fig. 4). Owing to its multitude of functions, it allows for comprehensive individualisation. An exact positioning of the incisors and canines is obtained by adjusting the incisal panel in angle and inclination individually. The bite can be raised by adjusting the incisal marker.

In addition to these options, the system allows the user to apply measuring data from
industry report  _therapy splints_

In the following step, the vertical length of the splint is defined using a preparation margin (Fig. 5). The minimum thickness of the splint is specified individually. It is very important, however, to create visible impressions in the occlusal areas. The dynamic occlusion (working and balance contacts, as well as protrusive movements) is ground gradually by clicking on the mouse. Finally, any excess material in the occlusal area is removed, and the positioning of the incisors and canines is corrected if necessary. Afterwards, the workflow can be closed (Figs. 6–9).

The open STL (Surface Tessellation Language) interface enables the user to mill the generated file in-house with a five-axis milling system, for example with the Tizian Cut 5 smart (Schütz Dental). The material of choice for therapy splints is a transparent blank made of PMMA, for example a Tizian Transpa (PMMA) blank (Schütz Dental). I discourage the use of a three- or four-axis milling system because such systems cannot provide the precision necessary for the production of a therapy splint.

Another simple option for producing the splint is sending the dataset to a milling centre to have the splint milled there. The finished splint will arrive at the laboratory only two working days after sending the STL dataset to the milling centre.

The remarkably high precision of the splint becomes obvious when first placing it on to the situation model (Fig. 10)—no matter whether it was milled in-house or industrially, or whether it was printed. Nonetheless, all occlusal contacts and movements (laterotrusion, protrusion) must be checked with an articulator and corrected if necessary.

Finally, the CAD/CAM-produced therapy splint is finished conventionally with polishing paste and a linen buff (Fig. 11).

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**Fig. 10**

The STL file of a finished therapy splint with occlusal contour.

**Fig. 11**

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Newest developments in the European dental prosthetics and CAD/CAM devices segments

Authors: Dr Kamran Zamanian and Ceren Altincekic, Canada

The European dental prosthetics and CAD/CAM devices segments are currently experiencing two opposing forces that will determine the future of these segments. On the one hand, the eurozone crisis is far from being over. Southern European countries such as Spain, Italy and to some extent France are going through an economic downturn, which is delaying dental restorations and slowing down industry growth. On the other hand, the segments are growing at a significant pace owing to technological innovations in restoration materials, CAD/CAM devices such as intra-oral scanners and smaller, but more efficient milling machines. The second trend is expected to trump the first one as countries slowly recover from the economic crises and new technologies revive the market.

All-ceramic and porcelain-fused-to-metal restorations dominate the European dental prosthetics market

All-ceramic restorations are becoming increasingly popular in the European market owing to their aesthetic value. In 2012, the all-ceramics segment grew by more than 5 per cent to constitute a third of all crowns and bridges sold. All-ceramic restorations are expected to approach the porcelain-fused-to-metal share by 2019. Non-precious restorations represent the largest portion of all crown and bridge work owing to their affordability. They will remain at the level of approximately 42 per cent over the next few years. Semi-precious and high-precious materials will be impacted adversely as their biocompatibility and durability are increasingly mimicked by other, less-expensive materials such as cobalt–chromium alloys. Precious metals used in dental restorations, such as gold, have experienced significant price hikes over the last decade. As their utility diminishes, these metals will begin to lose market share in the dental prosthetics segment.

New technologies are beginning to blur the lines that separate different dental restoration materials. Composite materials are becoming more popular, as they combine the most desirable characteristics of their components. New products such as translucent zirconia or hybrid ceramics are promising better value with increased resilience and a more natural look.

Higher demand for these products will drive higher prices for quality dental prosthetics. Composite materials are becoming more popular, as they combine the most desirable characteristics of their components. New products such as translucent zirconia or hybrid ceramics are promising better value with increased resilience and a more natural look.

Intra-oral digital impression-taking scanners becoming more popular in the European market

Intra-oral digital impression-taking scanners are attracting the attention of more dentists and laboratories alike owing to their ease-of-use, non-invasiveness and recent affordability. Newer-generation intra-oral scanners allow dentists to take impressions without the use of powder or paste, which makes the process much faster and less intrusive for patients. Once the impression has been taken, the technician can modify the image as he or she wishes and then send it to a laboratory for milling. The increase in the number of intra-oral scanners in the market is pushing scanner manufacturers to offer open-architecture software that will allow users the freedom to choose the milling centre of their preference. All these aspects of intra-oral scanners make them attractive investments for dental offices and laboratories alike.
Over the next few years, the sales of intra-oral scanners will reach double-digit growth. Dentists will increasingly opt for these scanners instead of chairside systems owing to their affordability and practicality. The prices of these scanners will decrease, making them even more affordable. The average selling price of an intra-oral scanner was a little over €28,000 in 2012, an investment that medium-sized laboratories and dentists can easily afford.

The main competitor in this market is Sirona. The company has over 20 years of experience in the intra-oral scanners segment. Its latest product, the CEREC Omnicam, has introduced a new technology with colour scanning, which allows the dental technician to scan the natural colour of the teeth in 3-D. A similar product was launched by 3Shape at the 2013 International Dental Show in Cologne. TRIOS Color can scan and capture the teeth and gingiva quickly, realistically and in great detail. Intra-oral scanners are evidently becoming the new standard at dental practices.

CAD/CAM blocks segment experienced double-digit growth

CAD/CAM blocks had a good year in 2012, despite the lingering effects of the eurozone crisis. Even though block prices have remained stable or dropped owing to increasing competition from Asian companies, the double-digit growth in unit sales largely made up for price cuts, as the segment grew by over 10 per cent in 2012. The growth in the blocks segment has been fuelled by the increase in CAD/CAM system sales, particularly chairside systems. Chairside systems come with a milling machine that mills the restorations from blocks. As sales of chairside systems have increased significantly and will continue to do so up to the end of 2019, the blocks segment has followed that demand closely.

The majority of crowns milled from CAD/CAM blocks on chairside systems are made of all-ceramic material. However, most dental restorations are produced from zirconia because dental laboratories are still the main providers of dental prosthetics. In 2012, zirconia crowns represented over half of the CAD/CAM blocks segment, with the remainder being divided between porcelain and acrylic/composite products. By 2019, porcelain blocks are expected to close the gap, exceeding half of all blocks sold. This trend is consistent with the ever-increasing demand for all-ceramic restorations and the technological developments that make ceramic restorations more resilient and natural-looking than their counterparts are.

AmannGirrbach and Dental Wings are among the rising stars of CAD/CAM systems segment

The CAD/CAM systems segment is experiencing new, dramatic trends. Smaller, cheaper and more-efficient milling machines capable of milling a variety of materials are taking their place in laboratories of various sizes and even in some dental offices. AmannGirrbach has made great progress with its motto "the in-house company", promoting laboratory independence by providing affordable milling machines.

The future of scanner software lies in open systems that create a scan file that can be sent to any milling centre in the world. Dental Wings is making great strides by providing this open-architecture software and affordable scanners to both laboratories and dentists. Through exclusive partnerships with Straumann and 3M ESPE, Dental Wings is aiming at creating common global software for a variety of stand-alone scanners.

Alongside these rising stars, companies like Sirona, 3Shape, 3M ESPE and DeguDent maintain their significant market share in the CAD/CAM systems segment. Sirona is the clear market leader in chairside systems and 3Shape dominates the stand-alone scanners segment, albeit with other competitors such as 3M ESPE, Straumann and Nobel Biocare following closely. The CAD/CAM systems segment is expected to become more competitive as new players emerge and devices become more affordable and efficient.

Editorial note: The information contained in this article is taken from a detailed and comprehensive report published by iData Research, titled "European markets for dental prosthetics and CAD/CAM devices". This report is part of a global series covering Latin America, Asia Pacific and the US.

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iData Research is an international market research and consulting firm focused on providing market intelligence for the medical device, dental and pharmaceutical industries.
“Innovation is in our corporate DNA”

An interview with 3Shape chief technology officer Tais Clausen

Less than a decade after its founding, 3Shape has become one of the most successful providers of digital dentistry solutions. The company based in Copenhagen in Denmark aims to build a powerful workforce to provide the market’s best products, support and services. Today international had the opportunity to speak with Tais Clausen, chief technology officer and co-founder, about the development of the company and new solutions for laboratories and dentists being presented at the International Dental Show.

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**DTI:** The growth of the company is attested to by 3Shape’s booth, which is bigger than the one at the last IDS two years ago. Which new products is 3Shape presenting at the exhibition, and what makes these products unique?

**Tais Clausen:** Two years ago, at IDS 2011, with the then brand-new TRIOS impression-taking solution, new laboratory scanners, feature-packed CAD software, and revolutionary digital workflows, we attracted many visitors to our booth. Since then, we have not rested on our laurels, and it has been a very busy and exciting time for our developers. This year, 3Shape is showcasing a completely new dental scanner for laboratories that captures textures in colours and boosts productivity with a new and fast multi-die scanning solution. Advanced technologies make this scanner extremely fast and accurate and a great solution for high-production laboratories working with all types of indications, including advanced restorations. We are offering live demos of 3Shape’s recently released Dental System 2013 and giving visitors a sneak peek at the next major software release: Dental System 2014. Our new brochure on some of the planned features of the 2014 version is also available. There have been many new improvements to TRIOS too, and we can certainly promise dentists much to look forward to. TRIOS technology has been boosted with greater speed and more functionalities through software updates, and the solution now comes with various flexible hardware configurations.

3Shape will be unveiling its newest innovations and we will be sharing some stunning product secrets saved exclusively for IDS 2013.

**IDS** is the ideal platform for reaching dentists from all over the world. Are there any additional 3Shape presentations planned for the exhibition?

Yes, we have set up an extensive programme of free public lectures on digital dentistry and 3Shape solutions. Topics such as CAD workflows, new digital service options, and industry trends will be covered. Prominent speakers include both 3Shape colleagues and other recognised dental industry experts. The lectures will be held at our stand.

Can you give us a brief outlook on the directions for future development in the industry and at 3Shape?

We foresee continued development by the material manufacturers to capitalise even more on the advantages of digital dentistry, along with software integration of different image technologies, design and production processes, new laboratory–dentist service tools, communication, training, and enhanced information sharing. We aim to develop new CAD/CAM technologies that will help digital production of restorations become better, faster and more consistent. We will continue to focus our efforts on creating tools that will allow both laboratories and dentists to prosper.

Thank you for this interview.

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“We aim to develop new CAD/CAM technologies...”

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Tais Clausen. (Photo courtesy of 3Shape)
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1 The Straumann Guarantee applies in favour of the attending physician/dentist only, provided that all conditions of the guarantee are fulfilled. Please see the full Straumann Guarantee brochure (152.360) for more details.

2 For validated workflow only. Precision is understood as the match of the restoration with the design data provided by the laboratory.
Immediate implantation in combination with biomaterials can effectively prevent bone resorption after tooth extraction. This was one of the key findings presented at the tenth International Osteology Symposium in the principality of Monaco last month. Well-known periodontologist Prof. Jan Lindhe from Sweden told event participants in a keynote lecture that although bone resorption in the mesiodistal dimension can be prevented through immediate implant placement preclinical studies have shown that ridge preservation procedures with biomaterials are usually required to preserve the buccopalatal dimension too, a discovery also confirmed by fellow presenter Dr Dietmar Weng from Germany.

Presentations on other important aspects of dental implant therapy included soft-tissue management and peri-implantitis, the frequency of which, according to presenter Björn Klinge from the Department of Dental Medicine at the Karolinska Institutet in Stockholm, Sweden, remains difficult to assess owing to contradictory scientific data and differences regarding its definition. While the prevalence of the condition itself remains a matter of debate, there was general agreement that primary contributing factors include inadequate bone volume, as well as the distance between and the position of the implants.

In addition, new clinical evidence was presented that supports the assumption that sufficiently keratinised mucosa around implants can prevent peri-implantitis. Biomaterials offer significant advantages over connective tissue grafts or free gingival grafts in this regard because their use has demonstrated greater patient satisfaction owing to the reduction in operating time and post-operative pain, according to US periodontist Todd Scheyer.
This year was the second time that the Osteology Foundation held its scientific symposium in Monaco. Established through a partnership between Dr Peter Geistlich, founder and former CEO of the company with the same name, Dr Philip Boyne from the Loma Linda University and Harvard professor Myron Spector a decade ago, the foundation based in Switzerland has become a leading platform for research on regenerative therapies for oral tissue.

Since 2003, it has spent CHF0.5 million annually for funding scientific studies on the topics of regenerative dentistry and dental-tissue engineering, according to its figures, among them a recent paper by a clinical team from the Faculty of Dentistry at the Complutense University of Madrid that evaluated a novel flapless technique for cleft-palate repair by injection of a BMP-2-containing hydrogel.

Overall, more than 40 studies conducted by researchers around the world have been financially supported this way over the last ten years, the foundation said. This year’s Osteology Research Prize was awarded to clinicians from Spain and Italy.

It also holds regular scientific symposia to educate practitioners on the subject of regenerative dentistry. This year’s edition drew 2,700 participants to Monaco. Besides 60 scientific presentations, the event offered pre-congress hands-on workshops, a research forum, a poster exhibition and an industry showcase. The next edition is to be held in 2016.
We are experiencing exciting technological growth in the dental industry. Those lucky enough to attend the 35th edition of the International Dental Show in Cologne, Germany, witnessed the vast number of companies showcasing and introducing first-time products in the field of CAD/CAM and digital dentistry, which has become a trend in the dental industry.

It is safe to say that digital dentistry is no longer the future, but the present.

In October 2013, dentists, dental technicians, hygienists and assistants will once again have the opportunity to gather together to discuss the latest developments in digital dentistry in Singapore during the second Asia Pacific CAD/CAM and Digital Dentistry International Conference.

Proudly supported by the Singapore Dental Association and following the success of the first edition, the second conference will take place on 4 and 5 October 2013 at the Marina Bay Sands hotel in Singapore. This year, attendees of the event can earn up to 14 CME/CPD points (recognised by the American Dental Association). Moreover, the conference will feature various stars in digital dentistry, such as Dr Eduardo Mahn, Dr Kurt Davirs, Dr Bernd van der Heyd and Werner Gotsch. Additional lectures and workshops will be announced in the coming weeks.

The event is supported by the Singapore Tourism Board and Singapore Exhibition and Convention Bureau. All information on attendance and registration can be found at www.capp-asia.com, and for any queries please contact Tzvetan Deyanov at deyanov@capp-asia.com.

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www.cappmea.com

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BACD Annual Conference
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Questions?

Magda Wojtkiewicz (Managing Editor)
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