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CAD/CAM

international magazine of digital dentistry

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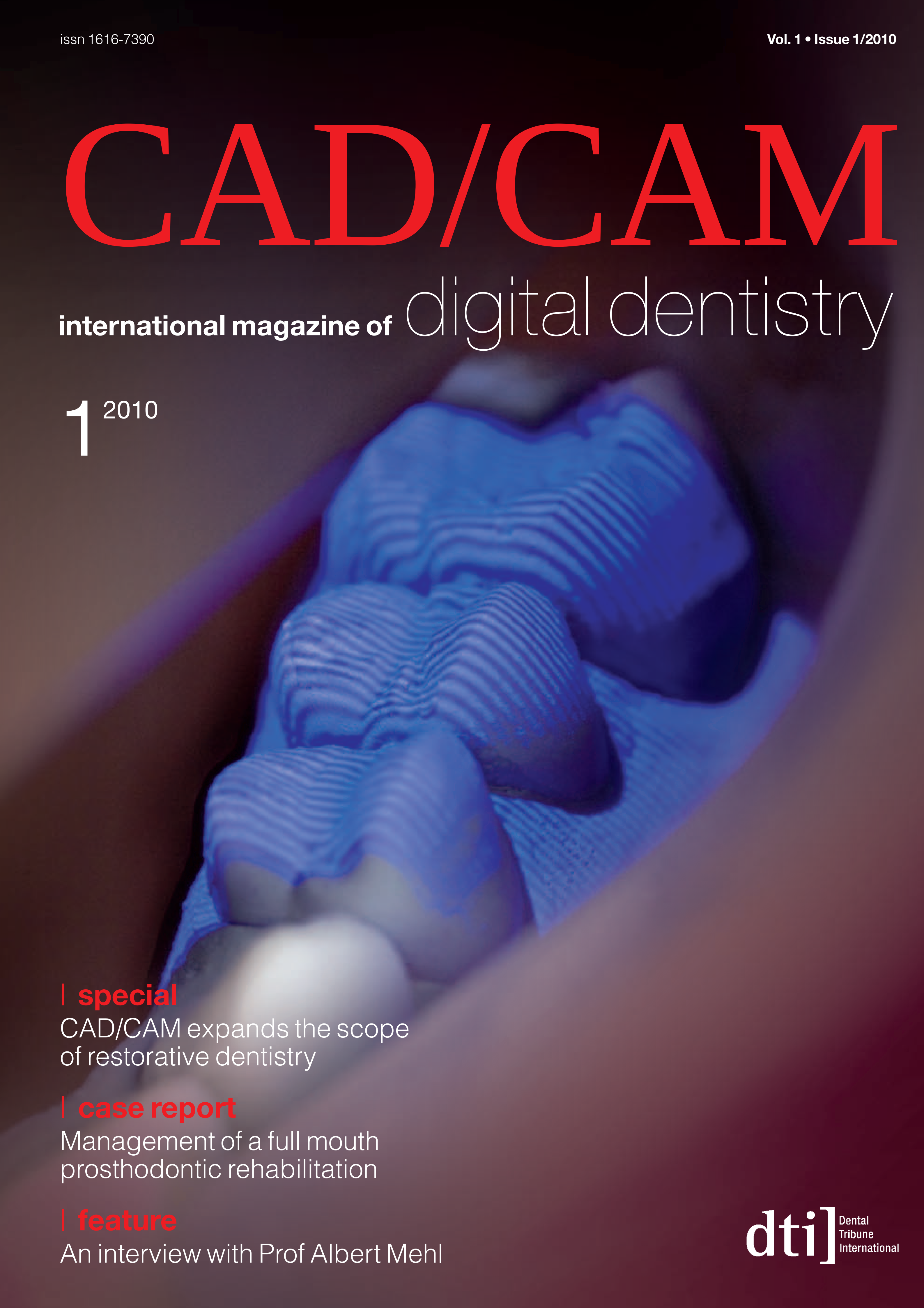

special
CAD/CAM expands the scope of restorative dentistry

case report
Management of a full mouth prosthodontic rehabilitation

feature
An interview with Prof Albert Mehl

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Dear Reader,

Torsten R. Oemus
President DTI

_**It is undisputable** that modern dental treatment procedures will increasingly become digitalised. The advantages this development offers to dental practices, laboratories and patients are convincing and supported by recent research results. Today, tooth restorations and replacements are being manufactured faster, more safely and with more precision than ever before.

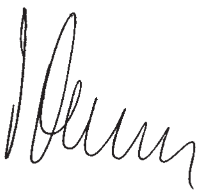
Their affordability and long-term clinical results will determine whether these technologies will become standard in dental practices and laboratories. I personally see clear potential here, as investing in new technology could attract orders previously met by companies in China and Eastern Europe.

However, the technology alone does not automatically make better dentists or laboratory technicians. New machines and technology are only as good as the person operating it. Therefore, it is the aim of CAD/CAM **international magazine of** digital dentistry to provide comprehensive knowledge and information regarding the latest technology that can profitably be integrated into treatment concepts. It shall also serve as a platform for sharing experiences of products and treatment procedures with colleagues across the globe.

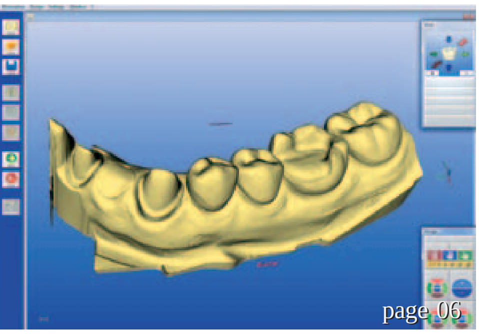
The range of topics covered in the magazine includes CAD/CAM, digital imaging, rapid prototyping, virtual articulation, dental materials, impressioning, radiography, software processing, and innovations in digital dentistry. The content is a combination of scientific articles, case reports, industry reports, reviews (meetings, products, etc.), news, practice management articles, and lifestyle articles.

I hope you will enjoy this inaugural issue of CAD/CAM, and invite you to send us your first impressions, as well as suggestions and questions.

Yours sincerely,



Torsten R. Oemus
President Dental Tribune International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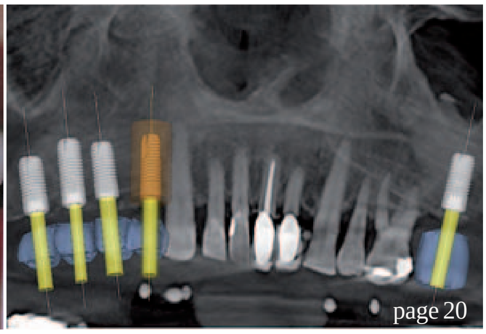
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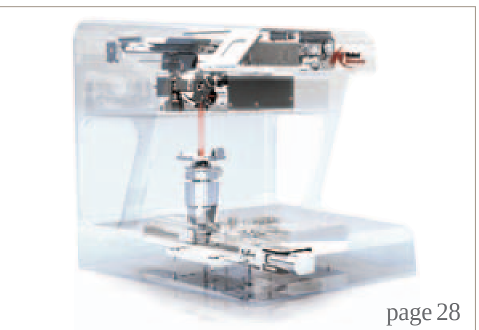
CEREC AC powered by Bluecam
(Courtesy of Sirona Dental Systems)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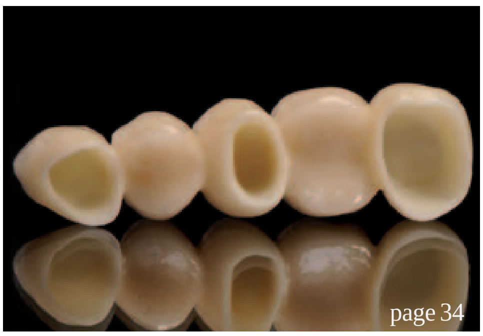
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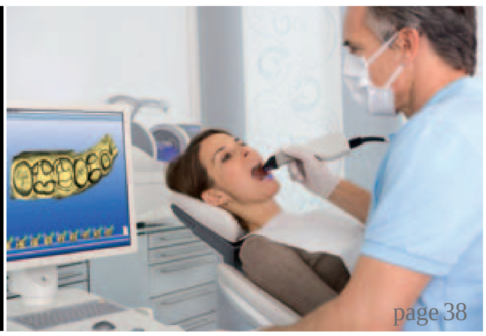
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CAD/CAM expands the scope of restorative dentistry

Author_ Manfred Kern, Germany

Fig. 1

Fig. 1_Prof Werner Mörmann and Dr Marco Brandestini in 1985 with the CEREC 1 prototype. (Photo: Prof Werner Mörmann/ Quintessenz)

_Today, it is impossible to imagine dentistry without digital technology and CAD/CAM procedures. Intra-oral and extra-oral measuring, the scanning of antagonists and bite registrations, 3-D design on a computer, the availability of countless tooth shapes in a dental database, the creation of anatomically shaped occlusal surfaces, functional articulation on a virtual model, the subtractive machining of high-performance ceramics—all this would be impossible without computers.

The groundwork for this quantum leap was laid in Switzerland in 1985. For the first time ever, a 3-D optical impression of a prepared tooth was acquired using an intra-oral video camera (triangulation measuring technique) and then transferred to a computer.[1] Using a computer, special imaging software and a CNC milling unit, Prof Werner Mörmann and Dr Marco Brandestini from Zurich University created the first CAD/CAM inlay from a silicate ceramic material (Fig. 1). This development was occasioned by Prof Mörmann's unpromising experiments with occlusion-borne composite inlays as a substitute for amalgam.

Owing to the high degree of polymerisation shrinkage, these inlays required extensive machining, did not fit exactly to the inner surfaces, and displayed large tolerances at the margins. In addition, Prof Mörmann wished to use ceramic on account of its similarity to natural enamel and dentine. Only with the aid of computer-controlled profile-grinding and milling machines was it possible to mill silicate ceramics (and later oxide ceramics) subtractively for highly aesthetic restorations—restorations that displayed constant and reproducible material characteristics, as well as scope for cost optimisation. The broad acceptance of dental CAD/CAM procedures is evident from the more than 20 million all-ceramic restorations (chairside plus labside) that have been produced worldwide.

_Adhesive bonding furthered the development of CAD/CAM restorations

Two factors played a role here. The first factor was the desire of proponents of computer-aided chairside restorations to machine an industrially manufactured silicate ceramic with defined physical characteristics directly adjacent to the chair, and treat the patient in a single visit, without the need for a temporary. The second factor was the introduction of adhesive bonding, which creates a force-locked link between the ceramic restoration and the residual tooth tissue, does not display a mechanical interface and hence prevents crack-inducing tensile stresses. Since the introduction of adhesive bonding, it has been possible to apply defect-oriented and substance-conserving preparation techniques.

The combination of CAD/CAM ceramics and adhesive bonding facilitated the permanent stabilisation of seriously weakened cusps (Fig. 2). It was possible to dispense with mechanical retention in the cavity geometry because adhesive bonding guarantees an intimate link with the residual tooth. In many cases, a partial ceramic crown eliminated the need for a metal-based crown. This latter type of crown has the disadvantage that it necessitates a circular preparation (and hence the loss of healthy tooth tissue) in order to achieve the necessary retention. The mechanical strength of individually machined silicate ceramics is transferred directly to the tooth tissue.

This is particularly beneficial in the case of inlays, onlays, partial crowns and seriously weakened cusps.

Prof Mörmann's goal was to deploy CAD/CAM technology to create immediate all-ceramic restorations chairside without the need for temporaries. This goal derived from his experience that temporarily restored inlay cavities have a significantly negative influence on the integrity of the enamel. In many cases, the non-adhesively bonded temporary was positioned like a wedge in the cavity and transmitted the chewing forces to the weakened residual tooth. The applied forces also deformed weakly protected cusp walls. This resulted in cracks in the oral and vestibular enamel surfaces.

A second goal was to make use of high-strength oxide ceramics, such as aluminium oxide (Al_2O_3) and zirconium oxide (ZrO_2), and computer-controlled milling machines in order to create crown-and-bridge frameworks and hence pave the way for metal-free prosthetic treatment.

Another recent development is the online transmission of intra-oral and extra-oral digital impressions and restoration design data to external dental laboratories, which then perform the milling tasks. As a result, the dental laboratories are now more closely integrated into the work flow of dental practices.

_Clinically proven

All-ceramic chairside restorations number amongst the most intensively researched dental treatment procedures. Numerous studies confirm that the clinical performance of inlays and onlays is at least comparable with that of cast-gold restorations. Durability is one of the most important evaluation criteria for ceramic materials. This underlines the importance of the study published in 2008 by Dr Tobias Otto (Aarau, Switzerland) that presented long-term clinical data going as far back as 17 years.[2] Since 1989, Dr Otto (one of the first CEREC users in Switzerland) has monitored 200 inlays and onlays produced using the CEREC 1 system and feldspar ceramic (VITA Mark I). These restorations were placed in 108 patients in his dental practice between period 1989 and 1991. He evaluated his findings on the basis of the modified USPHS criteria and summarised his clinical observations after 10 years and 17 years, respectively.

According to Dr Otto, 187 of the 200 restorations were still in place after 17 years. This was a survival rate of 88.7% after an average service time of 15 years (Figs. 3–5). In other words, the annual failure rate was 0.75%. Failures with Charlie and Delta ratings (USPHS) occurred between the 6th and 13th year. In most cases, these failures were attributable to ceramic fractures.

The probability of survival was significantly higher than that of layered laboratory-produced ceramic inlays and was approximately equivalent to that of alternative long-term restorations, such as cast-gold inlays, which have a survival rate of 87 % after 20 years and an annual failure rate of 0.7 %.[3] Dr Otto established that 166 of the CEREC inlays (of an original basis of 200 restorations in 1991) were clinically intact. This is equivalent to a success rate of 83 % after an average service time of 15 years. The survival rate was superior

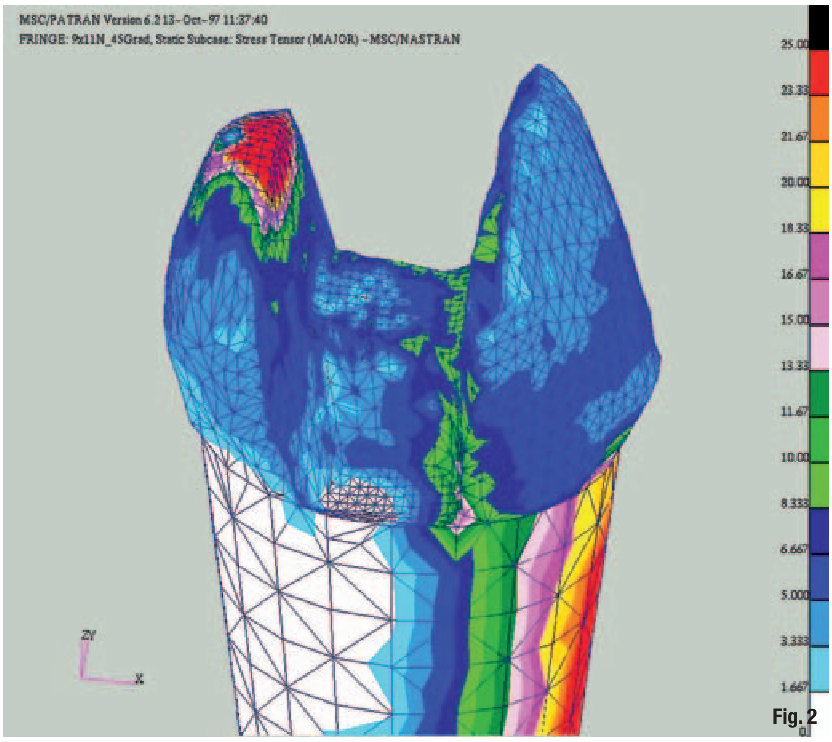


Fig. 2_Finite element measurement with the exertion of chewing forces: the ceramic inlay bears the chewing load; the tooth substance remains stress free (inlay is hidden). (Illustration: Prof Albert Mehl)

to that established by Smales[4] for cast inlays after 15 years (loss rate: 1.5 %). It also compares favourably with the 1.3 % annual failure rate established for all-ceramic, non-CAD/CAM ceramic inlays.[5]

A contributing factor is that chairside ceramic inlays can be placed immediately in a single appointment, thus eliminating the need for temporaries. In the case of conventional labside restorations, a temporary is unavoidable. Prof Roland Frankenberger established that under the influence of chewing forces, the tooth is subjected to torsional stress due to the low elastic modulus of the temporary composite material. These forces can deform inadequately protected cusp walls, cause partial fractures and incipient enamel cracking, and weaken dentine adhesion. By contrast, the immediate placement of the ceramic inlay facilitates a contamination-free adhesive bond with the hard tooth tissue and stabilises weakened cusps. The stabilising effect on the residual tooth and the existence of an adhesive bond obviously offset the consequences of wider adhesive gaps, as evidenced by long-term clinical findings.[6]

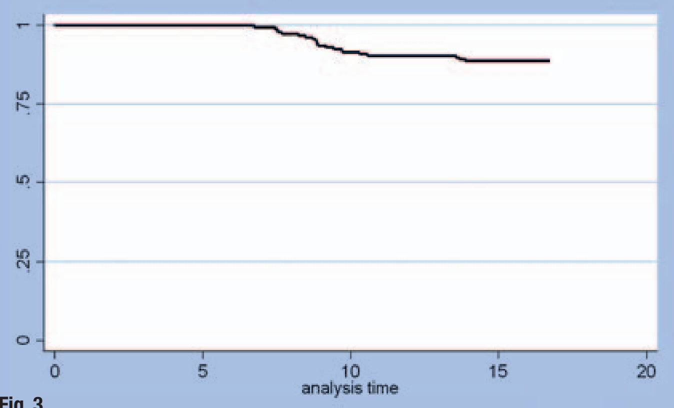


Fig. 3

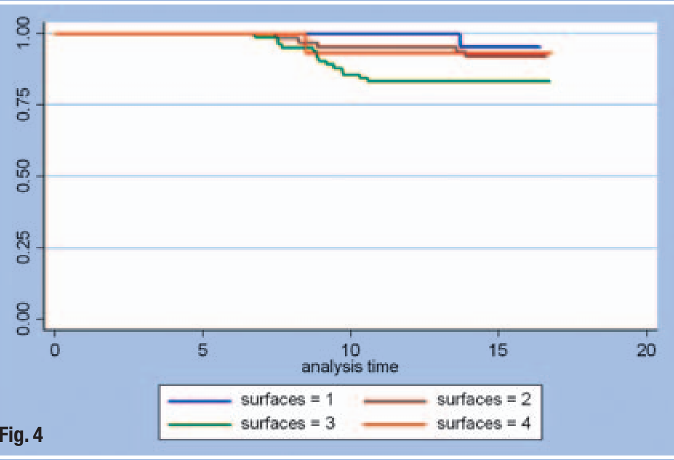


Fig. 4

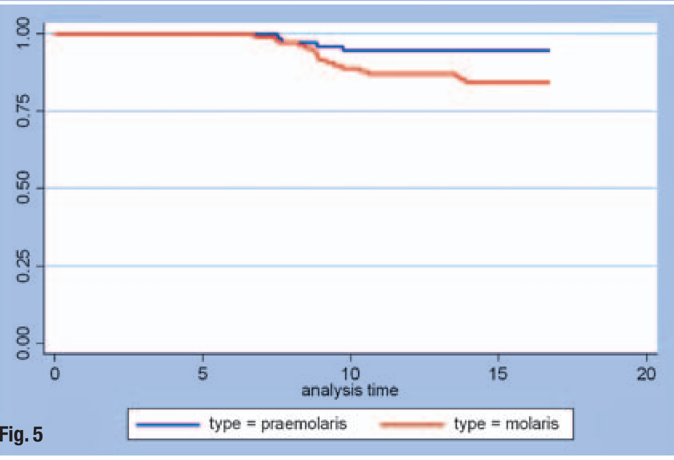


Fig. 5

Fig. 3_Survival rate (according to Kaplan–Meier) of CEREC inlays and onlays: 88.7% after maximum of 17 years. (Source: Dr Tobias Otto)

Fig. 4_Survival rate of one- to four-surface restorations (no significant difference) after maximum of 17 years. (Source: Dr Tobias Otto)

Fig. 5_Survival rates of restorations on molars and premolars: CEREC restorations on premolars display a slightly higher success rate. (Source: Dr Tobias Otto)

_CAD/CAM ceramics conform to the gold standard

A further long-term study of the durability of CEREC restorations was published by Dr Bernd Reiss in 2006. In a private dental practice, 1,010 CEREC inlays and onlays were placed in 299 patients. After 15 to 18 years, 84.4 % of these restorations were still clinically perfect (Figs. 6 & 7). Up to the end point of the study (18.3 years), no further events were observed. If the retention of the restoration is seen as the sole criterion for evaluating survival (that is, if therapeutic procedures such as trepanation and subsequent margin corrections with the aid of composite are ignored), the Kaplan–Meier survival rate was 89 % over the observation period. Dental adhesives were not yet available at the beginning of the study. If the patients are separated into two groups (that is, patients treated with and without the use of a dental adhesive), a significant difference is revealed. Without dental adhesive, the survival rate fell to approximately 80 % after 16 years; with dental adhesive, the survival rate was 90 %. The size of the filling did not play a role. Premolars performed better than molars. Vital teeth performed better then non-vital teeth. During the observation period, 122 events occurred. In 86 % of the cases, this resulted in the loss of the restoration. Fractures (39 %) were the most frequent reason for renewal.[7]

Similar findings were reported by Prof Gerwin Arnetzl. Between 1988 and 1990, Prof Arnetzl placed 358 two- and three-surface inlays made of Dicor, Optec, Hi-Ceram, Duceram and CEREC 1 (Mark I) using the adhesive bonding technique. The control group consisted of cemented gold inlays. After 15 years, CEREC and gold had a survival rate of 93 %. This was significantly higher than the equivalent figure for laboratory-produced sintered ceramic inlays, which had a failure rate of 32 %.[8]

Dr Reinhard Hickel and Dr Jürgen Manhart reviewed the scientific literature over a period of 10 years and calculated the annual failure rates of various materials used for Class I and II cavities. They found that CEREC restorations displayed 25 % fewer failures than cast-gold fillings.[9]

A particularly interesting investigation was carried out by Dr Anja Posselt and Prof Thomas Kerschbaum, who analysed the performance of 2,328 CEREC restorations placed in 794 patients in a dental practice.[10] The survival rate after 9 years was 95.5 %. The filling size, tooth vitality, the prior treatment of caries profunda, the type of tooth and the location of the filling (separated according to upper and lower jaw) did not have any influence. The most common reasons for failure were tooth extractions (22.9 %) and fractures (17.1 %).

Dr Andreas Bindl confirmed the suitability of chairside fabrication methods for anatomically sized CEREC crowns, milled and placed in a single visit.[11] Various stumps were prepared for 208 feldspar ceramic crowns. After 5 years, 97 % (premolar) and 94.6 % (molar) of the conventionally prepared crowns (chamfer preparation) were still intact. Clinically short crowns with a reduced stump height achieved a survival rate of 92.9 % (premolar) and 92.1 % (molar), respectively. The failure rate for endo-crowns placed on premolars was significantly higher.

Within the framework of a meta-analysis, the clinical survival probability of high-quality conservative restoration types with the respective production costs was investigated. Gold inlays and CEREC inlays had the highest success rates. The CEREC restorations perform better in terms of cost effectiveness versus durability. The higher production costs of cast-gold inlays are a disadvantage here.[12]

_Biogeneric occlusal surfaces

The design of functional occlusal surfaces poses a challenge to rehabilitating the chewing function. In this area, too, CEREC has exploited advances in digital technology. IT provides valuable assistance with recreating lost tooth tissue in such a way that the restoration harmonises well with the existing dentition in terms of its structural and functional characteristics. With the aid of biogeneric modelling software, Prof Albert Mehl et al. succeeded in automatically creating patient-specific occlusal surfaces for inlays, onlays and partial crowns.[13–15] In this case, the residual occlusal tooth tissue was compared with several thousand digital scans of natural occlusal surfaces contained in the CEREC tooth library (Fig. 8). The software identifies matching morphological characteristics (fissures, cusps, marginal ridges, gliding contact angle) and then inserts corresponding cusps, fossae, fissures and contact surfaces into the virtual model of the restoration. On the basis of the contact point distribution, the cusp apexes and the proximal contacts, the software is capable of creating a well-matched tooth and detecting possible collisions with the bite registration. This biogeneric modelling process creates natural, individual and functional occlusal surfaces.

The extension of the CEREC indications spectrum to chairside crowns and multiple-unit labside bridges (both temporary and permanent) has placed increased demands on the intra-oral measuring process. The recently introduced CEREC AC system deploys a short-wavelength blue LED light source. In combination with the built-in anti-shake system this blue light source reduces the measurement tolerance to 19 µm in comparison with a stationary reference laser scanner.[16] The preparation is optoelectronically scanned from various angles in the patient's mouth. The individual images are then combined to create complete quadrants (Fig. 9). Inadequate images are automatically detected. With a scan of the antagonists, the digital impression of the partial arch/quadrant is transmitted via a wireless link to the in-house dental laboratory. Alternatively, the data can be sent via the CEREC Connect web portal to an external dental laboratory or to an external milling centre equipped with a stationary CAD system. This is followed by the virtual design of the restoration. If required, a 3-D working model can be created using a special stereolithography process (SLA). This model provides the basis for the fine tuning of the CAD/CAM-milled crown or bridge framework.

'Impression-free' dentistry offers numerous advantages. The patient does not have to endure the discomfort of a conventional impression (such as gag reflex). In addition, dental laboratories can reduce their production times and achieve significant productivity gains.

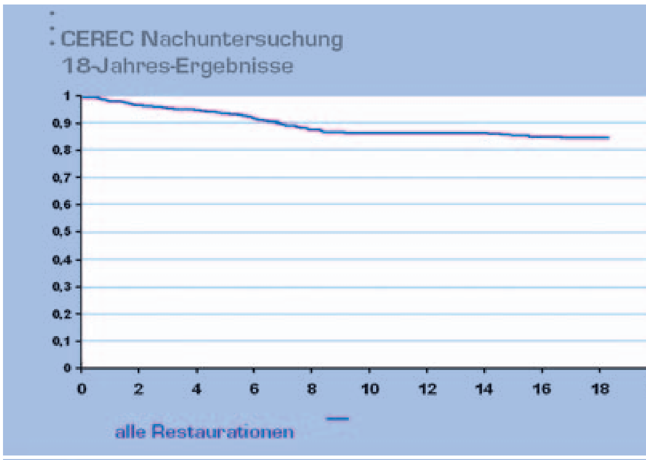


Fig. 6

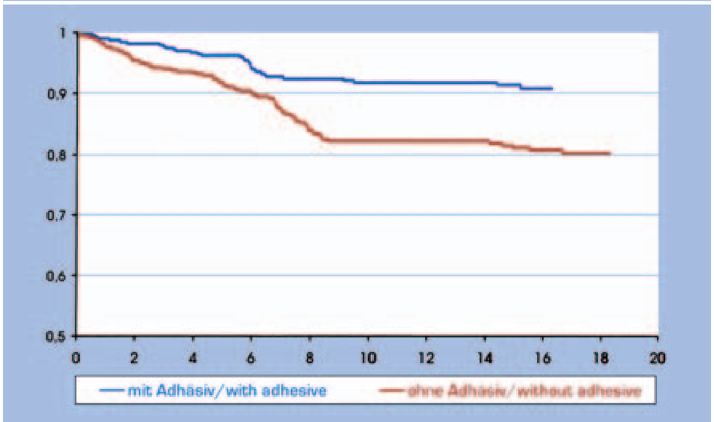


Fig. 7

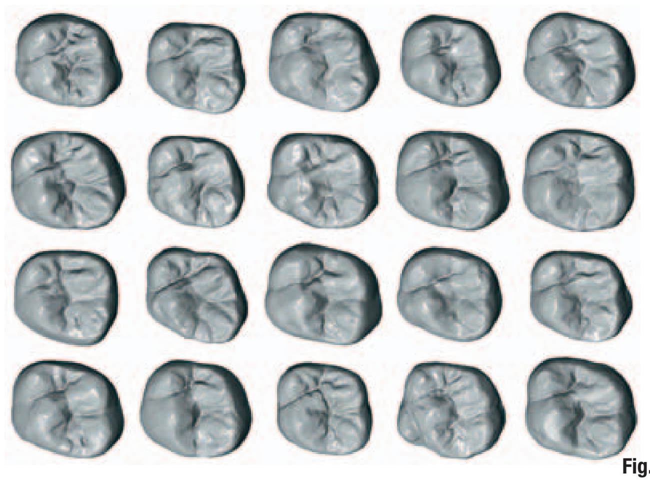
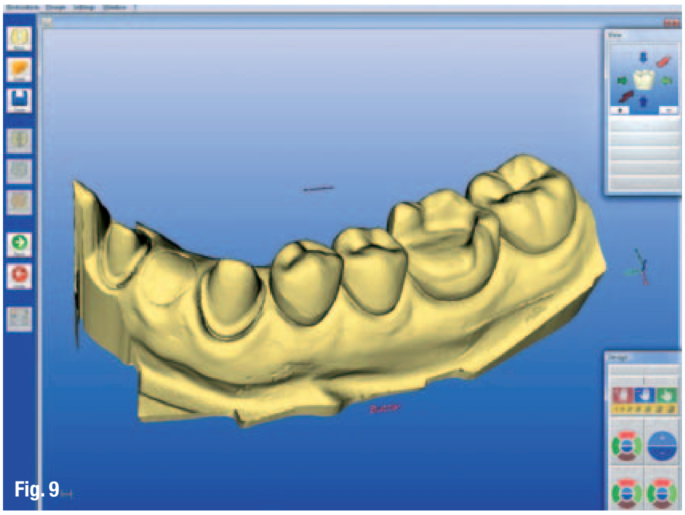


Fig. 8

Fig. 6_Survival rate of CEREC inlays and onlays: 84.4 % overall after 18 years. (Source: Dr Bernd Reiss)

Fig. 7_Survival rate: 90 % with dental adhesive; 80 % without dental adhesive. (Source: Dr Bernd Reiss)

Fig. 8_Examples of the tooth surfaces contained in the library (here: 6th molar of the upper jaw); at present, approximately 400 tooth surfaces are available for each posterior tooth type. (Illustration: Prof Albert Mehl)



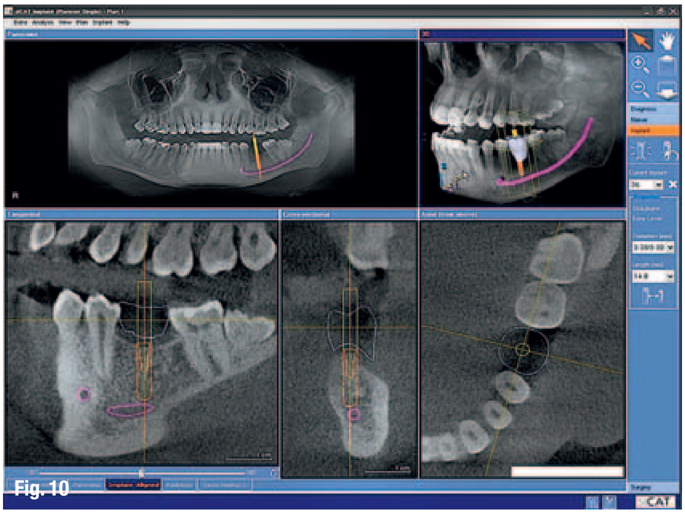


Fig. 9_The individual images are combined in an anatomically correct way in order to create a virtual quadrant model. (Photo: Dr Andreas Bindl)

Fig. 10_CBVT image showing the adjustment of the implant post; the CEREC data record shows the location and insertion axis of the planned crown. (Illustration: Dr Andreas Bindl/Sicat)

_Implant planning with the help of imaging systems

The integration of the CEREC system and cone-beam volumetric tomography (CBVT) enhances the reliability of implant planning. The low-radiation CBVT system generates a detailed 3-D image of the bone structure. This ensures greater diagnostic accuracy, as well as the precise localisation of the anatomical structures. CBVT thus provides the basis for the surgical planning of the implant.[17] The CEREC intra-oral camera is used to scan the implant site and the adjacent teeth. Following this, the software generates a virtual 3-D model, on the basis of which the future implant crown is designed and prosthetic planning conducted. The 3-D model with the implant crown is then superimposed on the 3-D CBVT image. This allows the clinician to position the implant with reference to the planned prosthesis and the available bone structure (Fig. 10).

Fig. 11_Prof Mehl, physicist and biologist (left), has been collaborating closely with Prof Mörmann in Zurich in his role as visiting professor. (Photo: DGCZ/Kern)

CEREC is already deployed for the fabrication of implant superstructures. Dr Daniel Wolf et al. reported that anatomically sized, adhesively bonded implant molar crowns (VITA Mark II silicate ceramic) with occlusal wall thicknesses of 1.5 mm have performed well in laboratory tests. This applies to crowns placed on titanium abutments and crowns placed on ZrO_2 abutments.[18]

_Summary

CEREC has been transformed from a computer-based 'inlay machine' into a highly versatile system for single-visit dentistry. In future, CEREC will co-ordinate various functions in dental practices and laboratories. Numerous internationally recognised studies have proved that chairside ceramic inlays and onlays achieve clinical survival rates that are comparable to those of cast-gold restorations.

With the introduction of optoelectronic impression-taking for entire quadrants, CEREC has opened the door to impression-free dentistry and has integrated dental laboratories more closely into the work flow of dental practices. CEREC technology has demonstrated to dental professionals that CAD/CAM processes and computer-aided treatment methods will determine the future activities and actions of dental practices and laboratories._

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

_contact CAD/CAM

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secretariat@dgcz.org
www.dgcz.org

Management of a full mouth prosthodontic rehabilitation

Authors_ Dr Ansgar C. Cheng, Dr Helena Lee, Dr Neo Tee-Khin & Ben Lim, Singapore


Fig. 1


Fig. 2


Fig. 3

Fig. 1_Pre-treatment frontal view showing attrition, erosion, discolouration and compromised aesthetics.
Fig. 2_Pre-treatment maxillary occlusal view showing general loss of enamel on the occlusal surfaces.
Fig. 3_Pre-treatment mandibular occlusal view revealing loss of occlusal tooth structure and differential erosion loss of dentine.
Fig. 4_Panoramic radiograph showing adequate alveolar support.
Fig. 5_Anterior view of the full maxillary and mandibular diagnostic wax-up.
Fig. 6_Completed maxillary anterior teeth preparations for full coverage restorations. Note the equi-gingival preparation margins.

_Introduction

_Prudent clinical judgement and careful consideration of the risks and benefits of various treatment options are essential for the treatment planning and long-term success of prosthodontic treatment.[1] It has been established that loss of the vertical dimension of occlusion (VDO) may pose significant clinical difficulties in prosthodontic treatment.[2,3] Yet, the re-establishment and maintenance of a new VDO is seldom taught in undergraduate dental curricula.

VDO is defined as the vertical measurement of the face between two selected points superior and inferior to the oral cavity when the occluding members are in contact.[4] Various methods have been proposed for the assessment and re-establishment of the VDO.[3] The difference between the vertical measurement of physiological rest position, which should have a higher value than the VDO, and the VDO is referred to as the inter-occlusal rest space,[4] which is essential for normal patient function. As teeth are worn down, the alveolar bone may undergo an adaptive process that may compensate for the loss of tooth structure.[5] The VDO should be carefully assessed before the initiation of restorative procedures.

Traditional porcelain-fused-to-metal anterior crown restorations require the placement of labial crown margins below the free gingival margin, in order to mask the hue and value transition between the root surface and porcelain-fused-to-metal restoration. However, intra-crevicular placement of crown margins is technique-sensitive and related to adverse periodontal tissue response.[6–9] From a periodontal point of view, preparation margins are best kept away from the free gingival margin.[8,9]

The dentition, masticatory muscles and temporomandibular joints form a Class 3 lever system. In such


Fig. 4


Fig. 5


Fig. 6


Fig. 7

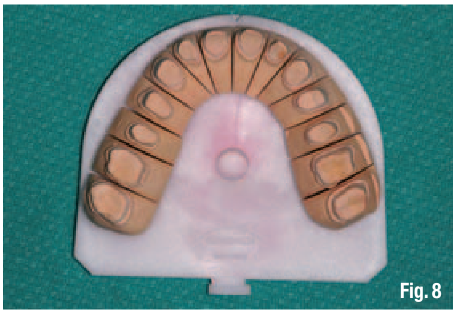
Fig. 8


Fig. 9

a lever system, functional load is inversely proportional to the length of the lever arm. Anterior teeth are under a reduced functional load in comparison with posterior teeth. Porcelain-fused-to-metal restorations are commonly used in the posterior teeth because of their well-documented long-term clinical track record in anterior and posterior teeth.[10–17] Newer zirconium-oxide-based materials are usually prescribed in the anterior region owing to their demonstrated promising physical properties[18,19] and reasonable clinical longevity.[20] *In vitro* studies also show that the wear of metal occlusal surfaces against porcelain occlusal material is acceptable when there are no bruxing activities.[21]

This article describes the prosthodontic management of a mutilated dentition using high-strength zirconium-oxide crowns.

_Clinical report

A 63-year-old fully dentate male patient presented with discoloured teeth and multiple areas of loss of tooth structure. The patient desired the restoration of function and aesthetics. He presented clinically with defective restorations, insignificant loss of VDO and compromised aesthetics (Figs. 1–3). There were signs of loss of enamel at the occlusal and labial surfaces of most of the teeth. The pre-treatment radiograph was within normal limits (Fig. 4). In spite of the overall condition, the natural teeth were free of active dental caries and oral hygiene was good. An occlusal examination revealed a stable maximal inter-cuspation position with insignificant centric relation to maximal inter-cuspation slide at the teeth level. No para-functional habit was reported.

A diagnostic dental wax-up on mounted maxillary and mandibular casts in a semi-adjustable articulator was performed (Hanau Wide-vue, Teledyne Waterpik; Fig. 5). The proportions of the anterior teeth were corrected to the estimated 0.618 width-to-height ratio of central incisors using the golden proportion[22–25] as a guideline. The results indicated that no increase of VDO was needed at the incisal pin level in order to restore proper incisal anatomy and anterior guidance. The overall treatment plan included placement of fixed, high-strength zirconium-oxide base restorations in the maxilla and mandible.

The maxillary and mandibular teeth were prepared in the usual manner for complete coverage crown restorations (Figs. 6 & 7). The margins of the tooth preparations were prepared at the gingival level under magnification, and no gingival displacement procedures on the prepared teeth were necessary prior to definitive impression making. High-viscosity vinyl polysiloxane material (Aquasil Ultra Heavy, DENTSPLY DeTrey) was carefully injected onto all tooth preparations, ensuring that all teeth surfaces including the margins were recorded. A stock tray loaded with putty material (Aquasil Putty, DENTSPLY DeTrey) was seated over the entire dental arch to make the definitive impression. A jaw relation record was made with a vinyl polysiloxane material (Regisil PB, DENTSPLY DeTrey). The maxillary and mandibular definitive casts were mounted in the centre of the articulator using standard settings.[26,27] Provisional crown restorations (Luxatemp Automix, Zenith/DMG) were placed on the prepared teeth at the established VDO.

The development of the planned definitive crown restorations was carried out using CAD/CAM. The maxillary and mandibular definitive casts (Figs. 8 & 9) were scanned (ZENO Scan, Wieland) and the crown copings were designed using a software programme (3Shape D700). The copings were milled in zirconium base material (ZENO ZrBridge, Wieland) with a milling machine (ZENO 4030 M1, Wieland; Fig. 10). The copings were

Fig. 7_Completed mandibular anterior teeth preparations for full coverage restorations. Less than 1.5 mm of tooth structure was removed at the cervical third, owing to smaller tooth size.

Fig. 8_Definitive maxillary cast. No die-spacer was required in the CAD/CAM manufacturing process.

Fig. 9_Definitive mandibular cast Tooth reduction was generally more conservative when compared with conventional porcelain-fused-to-metal restorations.

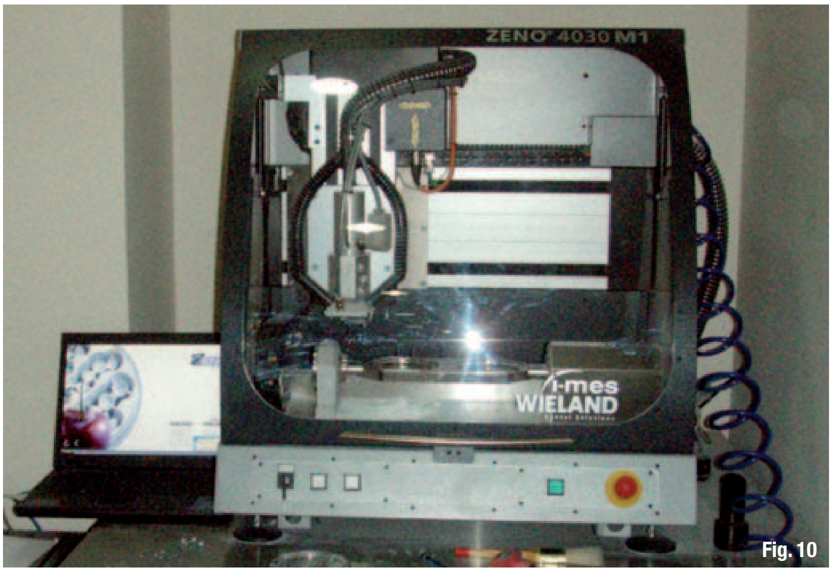

Fig. 10

Fig. 10_Coping milling machine ZENO 4030 M1 (Wieland).

Fig. 11_Occlusal view of completed definitive maxillary full ceramic crown restorations.

Fig. 12_Occlusal view of completed definitive mandibular full ceramic crown restorations.

Fig. 13_Side view at right latero-trusion, canine-guided occlusion.

sintered according to the manufacturer's recommendations. Subsequently, overlaying low-fusing porcelain material (IPS e.max, Ivoclar Vivadent) was manually applied onto the exterior to create proper anatomic form. All maxillary and mandibular anterior teeth were fabricated using the same process. The completed restorations were cemented in resin-modified glass-ionomer luting agent (RelyX Unicem, 3M ESPE; Figs. 11–12 & 15).

The patient was evaluated post-operatively. Anterior guided occlusal schemes were verified intra-orally before and after prosthesis cementation (Figs. 13 & 14). The patient reported no discomfort and adapted well to the new restorations. No abnormal clinical signs were noted.

_Discussion

The maintenance and re-establishment of the VDO is a crucial element in full mouth fixed prosthodontic rehabilitation. It was necessary to make impressions that registered all teeth preparations at once.

As the patient desired a high level of aesthetics, full ceramic restorations were chosen for all restorations. The minimum core thickness for this full ceramic system is 0.4 mm, this enabled conservation of tooth structure and achievement of reasonable aesthetics simultaneously.

By prescribing full ceramic restorations, intra-sulcular placement of crown margins on the labial surfaces become less important from an aesthetic point of view. In this report, the teeth were essentially caries free, teeth preparation margins were made at gingival level and gingival retraction procedures were eliminated. As gingival retraction cord placement was not required, there was less physical trauma to the gingival tissues and less clinical time was needed. This is particularly beneficial for thin gingival biotypes.

Full mouth rehabilitation using fixed prostheses usually requires longer-term provisional restoration in order to facilitate a predictable treatment outcome. In this patient, owing to his busy travel schedule, long-term provisional restoration for verifying his adaptability and multiple professional clinical adjustments of provisional restorations were not feasible. The anterior teeth were restored based on the diagnostic wax-up without long-term provisional restoration before definitive cementation of the definitive crown restorations. This treatment sequence left almost no room for clinical errors in the execution of the planned treatment.

Intra-oral verification of the new occlusal scheme and detailed in situ clinical adjustment of the restorations on the day of prostheses insertion are essential for proper treatment execution. In this unique treatment approach, the patient should be informed of the potential financial and time implications should any need for re-fabrication of the definitive restorations arise.

_Conclusion

The functional management of complex prosthodontic rehabilitation is a clinical challenge. A relatively new restorative material was used in this case. The use of high-strength full ceramic restorations enhances the overall aesthetic outcome and functional predictability over the long-term._

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

Fig. 14_Side view at left latero-trusion, posterior teeth were out of occlusion during eccentric movement.

Fig. 15_Anterior view of the completed maxillary and mandibular crown restorations. The crown margins were placed at the gingival margin with no sub-gingival extension.

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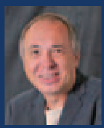

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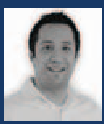

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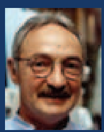

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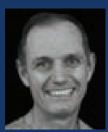

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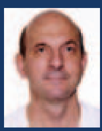

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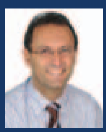

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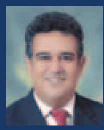

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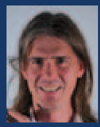

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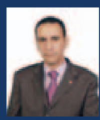

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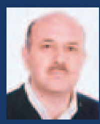

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A new approach for patient acceptance and appreciation

Authors_ Dr Lorin Berland & Dr Sarah Kong, USA

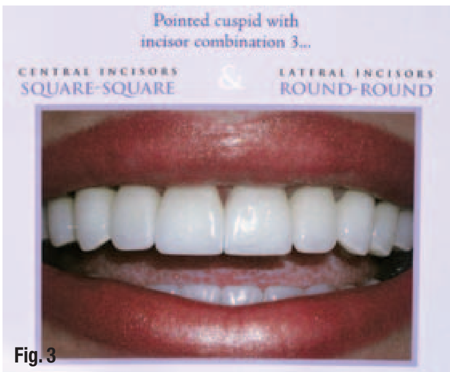
Fig. 1_Pre-op full face.

_**This 61-year-old executive** has lived with the effects of tetracycline-stained teeth since she was a little girl (Fig. 1). All her life she wanted to have a great smile, but she never knew what her dental options were. The general dentist she had seen for many years told her there was nothing he could do to help her, so he referred her to our office.

When the patient came for her first visit, she wished to address a number of dental concerns. In addition to the severe tetracycline staining, she felt her teeth were worn from years of grinding. Moreover, she had old resin bonding on her lower front teeth that was not only discoloured, but also mismatched from years of patching and re-patching each time something broke off.

After performing a thorough examination (paying particular attention to the areas noted above) and cleaning, we recommended she try deep bleaching. After evaluating the results of the whitening, we recommended a minimum of four minimal preparation Microveneers for her lower front teeth and her upper seven teeth, and a zirconium porcelain crown for tooth #5, in order to achieve the smile she desired.

Because her maxillary six anteriors had worn, flat incisal edges, it was essential that we understood what the patient desired in terms of shape and length. We examined the Smile Style Guide (www.digident.com) to select a smile design (Fig. 2). With the patient's input, we determined that P3—pointed canines with square centrals and round laterals—would be the best for her (Fig. 3). The length combination she liked the most was L-2—laterals slightly shorter than the centrals and canines (Fig. 4). We submitted her preoperative photo to SmilePix for a cosmetic image (Fig. 5) and concluded with PVS impressions (Splash, Discus Dental) and a bite registration (Vanilla Bite, Discus Dental).



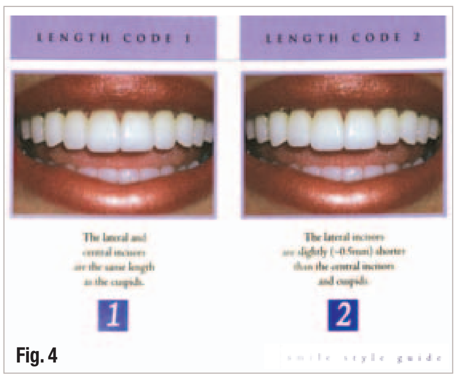


Fig. 2_Smile Style Guide.
Fig. 3_P-3, pointed canines with square centrals and round laterals.
Fig. 4_Length code L-2, laterals slightly shorter than centrals and cuspids.


Fig. 5


Fig. 6

Fig. 5_Cosmetic image.
Fig. 6_Diagnostic wax-up and putty matrices.

At her second consultation appointment, we confirmed the smile design and length combination she had previously selected by showing her a diagnostic wax-up of her upper and lower teeth (Fig. 6). Matrices were fabricated from the wax-ups before this appointment and used to make an upper and lower Slip-On Smile right on the patient's teeth. We loaded the matrices with an A-1 bis-acryl temporary material (examples are Temphase, Kerr; Integrity, DENTSPLY Caulk; and PERFECtemp II, Discus Dental)—and seated them in the mouth. After the material was set, the matrix was removed; remaining on her teeth was a new smile.

We took a series of photographs with the Slip-On Smile in place and the patient was ecstatic. She was able to see and feel what her teeth would look like before committing to any dental work (Fig. 7). The patient was truly amazed by this and wanted to wear the smile home to show her husband.

Though the patient had loved the selected smile design and cosmetic image, she was not convinced about pursuing this treatment. This demonstrates that the Slip-On Smile is an important part of treatment presentation. She accepted the treatment as soon as she could experience her new smile first hand. We began her treatment with a combination of in-office and at-home whitening. The incisals of the canines and bicuspids showed acceptable results. We used this as a base shade, planning to make the lower veneers even lighter towards the front and the upper veneers slightly lighter than the lowers. As planned, teeth #6 to 12 were prepared for Microveneers in order to preserve as much natural, healthy tooth structure as possible. Tooth #5 had an existing crown that the patient wished to replace to match tooth #12; thus, the tooth was prepared for a zirconium crown at the same time. Digital photographs of the preparation shades were taken for our ceramic artist (Fig. 8).

Once the preparations were finished and refined, it was time to provisionalise the teeth. While an assistant loaded a tray with alginate, hydrocolloid (Dux Dental) was expressed over the prepared teeth for an impression. Then the alginate-filled tray was seated in the mouth, directly onto the hydrocolloid. After a minute and a half, the impression was removed with a snap and handed off to an assistant to pour. In the laboratory, the impression was disinfected and dried. Next, Mach-2 PVS (Parkell) was dispensed into the impression to pour up the model on a vibrator. A fast-setting bite registration material (SuperDent, Darby Dental) was then placed directly onto the Mach-2 for a model base.

In less than two minutes, an accurate, instant silicone model was ready on which to fabricate a provisional—all of which was completed outside the patient's mouth by an assistant. Using the matrices made from the diagnostic wax-up and approved by the patient in her Slip-On Smile, the provisionals were fabricated.

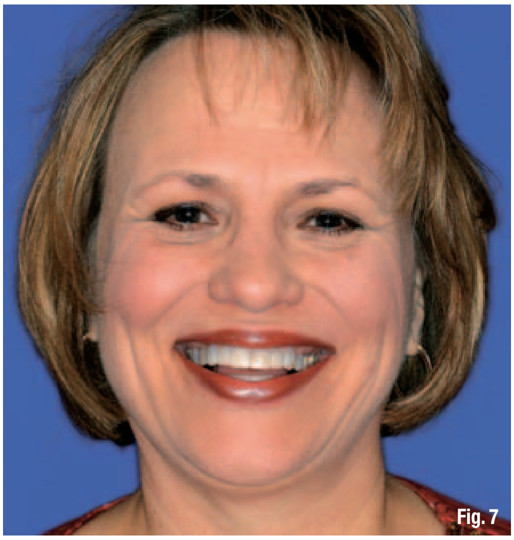


Fig. 7

Fig. 7_Slip-On Smile full face.

Fig. 8_Upper preparations and preparation shade.
Figs. 9a–10c_Upper and lower indirect provisionals on instant silicone models.

Fig. 8

Fig. 9a

Fig. 9b

Fig. 10a

Fig. 10b

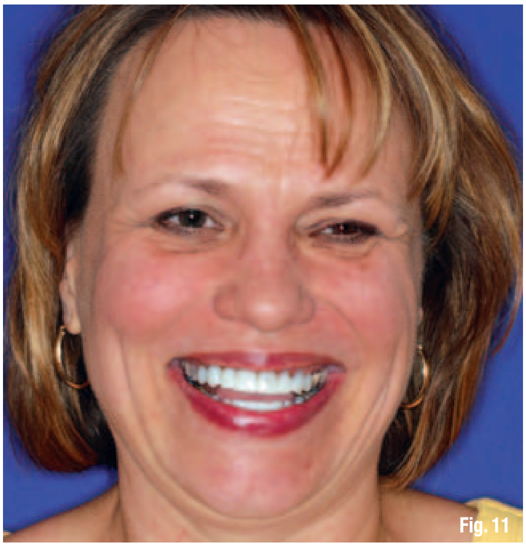
Fig. 10c

First, the instant silicone model was lubricated with a water-based lubricant (such as KY Jelly). Next, the putty matrix was filled with bis-acryl and then placed onto the silicone model. After a minute and a half, the provisional was set up and ready to be trimmed. Because this method of temporisation involves a quick way to make a model of the prepared teeth, the provisional can be trimmed and polished in the laboratory. Finishing provisionals in this manner is much more accurate, as well as kinder to and easier for the patient, and particularly the gingival and the prepared and impressed teeth (Figs. 9a–10c).

In order to prepare the gingiva for the final impressions, Expasyl (Kerr) was placed around the gum line. Final impressions with a PVS material (examples are Take 1 Advanced, Kerr; and Virtual, Ivoclar Vivadent) were then taken in custom trays. A slow-setting material was used to record her bite registration (SuperDent). In order to cement the provisionals, the same bis-acryl was placed in the temporaries and seated in the mouth. The excess was removed with a microbrush before the material set. The patient loved the way her provisionals looked and fitted (Fig. 11). There were no surprises, as she had chosen the smile design she liked best before any work had even begun.

When she returned for the final porcelain restorations, the patient was concerned that they might not look as good as her provisionals. Because the minimal preparation was all in enamel, we could try the restorations with no anaesthetic and no discomfort. This is important to allow the patient to gain a true feel of the teeth, especially when length is being increased. We assured her that we would try-in the restorations and gain her approval before seating them permanently. Thus, we invited her entire family to the seating appointment in order to offer their opinions. As is often the case, it was especially important to please one family member in particular, and for this case it was her daughter.

For the try-in, we used different shade combinations of try-in pastes in order to determine what looked the most natural. I call this the *mix-to-match method*. This method is especially important for extensive cases with multiple types of restorations and porcelains. In this case, feldspathic porcelain was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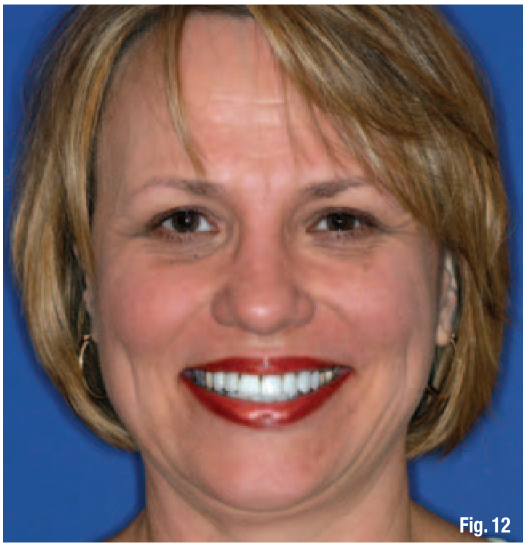


Fig. 12

Fig. 11_Provisionals full face.
Fig. 12_Post-op full face.

used to fabricate the veneers, while the crown was made with a zirconium core.

When it comes to mixing cements, we generally like to use the lightest shade for centrals and warmer shades as we go distally. This mix-to-match method helps to achieve a natural-looking smile. We ultimately decided, with the patient's input, to use a dual-cure resin cement (examples are Maxcem, Kerr; Multilink, Ivoclar Vivadent; and PermaCem Automix Dual, Foremost) for the zirconium crown on tooth #5; Cosmedent Ludicrous for #8, 9, 24 and 25; Bright for #6, 7, 10, 11 and 12; and Yellow-Red Universal for #23 and 26. A fresh bottle of bonding agent (examples are Optibond Solo Plus, Kerr; Excite, Ivoclar Vivadent; and Adper Single Bond Plus, 3M ESPE) was selected. Using a fresh bottle ensured that the bond would be at its strongest. The teeth were cured from all angles with the FLASHlite Magna (Discus Dental). Because it is a LED, there is little danger of overheating the teeth.

Once the restorations were seated, the patient was ecstatic with the results. She simply could not believe how natural her teeth looked. They were even better in shape and shade than she had anticipated (Fig. 12). The once tetracycline-stained smile was the only smile she had ever known. Now, for the first time in her life, she could look in the mirror and smile with confidence knowing she has a beautiful, natural smile.

In this case, a cosmetic image was helpful in showing the patient a 2-D photo of how her smile would look. Yet, it was not until she saw her personalised smile design in real life with the Slip-On Smile that she could really feel what her new smile would truly be like. She was pleased with every step of her smile transformation, with her provisionals and ultimately with the results.

Although the mix-to-match method is an extra step that requires more chair time, the results justify the means. And for this patient, this meant a beautiful new smile with minimal tooth reduction to achieve the most natural aesthetics. Each step of this process gained more of the patient's acceptance of the proposed treatment, which determined her appreciation of the results._

_about the authors

CAD/CAM

Dr Lorin Berland, an accredited Fellow of the AACD, is one of the most sought-after speakers and published authors on cosmetic dentistry in America. He has featured in national and regional magazines and major dental journals, and recently on NBC News, Fox News, and ABC's 20/20. For more information on *The Lorin Library Smile Style Guide*, the 8-AGD credit DVD, www.denturewearers.com, and The One Appointment Inlay/Onlay Kit and complimentary 8-AGD credit CD/ROM, call +1 214 999 0110 or visit www.dallasdentalspa.com.

Dr Sarah Kong graduated from Baylor College of Dentistry where she served as a professor in restorative dentistry. She focuses on preventive and restorative dentistry, transitionals, anaesthesia, and periodontal care. Dr Kong has worked with a master ceramist in one of the world's finest dental laboratories. She is an active member of numerous professional organisations, which include The American Dental Association, The Academy of General Dentistry, The American Academy of Cosmetic Dentistry, The Texas Dental Association, and The Dallas County Dental Society.

"Once you've tried it, you can't drink anything else"

Author_ Dr Jay B. Reznick, USA

Fig. 1

Fig. 2

Fig. 1_Pre-op view of failing tooth #10 in a 70-year-old female patient.
Fig. 2_Pre-op radiograph showing a horizontal fracture, root canal treatment and a cast post.

Fig. 3_CEREC 3D virtual model with proposal of provisional restoration.

_Way back in 2005, I was listening to a speaker discuss a new way of placing dental implants that would revolutionise the process. He showed a video of an elderly Swedish man strolling into a dental clinic with a bag full of ill-fitting dentures, and walking out later that same day with fully implant-supported final prostheses. The process used 3-D computed tomography (CT) imaging to plan the implant placement, and then a custom surgical guide was made that facilitated the flapless placement of a dozen or so implants so precisely that only minimal adjustments would be necessary to the prefabricated fixed bridges. The cost of this treatment was about US$100,000, rendering it beyond reach for the majority of patients.

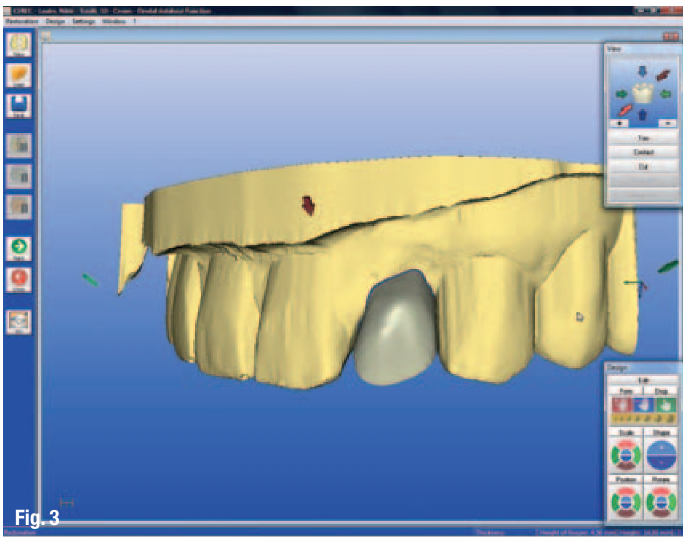


Fig. 3

This was an enlightening moment for me, as I saw the potential in this technique. As soon as it was available in the US and the cost became more reasonable, I vowed to bring this technology into my practice so that my patients could benefit from this amazing innovation.

Early in 2006, I flew to Chicago and took the NobelGuide training course, and within a short time I had half a dozen cases under my belt. I was amazed by how quickly and accurately I could place multiple implants, and that most patients needed only a few post-operative ibuprofens and were back at work the next day. Soon thereafter, I acquired SimPlant software and began using both methods for treatment planning and placing implants.

These two pioneering systems opened the door for the current tidal wave of CT-guided implant surgeries. For those of you not familiar with the concept, CT-guided implant surgery uses 3-D CT imaging to evaluate the bony anatomy of the edentulous jaw, uses this for implant planning, and then accurately transfers the treatment plan to the patient at surgery using a custom surgical guide that controls the position, angle, and depth of each drill and implant fixture. It is so accurate that a custom provisional or even final prosthesis can be made that is delivered with minimal, if any, adjustment needed. It is a panacea for the restorative dentist because implant placement is completely prosthetically driven, not dictated by the surgeon's whim if there are anatomical surprises when the tissue is flapped open. The anatomy is known with 3-D accuracy before surgery, and should bone or tissue augmentation be necessary to position the implants properly, this information is known ahead of time and additional procedures are planned. The result is perfectly placed implants in ideal bone that are straightforward to restore and function properly nearly all of the time.

Even though I did not use CT-guided surgery for every implant case, I probably completed a hundred cases or more in those first two years. It was a very time-consuming process. I had to have the laboratory make a radiographic template, arrange for the patient to have a CT scan, have the scan redone should the technician not have followed the protocol exactly, import the DICOM files into the software program, clean up the scatter, treatment plan the implants, and then see the patient for a second consultation to review the treatment plan. Because of the significant time and effort required to complete a computerised treatment plan, I generally reserved this process for the more complicated cases or those for which accurate implant placement was critical. Most cases were done the 'old-fashioned way' during this period.

My next revelation came in 2007, when I first saw the GALILEOS cone-beam computed tomography (CBCT) scanner and started thinking about incorporating this into my practice. The beauty of it was not the scanner itself, as most CBCT scanners on the market render a good image; it was the software. GALAXIS and GALILEOS Implant were developed with the dentist in mind, as opposed to most other CT viewing and implant-planning programmes, which were modified from existing medical CT software. With very little instruction, I was able to navigate through the images and start planning implant surgery like an expert.

Sirona, the manufacturer of GALILEOS, hit a home run, in my opinion, when they considered the entire work flow in designing the software suite that was included with their machine. With the simple click of a tab, the same software programme used for viewing the scan diagnostically could quickly and easily be used for treatment planning implants, and then ordering a custom surgical guide.

Once I had brought GALILEOS into my office, life became easier. Now, as soon as my patient was scanned, using a radiographic template, the images could be brought up on the monitor, and then implant planning could begin immediately. What previously took at least 30 minutes of my time and two patient visits was now possible in less than 5 minutes in a single appointment. As a result, cases that I previously considered to be too simple to treat using CT-guided surgery techniques were now suitable candidates. Before I knew it, I was utilising this technology for practically every implant case. The only exception was a case in which a patient could not wait the seven working days that it currently takes to have the surgical guide manufactured. CT-guided implant surgery has the benefits of increased accuracy of implant placement through a smaller, minimally invasive incision. Another major benefit to the implant surgeon is decreased surgical time, which allows one to schedule more patients and more procedures in the day. Of course, this is of little benefit if treatment planning becomes very time-intensive. The beauty of the GALILEOS Implant/siCAT system is in the integration of work flow that makes the implant planning phase rapid and effortless. An additional plus is improved inventory control. Instead of requiring a variety of implant sizes for a single case, the exact fixture diameter and length are predetermined, so only a single fixture has to be ordered per site.

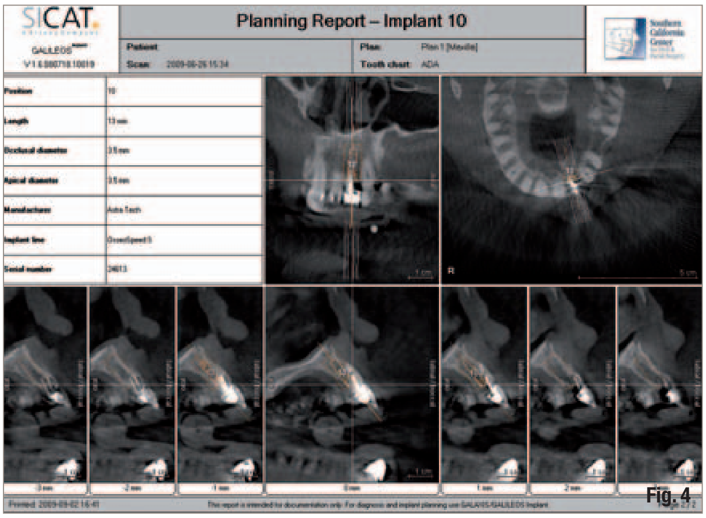


Fig. 4

Fig. 4_GALILEOS treatment planning report demonstrating position of implant in relationship to existing restoration.

We have traditionally relied on panoramic radiographs and study models to plan our implant placement. Surgical stents have always been used in implantology to aid in this process. The traditional surgical

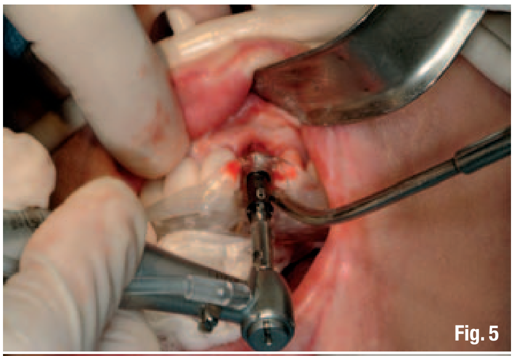


Fig. 5


Fig. 6


Fig. 7

Fig. 5_Placement of implant through siCAT surgical guide using Facilitate Surgical Guide.
Fig. 6_Provisional abutment attached to immediately placed implant.
Fig. 7_Provisional crown on implant immediately after placement.

Fig. 8

Fig. 9

Fig. 8_Post-implant cross-sectional CBCT image demonstrating good position and angulation in relationship to provisional prosthesis.

Fig. 9_Tangential slice CBCT showing implant and provisional restoration immediately after placement.

guide is made from a wax-up on a stone model that does not allow representation of the true bony anatomy of the underlying edentulous ridge nor the position of adjacent tooth roots. There are various styles of surgical guides that have been in use, ranging from thermoplastic sheets to solid acrylic replicas of the final prosthesis. These guides only estimate the position for the initial drill, leaving this up to the discretion of the surgeon, and do not control the depth of drilling. Sequential osteotomies are then generally drilled free hand. This introduces many opportunities for aberrant implant positioning. Even in the hands of the most experienced implant surgeons, up to 20 % of implant placements vary from their intended position. Dentists need only look in their favourite implant textbook or journal to find examples of textbook cases that are less than perfect. And, I have never met a restorative dentist who has not had his or her share of similar experiences.

Often, these restorative challenges can be managed with custom abutments and other prosthetic tricks, which significantly increase the dentist's laboratory bill and affect the profitability of the case. However, in some cases, the only solution is either to not restore the fixture or to remove it and start over. Anatomical variations also pose challenges, such as a high lingual mylohyoid concavity, a surprise pneumatised sinus, or a divergent root that came a little too close to the implant fixture. We do not like to have to deal with these complications, but even the best of us have faced them more than we like to admit.

Many of my surgical colleagues are of the opinion that CT-guided surgery is unnecessary because they have been placing implants for many years using the technique they learned 15 or more years ago. I completed my surgical training in 1990, and have done more implants than I can count since then. And for the most part, I have a very high success rate, with minimal problem cases of which to speak. But, am I perfect? Of course not. Are my colleagues any better? I don't think so. I strongly believe that CT-guided techniques will become the standard of care for implantology within the next ten years, or sooner. Those clinicians reading this article have already demonstrated an understanding of what new technologies can do for the practice of dentistry. I'm sure that few of you who own dental CAD/CAM systems could imagine practising without them and the benefits that this technology gives to your patients and your practice. The same holds true for CBCT and guided implant surgery.

In September 2009, I was honoured to be the surgeon for the introduction and first live demonstration of the integration of GALILEOS CBCT data with that from a CEREC digital impression and prosthetic proposal. CEREC uses surface-scanning technology to capture a digital impression of the hard and soft tissues around an area where a dental implant is being considered. GALILEOS uses a radiographic source and sensor to image the bony anatomy in the area of interest. The multiple views are then processed by a computer to create a 3-D image of the teeth and bone, which can be viewed in an infinite number of cross-sectional cuts. Both types of images are nothing more than a set of digital data translated into an image that can be viewed on a monitor. Merging these two sets of numbers appears to be a simple process. However, I am not a software engineer; I am just a dentist. Luckily for us,

Fig. 10_Clinical photograph of provisional restoration at three months after surgery.

Fig. 11_Panoramic CBCT reconstruction of a 62-year-old male patient missing multiple teeth in the maxilla. Bilateral sinus-lift procedures had been performed six months prior.

Fig. 10

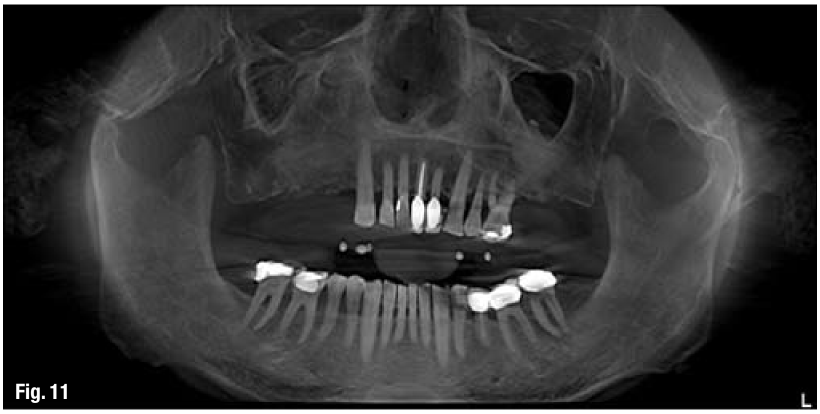


Fig. 11

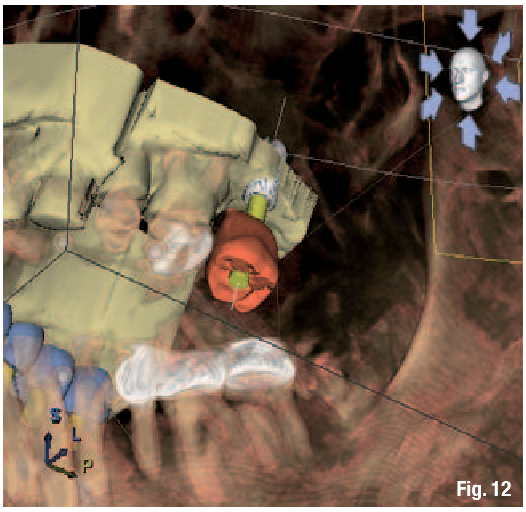


Fig. 12

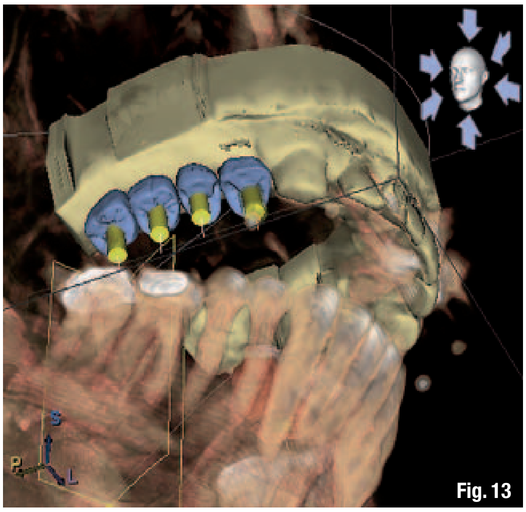


Fig. 13

Fig. 12_3-D image reconstruction from GALILEOS Implant software showing implant planning for tooth #15, based on imported CEREC virtual model and prosthetic proposal.
Fig. 13_3-D image reconstruction from GALILEOS Implant software showing implant planning for teeth #2 to 5, based on imported CEREC virtual model and prosthetic proposal.

there are some smart people at siCAT, Sirona's software subsidiary in Germany, whose mandate was to do just that. Their efforts have changed implant dentistry forever. With the integration of CEREC and GALILEOS, we now have the opportunity to practise real digital implantology. The restoration of a patient's missing dentition can be treatment planned in virtual reality, without the need for physical impressions, pour-up study models or wax-up prostheses. The ability to visualise the patient's bony- and soft-tissue anatomy in relationship to the proposed prosthesis is a tremendous advantage in attempting to follow the principles of prosthetically driven implant dentistry. This facilitates restoration, optimises functional forces on the implant fixture, and improves long-term implant success.

Another benefit of CT-guided implant surgery is the ability to perform the procedure through a minimal incision. This is possible because the underlying 3-D bony anatomy is known preoperatively. Also, since the surgical guide directs the position, angulation and depth of each drill, the surgical time is significantly reduced. This translates to an easier post-operative course for the patient. Because the implant is placed in the ideal position, functional loads on the implant fixture are more ideal. This helps maintain optimal peri-implant bone levels and reduces the failure rate. The resulting time saved can be used by the surgeon to schedule another consultation, surgery, or recreational activity.

The following cases demonstrate the types of implant treatment plans that can be treated using 3-D CT-guided surgical techniques through the integration of GALILEOS and CEREC.

_Case I

This first patient was a 70-year-old woman with a failing maxillary left lateral incisor. The tooth had been treated endodontically many years before and had a post-retained fixed prosthesis that was subject to repeated failures (Fig. 1). The tooth was not restorable and a decision was made to remove the tooth and replace it with an immediately placed dental implant and provisional prosthesis (Fig. 2). The patient understood and agreed that the immediate implant and prosthesis would not be placed in function for three months after placement.

A stone study model was made, and the crown of tooth #10 was removed. This modified model was captured by CEREC in order to create a digital model that represented the site after tooth extraction. The opposing dentition was captured in a Futar D

Fig. 14_Panoramic reconstruction of CBCT showing proposed implant positions and abutment screw paths.
Fig. 15_Prepared siCAT surgical guide for Facilitate Surgical Guide.

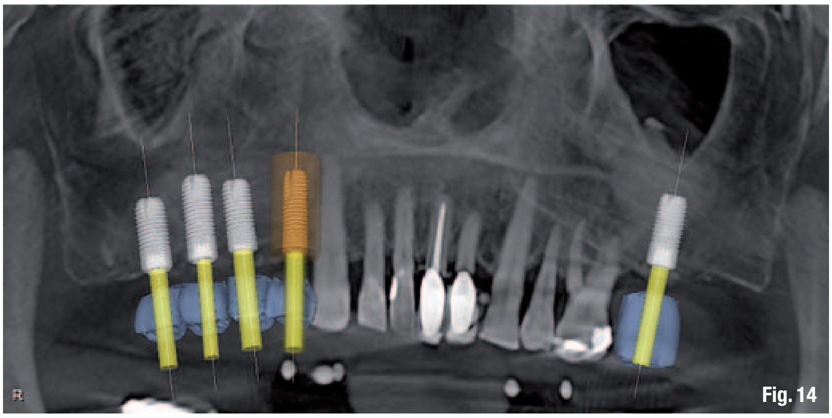


Fig. 14

Fig. 15


Fig. 16

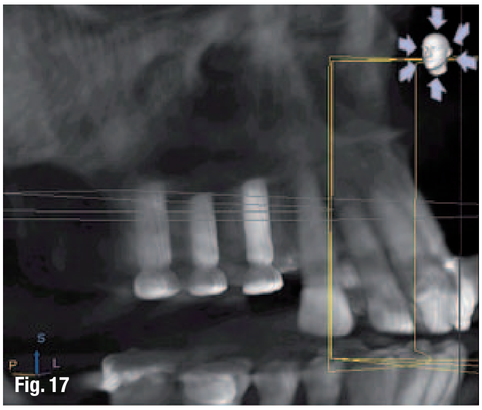


Fig. 17

Fig. 16_Post-op panoramic CBCT reconstruction showing position of placed implants.

Fig. 17_3-D reconstruction of post-op CBCT showing placed implants in the right maxillary posterior region.

(Kettenbach) bite registration and the prosthetic proposal was created in CEREC (Fig. 3). The digital model and prosthetic proposal were then imported into GALILEOS. The ideal implant size and position were determined within the GALILEOS scan, based on the bony anatomy data, as well as the mucosal surface and prosthetic data from CEREC (Fig. 4). The treatment planning data, along with the stone model and a special scanning template were sent to siCAT, and a custom surgical template was returned.

This template was used in surgery once the tooth had been atraumatically extracted in order to direct the placement of the implant fixture into the site of tooth #10. The position, angulation, and depth of implant placement were all controlled by the guide, so that the implant was placed exactly where it had been planned in the 3-D imaging software (Fig. 5). A provisional abutment was placed (Fig. 6), and the patient was sent to her dentist for a digital impression and fabrication of a CEREC-produced provisional crown (Fig. 7). The procedure to remove the tooth and place the implant took under ten minutes. Post-operative GALILEOS scan images indicated accurate implant placement (Figs. 8 & 9). At the three-month follow-up appointment, the provisional restoration was stable. The gingival architecture and tissue health were excellent (Fig. 10).

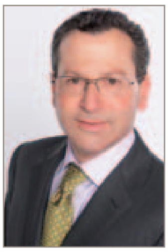
_Case II

This second case illustrates the tremendous power of the integration of GALILEOS and CEREC for treating the partially edentulous patient. This patient was a 62-year-old man with moderate bone loss due to smoking. He was otherwise healthy. He was missing teeth #2 to 5 and 15, and had undergone bilateral sinus-lift surgery to augment the bony deficiency in the posterior maxilla (Fig. 11). In preparation for implant placement, a GALILEOS CBCT scan was performed with a siCAT scanning template. A full-arch digital impression was acquired with the CEREC AC unit, and then prosthetic proposals were designed for teeth #2 to 5 and 15. This data was then imported into GALILEOS for implant planning (Figs. 12 & 13). The position of the implants was verified (Fig. 14) and the surgical guide was ordered from siCAT (Fig. 15). This was used to place four Astra Tech dental implants accurately using the Facilitate Surgical Guide (Astra Tech). Post-operative radiographs demonstrated that all four implants were accurately placed and in accordance with the treatment plan (Figs. 16 & 17). The patient had an uneventful post-operative course.

One of my favourite cocktails is the Vesper Martini, which was introduced to the world in the novel *Casino Royale* when James Bond asked the bartender to mix him this variation on his standard drink. Bond named the drink after Vesper Lynd, his love interest in the story because, he confessed, as with her, once you've tasted it, that's all you want to drink. CT-guided implant surgery is no different for me. After years of planning and placing dental implants the old-fashioned way I learned in residency, I was given a taste of a new way to do so. It was a radical change at first, but once I knew the recipe, I realised that it was a faster, better and more accurate way to treat my patients. Now, I can't drink anything else. Hopefully, you will give it a taste too and agree._

_about the author

CAD/CAM



Dr Jay B. Reznick is a Diplomate of the American Board of Oral and Maxillofacial Surgery. He received his dental degree from Tufts University, and his MD degree from the University of Southern California, and trained in Oral and Maxillofacial Surgery at LA County-USC Medical Center. His special clinical interests are in the areas of facial trauma, jaw and oral pathology, dental implantology, sleep disorders medicine, laser surgery and jaw deformities. He also has expertise in the integration of digital photography, 3-D imaging, and CT-guided implant surgery in clinical practice.

He frequently lectures at continuing education meetings, and has published articles in the *Journal of the American Dental Association; Journal of the California Dental Association; Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology; Compendium of Continuing Education in Dentistry; DentalTown Magazine; CE Digest;* and *Gastroenterology*. Dr Reznick is a founder of OnlineOralSurgery.com, which educates practising dentists in basic and advanced oral surgery techniques. He serves on the editorial and advisory boards of a number of journals and organisations. He is the Director of the Southern California Center for Oral and Facial Surgery (www.sccofs.com) in Tarzana in California, and a consultant for various dental and surgical manufacturers. He can be contacted at jreznick@sccofs.com.

Does CAD/CAM pay off?

An interview with Prof Albert Mehl, University of Zürich, Switzerland

Prof Dr Dr Albert Mehl

_IDS 2009 showcased the impressive advancements in CAD/CAM dentistry. For private dentists, however, there is much uncertainty regarding response to these developments. cad/cam spoke with Prof Albert Mehl, currently Guest Professor at the Centre for Dentistry and Oral Medicine at the University of Zürich, about whether investing in CAD/CAM pays off and for whom.

_CAD/CAM: *Most failures with conventional technology occur during impression preparation (insufficient illustration of the preparation margins, insufficient drainage). What advantages do CAD/CAM systems offer for the dental practice?*

Prof Mehl: Most importantly, treatment times are reduced because the dental restoration can be manufactured in the same session as the preparation (chairside method). Temporaries become obsolete, thus making uncomfortable and unaesthetic transition times a thing of the past. Owing to adhesive technology, sufficient retention for a temporary is in some cases not available because of the minimally invasive preparation. Furthermore, the latest studies demonstrate improved bonding to teeth with freshly cut dentine and enamel. Computer-aided milling and polishing allows the use of high-quality materials, which are manufactured industrially under optimal conditions, resulting in longer-lasting restorations compared to conventionally manufactured restorations. This has already been documented in numerous scientific studies. Through the combination of time saving, cost reduction and increased quality, the chairside method offers an interesting perspective for modern dentistry. This pertains mainly to single-tooth restorations but we can expect new possibilities in the production of fixed partial dentures with small span widths in the near future.

_How does the significant investment in digital impression technology pay off?

When considering concepts that entail the sending of data of a digital impression to a decentralised production site via the Internet, one can say that the time-frame equals that of conventional impression techniques. The extent to which the accuracy of digital technology is comparable to conventional impression techniques (including preparation of models) has not yet been determined, particularly in larger span widths. Comparative studies are now being conducted, and it is upon this issue that the further expansion of these concepts is dependent. However, first experiences suggest that this is indeed possible. Digitalisation would then enable the same advantages in other areas. The virtual 3-D model is important not only for the computer-aided fabrication of dental restorations, but also for every other kind of diagnostic, such as the exact 3-D determination of tooth movements, archiving of virtual models and the documentation of 3-D changes to the tooth and surrounding soft tissue. According to the industry, amortisation could be achieved through the cost savings of computer-aided production in production centres, software updates and systems for the chairside production of single-tooth restoration, and extension to diagnosis and treatment planning software. The enormous potential of digital scanning has been recognised by the industry and thus is currently in heavy development. As soon as quality and practicability have been demonstrated within clinical environments, amortisation will no longer be an issue.

_How can the aesthetic disadvantages of the single-session treatment (CEREC/E4D) be solved in the future?

Sophisticated, aesthetic single-session treatments in the anterior region are difficult and achievable only with much experience. Hence, most dentists will probably prefer the conventional veneer layered crowns. However, aesthetically pleasing results can be obtained using multi-coloured blocks. It is expected that these blocks will be improved by optimising the form and position of the layers and that the software will position the restoration within the block for optimum colour effects. In order to standardise this process, the use of tooth colour measurement systems may also be relevant.

_Are you referring to integrating digital colour measurement systems with CAD/CAM?

This is an interesting aspect. This kind of integration is likely to be available soon. In my opinion, this is another major advantage of CAD/CAM technology. Through the means of standardised calculation processes, the ideal layer thickness of frames and veneers for every required shade can be obtained individually for each combination of materials and type of restoration. A systematic analysis of these combinations and the resulting colour effects through large test series are essential though. Such tests have not been available thus far.

_Does the extended workflow—from practice to centre to laboratory and back to the practice—offset the time-saving factor?

This is the case and certainly a disadvantage of a centralised production process. The advantage, however, is that such centres can invest in high-quality and highly precise production technologies. These machines are maintained by specialists and ensure high capacity. The storage of many different materials including a variety of shades and implant systems is easier and more economical as well. Overall, production costs are very low and theoretically offer superior quality at the same time, which is something that needs to be considered when we speak of the time disadvantage. I anticipate that decentralised production will play a vital role in dentistry for larger restorations such as fixed partial crowns and implants.

_The first IT systems that were available to dentists at the end of the 1970s/beginning 1980s were expensive mini-computers (VAX) that were never actually amortised. Will it be the same with CAD/CAM? What do you foresee price development to be?

An amortisation of CAD/CAM systems depends not only on the possibilities and range of indications, but also on clinical concepts and the patient base (for example, the number of ceramic restorations produced and the extent of the potential for this kind of treatment). This needs to be analysed case by case. Generally speaking, we have already undergone the introduction phase and many CAD/CAM practices now demonstrate impressively that the system can actually be amortised quite well. Many companies have found CAD/CAM technology to be one of the key technologies in dentistry today, and large sums are invested in research and development, which will boost development processes. Many of these improvements can be incorporated into the systems later, as a large part of the expertise is incorporated into software. There are likely to be changes in the hardware as well, but those will take much longer. Dentists thinking about investing in a CAD/CAM system should make their decision regardless of such considerations. After all factors—range of indication, user friendliness, testimonies of fellow colleagues, economic efficiency, and scientific approval—have been analysed, entry into the CAD/CAM world clearly does make sense. In the short and intermediate term, we do not expect a significant decrease in price. But as a scientist, I always look far into the future and am convinced that after the high development costs have been amortised, prices will have the potential to decrease in the long term. The vision is that someday every dental practice will own such a system. IT technology is a good example and CAD/CAM technology, which is based on this IT technology, will follow suit.

_iTero, 3M ESPE Lava COS, CEREC, E4D—How many points of laserlight are technically required?

For dental restorations, an accuracy of 50 µm is demanded. Surprisingly, little is known about how critical this level really is, but we apply this standard, and surfaces should be scanned with a grid of at least comparable size. Double resolution (25 µm) would be even better. An average molar surface of 2 cm^2, for example, would yield 320,000 measuring points. The ideal number then depends on the data processing. By combining several scans, these numbers can be increased significantly. The software can then calculate the optimum distribution of measuring points, thereby improving the results even more.

_LED (CEREC) versus laser (3M ESPE, iTero, E4D), parallel confocal imaging (iTero) versus triangulation (CEREC, 3M ESPE, E4D)—what are the advantages and disadvantages? How much interpolation is acceptable?

These technical details principally influence accuracy and clinical adaptability. However, we cannot fully evaluate the quality of intra-oral scanners based on these details because they only constitute a small percentage of the overall complex measurement systems. In addition, there is the decisive factor of software interplay. Clinical and scientific experiences of each measuring system are far more important.

_What are the advantages and disadvantages of digital bite registration versus traditional bite registration with subsequent manual adjustment?

The software allows a more precise positioning of the jaw and a superior analysis of the occlusion compared to the conventional, manual procedure on the plaster model, on condition that the digital impression ensures a high degree of measurement accuracy for the jaw impression. In addition to the controlling of the restoration material thickness, contact patterns can be analysed, 2-D slices can be adjusted for visualisation in different areas, and articulation movements can be measured. Using software, the resilience of teeth can be simulated, enabling new possibilities for diagnosis of the contact situation.

_iTero and E4D do not require powder coating. Why isn't this possible with CEREC and 3M ESPE?

Powder-free impressions are the preferred option. However, they still are a significant challenge in intra-oral scanning technology. Based on my experience, I am not able to evaluate whether this is possible with sufficient accuracy at the present stage. There are many different approaches to analysing the light reflected from tooth surfaces without using powder; however, the accuracy of the measurement is dramatically reduced. At the end of the day, it is the results that count and it is up to us to analyse these closely.

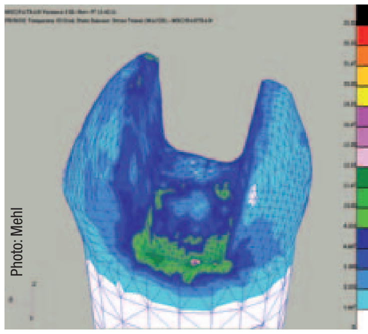


Photo: Mehl

_Do you believe that prostheses manufactured via rapid prototyping can be done in practice with better aesthetic quality and without the assistance of a dental technician?

There is debate about whether this is possible. While this procedure has become common in some milling centres with regard to metal and acrylic resins, restorations with aesthetic materials such as dental ceramics and composites have shown some principal and unresolved issues. Basic research is needed in this field. As a second step, production devices should be made compact so they become more cost-efficient for dental practices. In conclusion, this technology is unlikely to experience a major breakthrough in the medium term._

Digital dentistry is finally becoming a reality

An interview with Hans Geiselhöringer, Head of Global Marketing & Products, Nobel Biocare

Fig. 1_Hans Geiselhöringer at a NobelProcera symposium in Singapore.

_NobelProcera, which was first introduced to the public in March 2009 at the International Dental Show, is the most comprehensive prosthetic solution in the history of Nobel Biocare. According to the company, it can design and fabricate prosthetics for every clinical indication and treatment option, from single tooth to full mouth. CAD/CAM spoke with Hans Geiselhöringer, Head of Global Marketing & Products, Nobel Biocare, about the system and how it will affect the dental lab sector in the years to come.

_CAD/CAM: *The new NobelProcera scanner has been available since June 2009. How is it intended to influence the workflow between dentists, technicians and patients?*

Hans Geiselhöringer: The new NobelProcera system has to be considered as a single unit. By combining high-precision scanning technology, intuitive design software and industrial manufacturing processes, excellent product quality is guaranteed for almost every clinical indication whether it be on natural teeth or dental implants.

Our years of experience with NobelProcera are helping users not only to begin using digital dentistry but also to achieve immediate success in mastering the new technology. Of course, CAD/CAM-supported work processes contribute to the improvement of efficiency and precision, but the quick exchange of data and information among all partners involved in the treatment process is an important criterion for success. In this way, NobelProcera is breaking ground in dentistry.

_These are challenging economic times. Why should dentists and dental laboratories change to NobelProcera?

Dentistry will see significant changes through these new technologies in the years to come. We have indeed reached the moment at which 'digital dentistry' is finally becoming a reality and I am convinced that this is the time to change from conventional to CAD/CAM technologies. NobelProcera was designed to grow with the rising demands of the user through regular updates of the system and the software.

With the new generation of CAD software, the construction of frameworks is no longer necessary, which is another important element. Automated processes no longer provide only a recommendation for the later framework production after scanning the master model or the impression. Moreover, ideal dimensioning can be achieved through only an additional scan of the setup with the help of lateral scans. Working processes that once took hours to complete can now be achieved in a few minutes.

I know that it is difficult to introduce new systems into the daily work routine of a laboratory and to keep technicians up-to-date with new developments, but from my point of view, it is better and more efficient to have one system for all indications. In addition, a system like NobelProcera gives users the opportunity to outsource production, which saves time and the need for continued special training of technicians. NobelProcera also helps to reduce costs for each step in production.

Our systems, products and concepts are certainly validated by scientific research, as we want to be a reliable partner for our clients.

_NobelProcera utilises conoscopic holography technology. What are the advantages of this technique over comparable systems?

There is no truly comparable system available on the market yet; NobelProcera is the only scanner that exclusively utilises conoscopic holography technology. Most other systems are based on triangulation, which does not offer the same amount of applications offered by NobelProcera. These disadvantages have already been discussed in several publications and, therefore, I won't discuss them here.

The conoscopic holography technology of NobelProcera is based on a particular type of polarised light interference process that has been proven in several long-term trials and in other fields of industry. The main advantage over conventional CAD/CAM systems is that the conoscopic system is based on collinear measurement, which means that the light source and the detector are not arranged at the same angle. The collinearity offers not only higher accuracy of measurement and sensitivity robustness against optical defects, but also the ability to scan a wide range of geometric figures and shapes, including cavities. Besides high accuracy, productivity in dental laboratories can be further increased by batch scanning.

However, it is the precision of NobelProcera that gives the ability to scan several implants or whole implants systems in a patient in order to realise supra-constructions like the NobelProcera Implant Bridge or the new NobelProcera Overdenture solutions. I think the sheer amount of applications cannot be achieved by any other system on the market right now, with the exception of high-precision industrial scanners.

_Although a wide range of materials is available for almost all indications, the focus is often only on zirconium oxide. What other materials are available, and what are the main differences between them?

You are talking about something that has been on my mind for quite some time and it is something I see everyday in my own laboratories here in Munich. Zirconium oxide is an excellent material for many clinical indications but not for all. Long-term stability is not the only decisive factor; the

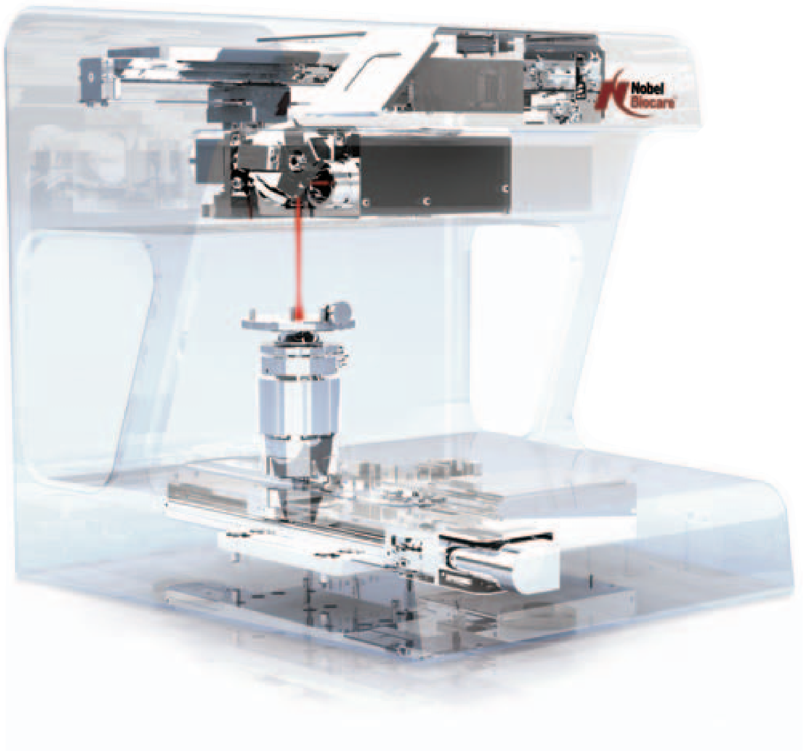


Fig. 2_The NobelProcera Scanner.

requirements and preferred treatment methods of the practitioner involved, and the financial costs to the patient have to be considered as well.

Besides zirconium oxide in four different colours for restorations on natural teeth, implant abutments and screw-retained prosthetic solutions, aluminium oxide is available as the material of choice in aesthetically demanding areas, for example in the anterior dentition. Titanium can be used in all cases in which zirconium oxide is not clinically acceptable.

We are also going to extend the material offering in the upcoming weeks with cobalt-chrome alloys and acrylics. I expect our laboratory clients will appreciate this offering, as they can pass this on to their clinical partners for support of all clinical indications.

_How do these developments benefit the long-term success rates of conventional and implant-supported restorations?

For Nobel Biocare, long-term success is primarily connected to the safety and quality standards we offer our patients and customers. Owing to our many years of experience in the CAD/CAM field and our high requirements of material and product quality, we are able to offer a five-year warranty on all our products, based on the harmonised working processes and the support we give the user regarding optimal construction design. For example, the software takes material-related specifications during the virtual framework design into account and warns users if requirements for dimensional stability are not met.

_Critics say that the automated fabrication of dental restorations may be the death of dental technology as we know it. What is your response?

Definitely not. In a tough market environment like the one we are operating in now, large-capacity laboratories, as well as small- and medium-sized companies gain significant advantages from using CAD/CAM. Improved efficiency and rationalisation do not automatically result in a reduced workforce. In fact, there are new opportunities for specialisation. Human resources, for example, can be used more economically, as uneconomical and time-consuming production steps, such as cast fabrication and moulding, are eliminated.

The answer to whether it would be profitable to run an own milling system in the laboratory is also no. Only large-capacity milling centres can do this. Ongoing observation of all production processes, constant surrounding conditions and freedom of choice of materials and their complementary milling systems are only a few reasons that speak for a centralised fabrication of frameworks. In addition, time-consuming maintenance, updating and the need to change milling heads are eliminated, which can only be economical under full capacity.

However, we do not only talk about shortening and simplifying the production processes but also about minimising risks that could result from CAD/CAM-produced restorations. Remaking incorrectly fitting restorations no longer strains the budget of laboratories because if these systems are utilised correctly, free remakes are usually included in the warranty.

_What consequences will arise from these developments for dental technicians?

In the near future, we will see further specialisations and the rise of new professional categories, for example dental designers and dental engineers. These new professionals will play a pivotal role in dentist–patient communication. By eliminating inefficient and error-prone working processes, more resources will be available for such important aspects as treatment planning and communication with practitioners, as well as the functional and aesthetic finish of the restoration.

Needless to say, this new CAD/CAM technology won't be able to replace the individual experience and expertise of dental staff. However, it is a useful addition to ensuring our patients the best quality and safety._

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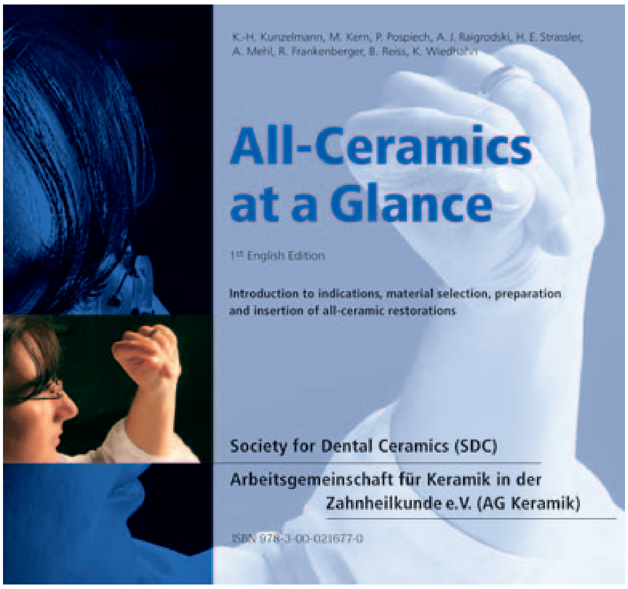
All-Ceramics at a Glance

Authors_ Dr Ariel J. Raigrodski & Dr Howard E. Strassler, USA



_Up until a few years ago, the most commonly used materials for tooth restorations were metal-based. For some time now, however, dentists and patients alike have been requesting all-ceramics restorations as an alternative, because they are metal free, corrosion resistant, aesthetic, chemically inert and thus highly biocompatible. In terms of durability and in some clinical situations, all-ceramic crowns can perform as well as the 'gold standard' metal-based restorations provided they are used for the right indications. All-ceramic restorations, due to the use of the current dental bonding technologies, offer dentists the option to conserve tooth structure while providing highly aesthetic therapy solutions. It's no wonder that the trend towards all-ceramic restorations is growing rapidly, and that all-ceramics can often substitute for metal in many clinical scenarios.

The use of all-ceramics for inlays, onlays, partial crowns, veneers, fixed partial dentures, implant abutments and superstructures, places special demands on material selection, preparation design, fabrication and insertion and cementation. To ensure that the use of all-ceramic restorations in both teaching and practice is supported by a solid clinical and technical foundation, two experienced and well respected experts and educators on dental ceramics in collaboration with German co-authors and the Society for Dental Ceramics and produced a ceramics manual for the professional community as well as the international dental market. Led by Dr Ariel J. Raigrodski, University of Washington, Seattle, and Dr Howard E. Strassler, University of Maryland, Baltimore, *All-Ceramics at a Glance* has now been published. The manual is a practice-oriented guide to ceramic materials and CAD/CAM systems. The clinical application of all-ceramics in restorative and prosthetic dentistry is described concisely and illustrated richly. The German edition of this manual has already established itself as a bestseller.

This vade mecum of all-ceramic restoration consolidates international specialist knowledge, and —thanks to the authors' years of experience—gives the clinical methodology a common denominator. This book is geared not only towards opinion leaders, university and college instructors, and scientists with obligations to teaching, research, continuing education, journalism, but also towards dental clinicians and practitioners who will find a platform to define the quality standards of dentistry with all-ceramics._

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All-Ceramics at a Glance
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Safety and reliability with CAD/CAM technology

Authors_ Hans Geiselhöringer & Dr Stefan Holst, Germany


Fig. 1a


Fig. 1b

Figs. 1a & b_Application of zirconia for long-span restorations requires high manufacturing precision and excellent material quality. Only if colouring pigments are equally distributed in the framework will material properties be optimal.

_Today, dental technicians and general practitioners are challenged by an ever-increasing number of CAD/CAM systems in the dental market. In order to determine which system is best suited, various aspects need to be considered. While CAD/CAM technology was initially associated with zirconia-based restorations, advanced systems offer an extensive range of materials and solutions for both natural teeth and implants. The benefits are not limited to a more cost-efficient fabrication of dental restorations in the laboratory; practitioners and patients benefit from the technological advancements equally. This article discusses the various aspects that need to be considered in the decision-making process.

_Simplicity in clinical and laboratory routines

A key aspect of the successful application of new technologies and clinical protocols is the time required to adapt to and utilise a system in a daily routine. This aspect is not only of relevance for the dental laboratory in manufacturing a restoration, but also to the practitioner considering changes in clinical protocol. Simplicity for the dental technician primarily concerns the time required to design and manufacture a restoration. However, in order to ensure an efficient workflow, a user-friendly software interface and intuitive handling are also of utmost importance.

Current scientific findings and clinical experience underscore the need for adequate material manufacture and framework design to minimise clinical failures, such as chipping of veneering ceramics or fracture of frameworks. The most important request, especially when working with zirconia substructures, is that the framework be anatomically designed and require no manual post-processing adjustment. In the past, double scans were performed in order to achieve this goal. New software design tools eliminate these time- and cost-intensive steps, as anatomic tooth-libraries support the user in ideal coping and framework design. Automatic cut-back functions increase ease of use and provide an additional margin of safety by ensuring homogenous veneering material thickness. An equally important aspect to consider is the design and dimension of the connector cross-section for fixed dental prostheses. Only if minimum connector dimensions are respected will long-term clinical success not be jeopardised. Newly developed software tools support the user in the virtual design of the frameworks and provide immediate feedback on the cross-sectional area, connector height and width, and coping thickness.

The most eminent facts for the practitioner are that no major changes in clinical protocol are required when working with CAD/CAM technology and industrially manufactured components. Only when it comes to oxide ceramics are slight modifications of preparation design required for long-term success. These are limited to a slight chamfer margin preparation, provision of an adequate occlusal space of 1.5 to 2 mm and rounded edges (eliminating sharp transitions). The true benefit when working with materials such as zirconia or aluminium oxide is that conventional cementation protocols can be applied. Adhesive luting—a require-

ment for all glass-based ceramics—is only applicable in clinical situations with reduced vertical crown height or extensive preparation taper in which loosening of a restoration is likely (Figs. 1–5). Clinical simplicity is relevant not only to restoring natural teeth, but also to placing dental implants. It is important to realise that CAD/CAM-manufactured implant superstructures do not require any change in clinical protocol when compared to conventional cast restorations. Rather, the consistent fit of milled components reduces the need for chairside adjustments significantly.

_Safety for the patient

Providing the patient with a reliable and long-term successful restoration is key in today's highly competitive dental market. Product and material quality significantly influence the long-term clinical outcome. From a clinical perspective, important aspects to consider include long-term stability in the oral cavity, bio-compatibility, post-processing options (for example, type of veneering material), reasonably low costs and clinical versatility. While the aesthetic potential was initially due to using high-strength all-ceramic restorations, the true benefit of Y-TZP/ZrO_2 (yttria-stabilised polycrystalline tetragonal zirconia), for example, is its excellent bio-compatibility paired with flexural strength values that allow for application in any area of the oral cavity for both natural teeth and dental implants. When in close contact with the surrounding tissues, the reduced plaque and bacterial accumulation, as well as the development of currently undefined pseudo-attachments leads to long-term tissue stability around these components (Figs. 6 & 7). This fact makes zirconia products the primary choice not only for non-compromised clinical situations, but also for pre-existing periodontal conditions whenever restorations, such as implant abutments, are in close contact with surrounding tissues.

Despite these advantages, it is important to understand and respect the material properties of these materials. If inadequate space or extensive leverage arms are unavoidable, alternative materials should be selected. Advanced systems such as the NobelProcera system (Nobel Biocare) offer

Figs. 2a–3c_Efficient CAD/CAM systems support the dental technician (NobelProcera System software, Nobel Biocare) by providing automated tools for anatomic framework design (Figs. 2a–c) and in manufacturing the ready-to-use components to eliminate any alterations after sintering (Figs. 3a–c).

Figs. 4a & b_Shaded zirconia (NobelProcera Bridge Shaded Zirconia, Nobel Biocare) guarantees maximum strength combined with excellent aesthetic results and application of any veneering material within the CET range of zirconia.

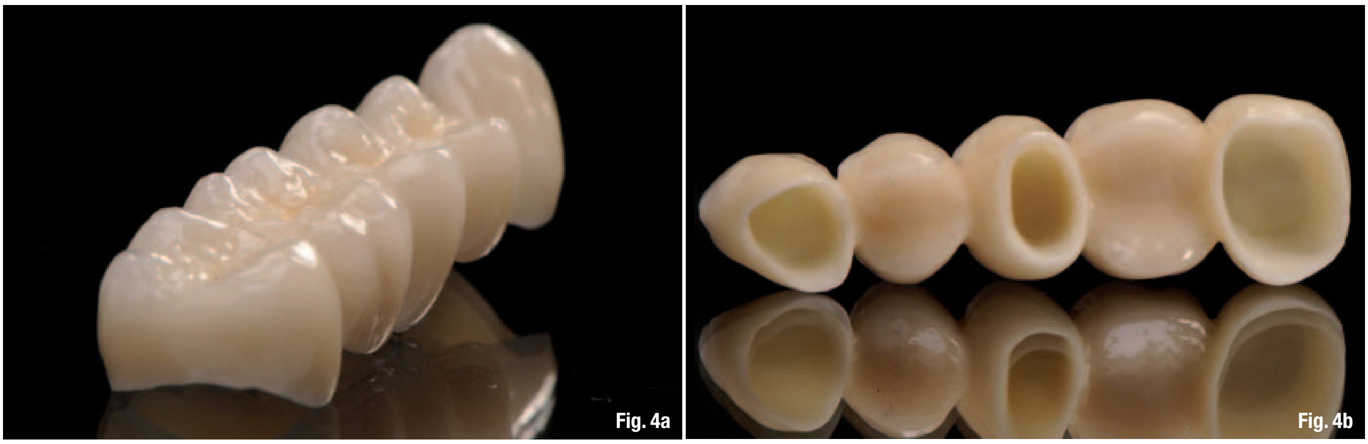



Fig. 5a


Fig. 5b

Figs. 5a & b_Intra-oral lateral and occlusal view of definitive solutions; the clinical benefit of zirconia products is the application of everyday clinical protocols, including cementation with conventional cements.

Figs. 6a–d_Standard clinical protocols apply when restoring natural teeth or dental implants with cement-retained crowns. For long-term success, it is important to position the abutment-crown margin at the level of or slightly below the gingival margin to ensure complete removal of excessive cement.

a wide range of materials ranging from aluminium and zirconia-based oxide ceramics, titanium, acrylics and non-precious alloys.

An indispensable factor for long-term clinical success of implant-retained superstructures is the precision of fit. Depending on the complexity of a restoration, poor fit can have a significant impact on function and stability in the oral environment. In terms of reproducible precision, CAD/CAM technology clearly outperforms conventional framework-manufacturing techniques. New generation software tools eliminate the need for time-consuming framework design on the master cast. Instead, the scan of the implant position can easily be matched with the scan of a wax-up, followed by a virtual framework design in the CAD tool. Adjusting the design and dimensions according to the anticipated final contour of the definitive restoration is achieved in a few minutes instead of taking several hours with conventional fabrication protocols.

_Cost-efficient solutions for laboratory and patient

Another aspect of providing cost effectiveness and safety is centralised manufacturing of products. Centralised milling evidently outperforms in-house systems: the workflow is permanently monitored; industrialised fabrication guarantees consistent quality; materials can be ordered as needed for any particular situation, eliminating the need for stock components; and time-consuming and expensive adjustments, updates, or repairs do not

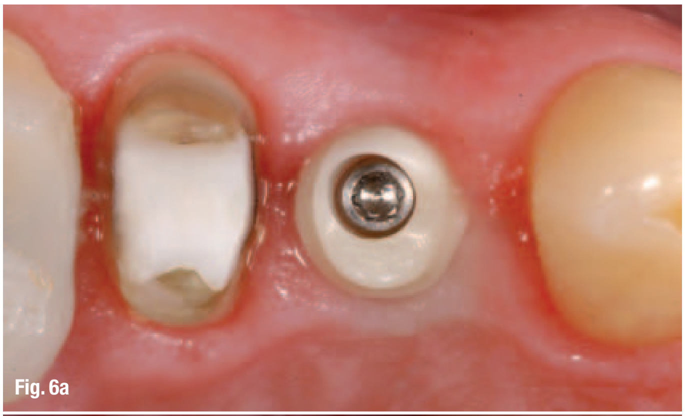


Fig. 6a

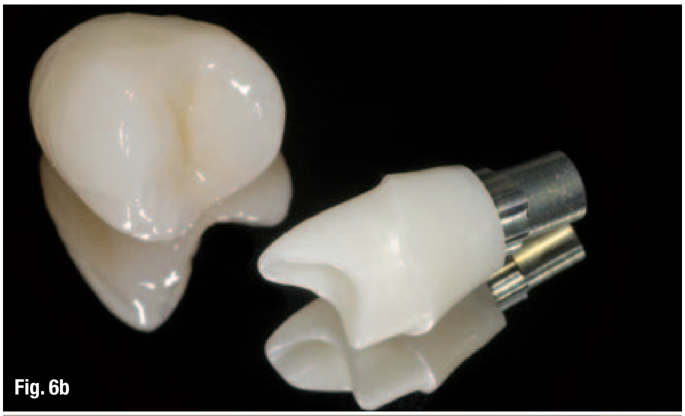


Fig. 6b


Fig. 6c

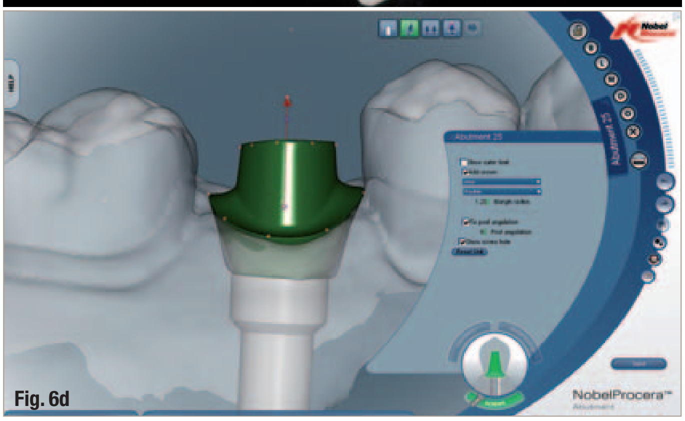
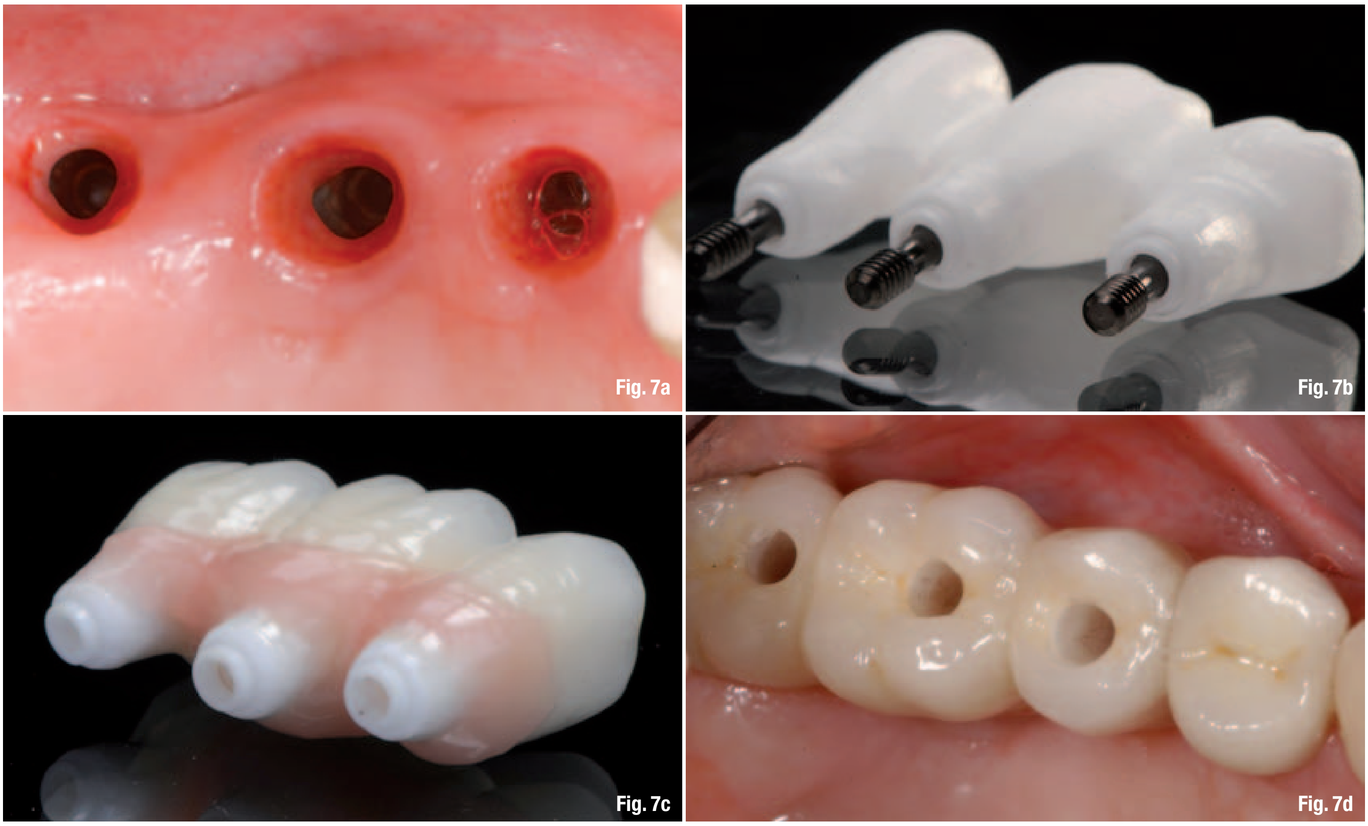


Fig. 6d



accumulate. From a cost-saving perspective for laboratories, the delivery of all metal frameworks of the NobelProcera system highly polished and ready-to-use adds to the true benefits of centralised manufacturing. The five-year warranty on all products cannot be met by conventional fabrication techniques. The warranty ensures that if complications occur during clinical function, a new product can be ordered free of charge. Here, the uniqueness of virtual planning comes into play again, as all data is always available even after years and merely requires the click of a button to reorder.

_Benefits of a versatile CAD/CAM system

CAD/CAM technology has significantly revolutionised dental laboratory techniques and protocols. Advantages related to material and manufacturing processes will promote the continuous adoption of CAD/CAM systems over conventional casting techniques, as the technology offers several benefits compared to conventional framework fabrication. This development provides true benefits for the dental laboratory, the practitioner and, above all, the patient. From a laboratory perspective, the benefits of the technology and the new NobelProcera system are obvious. Cost-efficient and time-saving workflow with only one CAD/CAM system in the dental laboratory, high-quality products with unrivalled precision and free-virtual design options, and centralised production.

The greatest advantage of the NobelProcera system is its clinical versatility. Not only the clinical situation, but also patients' expectations and means can be met. The base components such as copings, frameworks and bars always guarantee maximum precision, material homogeneity and stability for all patients. This is true whether a low-cost, non-precious alloy substructure is veneered with resin or ceramic material or a high-end all-ceramic solution is requested, whether a conventional denture set-up is retained by an overdenture bar or an implant-retained removable restoration is finished with custom all-ceramic teeth and individualised gingiva-coloured composite._

Figs. 7a–d_Screw-retained restorations on dental implants (Nobel Active Implant, Nobel Biocare) simplify the clinical protocol by eliminating the need for correct alignment of multiple single abutments, in the case of a cement-retained bridge, allowing for easy removal if required (NobelProcera Implant Bridge Zirconia). The availability of NobelProcera restoration for use with numerous implant systems and platforms increases the laboratory and clinical efficiency of the system. The application of zirconia frameworks allows for easy closure of screw access channels with conventional composite resin.

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Simplified digital impression-taking

Author_ Dr Helmut Götte, Germany

_As the only system in the world that uses the principle of triangulation for intra-oral measurements, the CEREC system is setting higher standards in CAD/DAM technology with CEREC AC and the CEREC Bluecam camera. Never before have intra-oral scans been made as fast, sharp, or accurately in 3-D. Whole-jaw images broaden the indication spectrum and, with virtual models, allow the dental office and the dental laboratory to work together impression-free.

The acquisition unit of the CEREC 3D system—called CEREC AC (acquisition center)—has been equipped with a new camera (Bluecam). CEREC AC replaces the previous CEREC 3 acquisition unit; however, the new software still supports the CEREC 3 camera. CEREC AC is compatible with both milling units—CEREC 3 milling unit and CEREC MC XL (extra large).

The advantages of an improved intra-oral image-capturing system do not stop at producing larger restorations chairside. The simplified inclusion of the adjacent teeth and the opposing jaw makes it possible to improve the occlusal and functional design, and the more exact measurement of the preparation enables an increase in the information content of the image. Furthermore, intra-orally recorded 3-D data sets of gnathic situations offer new diagnostic possibilities.

The heart of CEREC AC is the Bluecam camera. Instead of infrared light, Bluecam emits short-wave blue light produced by diodes. In addition, the lens configuration is new: aspherical lenses bundle the light beam and orient it parallel to the image sensor (CCD). The light sensitivity has been increased, the image capture time shortened by 50 per cent, and the image sequence accelerated. The projection matrix still employs the tried-and-tested light-stripe grid.

_Faster, sharper, blur-free

As a result, the new Bluecam offers higher image accuracy in the clinical situation: the meas-

Fig. 1_CEREC Bluecam Intra-oral Scanner. *(Image: Götte)*

Fig. 2_Quadrant scan with preparations, created from automatically joined individual images to yield a 3-D preview. *(Image: Götte)*

Fig. 1

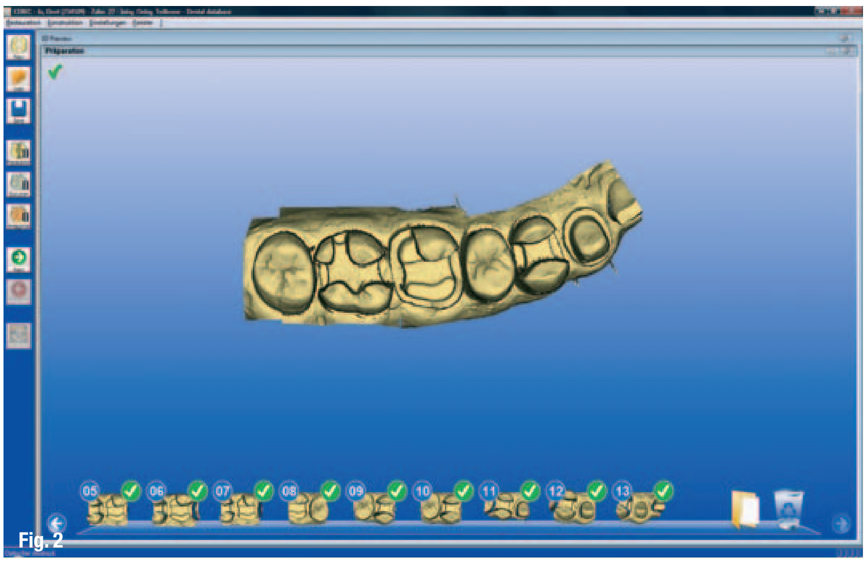
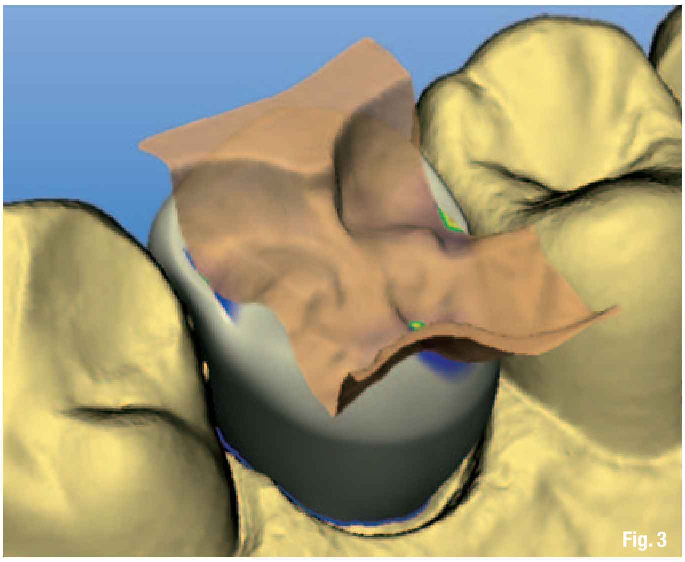
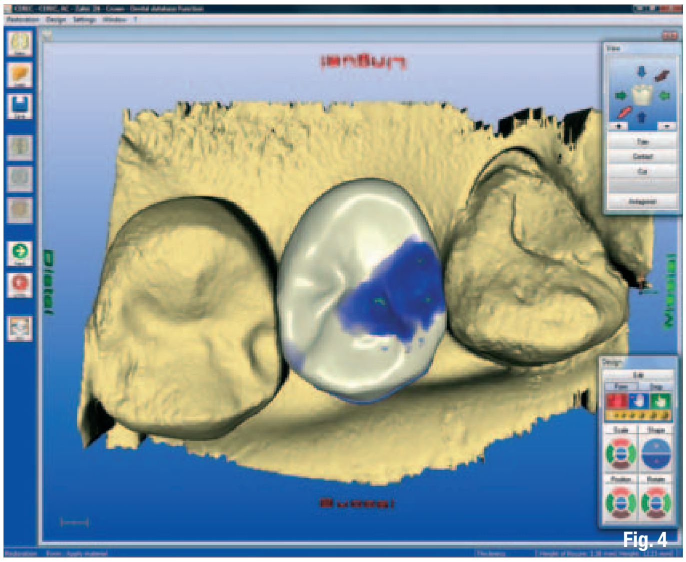


Fig. 2





urement depth has been increased by 20 per cent and the focus depth deepened to 14 mm. The sharpness of individual images has been heightened, and marginal blurring eliminated. Blur control (automatic capture), the sensitivity of which can be pre-selected, checks the intended image, and the camera automatically takes the image only when it is certain there is no blurring. In quadrants and across the dental arch, any number of pictures can be taken as an overlapping sequence.

The 3-D image catalogue manages the individual images on the screen. The software assesses their usefulness, marks and rejects useless scans, and joins the images to form a complete row of teeth (matching) and a virtual cast modelled on the natural example. Images acquired at the beginning of the sequence, the quality of which may have been lessened owing to the presence of rubber dam or cotton rolls, are automatically exchanged for a suitable image pair as soon as this is found. In this way, inadequate images are quickly replaced.

In vitro studies in the laboratory at the University of Zurich in Switzerland have shown that the image accuracy deviates from the reference measurement of a master laboratory scanner by only 19 µm—this is equivalent to one-third of the diameter of a human hair. This means Bluecam's accuracy is similar to that of stationary laser scanners. Such precision increases the marginal fitting accuracy of the restoration; thus, less excess occurs during adhesive luting, which in turn takes less time to remove.

Because of the image depth and focus depth, it is not necessary to keep an exactly determined distance from the preparation; the camera's prism window can be placed directly on the tooth, which makes image acquisition easier, particularly in the distal region. The Autocapture function, responsible for actually taking the image, engages automatically upon ensuring that the image is in focus. Hence, there is no need to operate a footswitch, which requires eye–foot coordination. This means that an entire quadrant can be scanned in 30 seconds. The blur control makes the image sequence and menu operation accurate and simple; thus, this phase can be delegated to the dental assistant. If the acquisition unit has a wireless or WLAN connection to the milling unit, the system can operate without power with no data loss for up to six minutes, thanks to its own optional, uninterrupted power supply—ideal for changing location during the milling/grinding phase.

_Up to four-unit bridges chairside

Bluecam takes about 30 seconds to scan a complete quadrant and is suitable for scanning stone casts. In addition, bite records with static and dynamic occlusion are digitised and prepared for functional articulation of the restoration. After selecting *bridge tooth databank*, the preparation for a four-unit bridge can be scanned with Bluecam. This enables the construction and chairside manufacture of long-term, provisional composite-resin restorations employing the CEREC milling unit, which broadens CEREC's indication spectrum considerably.

As when constructing crowns with CEREC 3D, fissure axes and cusps of the adjacent teeth are analysed—if desired, the antagonists' morphology is also analysed—and incorporated into the occlusal surface calculation. The software adjusts the occlusal contact points and sliding planes of the crown construction to the occlusal surface

Fig. 3_Crown restoration: adjusting the counterbite for occlusal surface design, region 24. *(Image: Götte)*

Fig. 4_Completing the crown's occlusal surface. *(Image: Götte)*

Fig. 5

Fig. 6

Fig. 5_Crown 24 after adhesive insertion. *(Image: Götte)*

Fig. 6_CEREC AC showing Bluecam and Quadrant Scan. *(Image: Sirona)*

of the antagonist. The wall thickness of the projected ceramic framework is checked beforehand, as are the insertion paths of the abutment crowns.

After designing the restoration, the data set can be transmitted to the milling unit or the practice's laboratory, or sent via LAN or wireless LAN to the dental laboratory. In the rapid milling mode of the CEREC MC XL milling unit, a four-unit bridge can be produced in about 20 minutes. Composite resin blocks by VITA (CAD-Temp) and Merz (artBloc Temp) can be used to fabricate the provisional restoration. The milling preview shows the size of the block required and the positioning of the restoration in the material—ideal when using ceramic blocks with integrated, density-determined enamel/dentine colour progression (VITA TriLuxe, Ivoclar Multishade).

_The virtual cast, online

Using the CEREC Connect system, the digital data of the optical impression, even of the whole jaw, can be sent from CEREC AC to the dental laboratory. This enables the cast-free manufacture of the restoration. In the future, it will be possible to manufacture a physical cast using these data from a portal, for dental laboratory use. In this manner, all single-tooth restorations could be manufactured, such as inlays, onlays, partial crowns, veneers, crowns and temporaries.

For crown-and-bridge frameworks of up to four units, any dental laboratory lacking a CEREC milling unit will in the future be able to access the Internet portal infiniDent to have a cast manufactured, which will serve as the starting point from which the laboratory itself can manufacture the framework. Thus, CEREC AC and CEREC Connect together offer the smallest possible initiation into the CEREC system, which can be expanded upon to any extent desired. Every inLab laboratory can make use of this option to accept work from impression-free practices and manufacture all-ceramic crowns and bridges using CAD/CAM technology.

With the milling unit CEREC MC XL, the new CEREC 3D software and CEREC Connect, CEREC AC sets a new standard in restorative dental treatment. The system's ease of operation allows a constant and time-saving workflow in the dental office. The progressive technology also offers new opportunities for highly efficient cooperation with the dental laboratory. In addition, the modular nature of the CEREC system, its consistent development, and its total compatibility with all system components, including the labside system inLab, ensure complete treatment flexibility and sustainable investment security._

_about the author CAD/CAM

Dr Helmut Götte
studied dentistry at the University of Munich were he graduated in 1993. Today, Dr Götte runs a fully digitalised, paperless dental office in Bickenbach, Germany. He has been using CEREC since 1996 and is a member of German Society of Computerized Dentistry.

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New inLab software with biogeneric capabilities

_**Sirona Dental Systems** recently launched a new user-friendly software that has been developed for its inLab system, which is based on Sirona's patented biogeneric technology.

Like fingerprints, no two human teeth are identical and each tooth has its own unique characteristics. A group of researchers led by Prof Albert Mehl (University of Zürich) and Prof Volker Blanz (University of Siegen) found that the shape of natural teeth is based on a person's genetic make-up. Sirona has harnessed this understanding in its new biogeneric inLab software, which enables dental technicians to create lifelike reconstructions, even while working with completely damaged occlusal surfaces.

On the basis of a single intact tooth, the programme extrapolates the natural morphology of that tooth to the patient's damaged tooth structure. "Biogenerics is based exclusively on the patient's individual dentition status," remarked Prof Mehl. "This is a major advantage in terms of clinical reliability. The more individual the occlusion, the better the resulting functionality."

Currently, all occlusal design approaches are based on limited dental libraries and databases containing data records of various teeth of standard types. Conventional CAD/CAM programmes retrieve a matching tooth from the archive, and then generate a design proposal for the given clinical situation. The user then manually edits and adapts this proposal. This selection is not justified according to any objective principles. Furthermore, using matching databases can be subjective and time consuming.

"Biogenerics will revolutionise occlusal surface design," said Bart Doedens, Vice President of Dental CAD/CAM Systems. "With a single mouse click, the user will obtain a natural and individually designed restoration that requires hardly any manual adjustment. Such made-to-measure restorations are simpler, quicker, and, above all, more precise than their off-the-rack equivalents."

The biogeneric design feature will replace the dental database feature in previous inLab software versions. With the new software, which can be used for all single-tooth restorations and three-unit bridges, it will be possible to create crowns, veneers and anatomically sized bridges easily. The user will only require an intact reference tooth of the same type, that is anterior or posterior._

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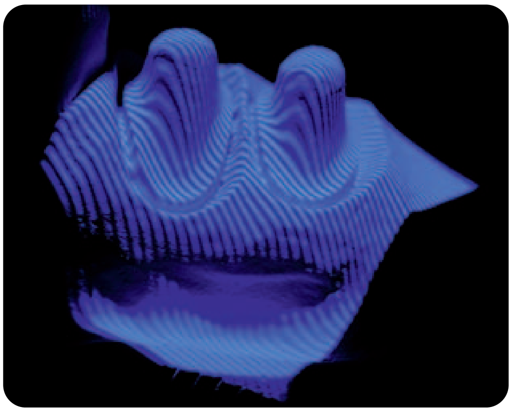
Sirona launches inEos Blue

_**Sirona Dental Systems**, a pioneer in digital dentistry and leading producer of dental CAD/CAM systems, has announced the launch of the inEos Blue desktop scanner. The advanced 3-D scanner allows dental technicians to scan dental models quickly, precisely and easily.



InEos Blue is based on Sirona's innovative blue light-emitting diode (LED), also know as Bluecam technology. Bluecam technology utilises short-wavelength visible blue light to facilitate flexible recording options, resulting in substantially faster scanning and precise 3-D digital models.

The scanner affords dental technicians more control to determine what they want to record, allowing the design process of 3-D digital models to be performed with precision and speed. With inEos Blue, the technician can now utilise an automatic image capture function (auto capture) that allows free movement of the model in any direction, providing complete control of the angle of the scan. Thus, the user takes a digital impression only of the required treatment area with interactive control and increased flexibility.

The inEos Blue scanner is available along with a computer and inLab 3D software. The scanner can be utilised as a stand-alone unit or in combination with the inLab milling unit for complete in-house production. In addition, inEos Blue can save and export scanning data in .STL format, thereby allowing the data to be processed using third-party software.

"Our goal for inEos Blue was to create a scanner that provides superior optical precision, reliability, and speed, while providing the technician full control of the scanning process," remarked Bart Doedens, Vice President of Dental CAD/CAM Systems. "Through our innovative Bluecam technology, we are now able to bring the best digital dental scanning capabilities to our valued laboratory clients."_

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All-ceramics works

Author_ Manfred Kern, Germany

_**The Society for Dental Ceramics** (SDC) has followed the development of all-ceramic materials and CAD/CAM technology for the last ten years, reviewing and commenting on the clinical results in the professional community, supported by experience from its own field studies in private practices. During this period, the number of inserted all-ceramic inlays, onlays, crowns and bridges has increased steadily to over 5.5 million restorations per year, thus attaining 20 % share of the treatment volume indicated for long-term restorations.

At the 9th Ceramics Symposium *All-Ceramics at a glance*, which was held from 4 to 5 November 2009 in Munich in Germany, the moderator Dr Bernd Reiss (Germany) called attention to the results of the Tele-Dialog Survey, which demonstrated that 87 % of the symposium attendees judged the quality of polycrystalline oxide ceramic frameworks to be better than or at least equal to that of porcelain-fused-to-gold. Prof Sven Reich (RWTH Aachen University, Germany) supported this assessment and presented a thematic tour of millable CAD/CAM ceramics.

Thanks to a combination of different properties, today there is a suitable ceramic for every indication. Silicate ceramic, known for its translucent chameleon effect, has established itself for inlays, partial crowns, veneers, and crowns, chiefly in the anterior-tooth and premolar regions. For extended aesthetic demands, as well as crowns and three-unit fixed dental prosthesis (FDP) up to the second premolar, lithium disilicate (LS_2) ceramic is available in graded opacities for press and CAD/CAM techniques. Framework ceramics of aluminium oxide (Al_2O_3) and zirconium dioxide

Figs. 1a–f_Cusp overlay, indicated for weakened cusps. (Photographs courtesy of Prof Karl-Heinz Kunzelmann, Germany)

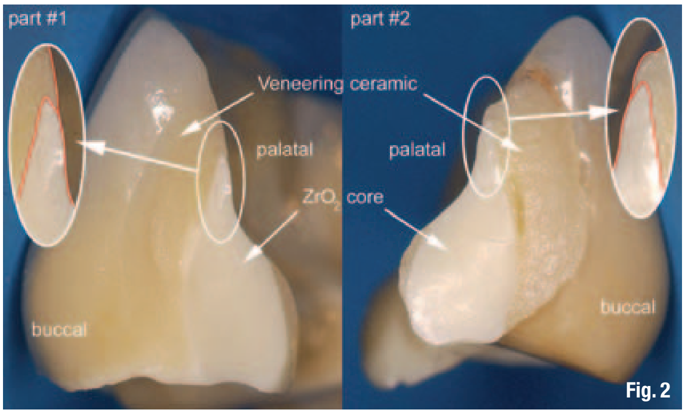

Fig. 2

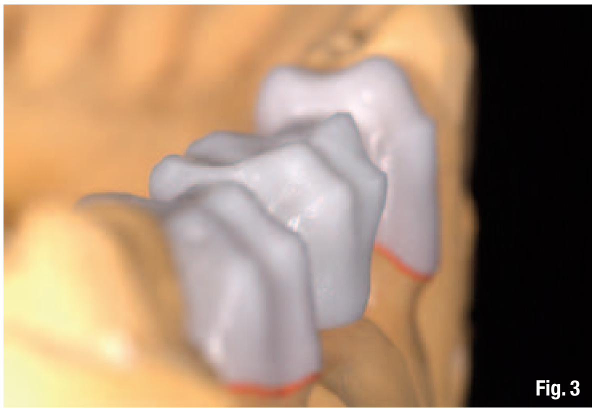

Fig. 3

(ZrO_2) have an opaque structure and require veneering. Owing to its partial translucency, Al_2O_3 is especially suitable for crown and FDP frameworks in the anterior and premolar regions. ZrO_2 is indicated for use not only in the posterior dentition, but also as a framework with wings for adhesive FDPs. Prof Reich discussed the veneering fractures on ZrO_2 frameworks, which have been under discussion in the professional community for some time. The underlying problem is that up until a few years ago, thin-walled crown copings were covered with thick veneer layers, and the bridges lacked anatomically designed frameworks with cusp support.

_Substance conservation as the goal

Prof Karl-Heinz Kunzelmann (Ludwig Maximilian University of Munich, Germany) lectured on *Ceramic inlays and partial crowns: New preparation concepts*, pointing out that current preparation criteria are still heavily influenced by—the limitations of early ceramic materials and CAD/CAM systems. Today, given the good fitting accuracy of ceramic restorations, the enlarged divergence angles of the gold era are no longer necessary (Figs. 1a–f). Thus, classical divergence angles of 6 to 10° are to be avoided, owing to the risk of the cavity margin ending in the area of the cusp tips or contact points. Occlusal surface veneers of pressable ceramic, suitable for the treatment of occlusal defects and vertically increasing occlusion, do not require a chamfer and conserve considerable substance. In partial crowns with cusp reconstruction, a substance-conserving supporting area in the enamel-dentine region is preferable to a supporting shoulder. An overlay is indicated when cusps are very thin (<2 mm cusp thickness). According to Prof Kunzelmann, the reimbursement for overlaying cusps should be adjusted because the statutory health insurance criteria for the partial-crown indication require that all cusps be sacrificed. However, this contradicts the principle of substance conservation.

Dr Andreas Kurbad (Germany) covered the range from *Classical crown to minimally invasive*. In the preparation of a fully anatomical ceramic crown with a circular chamfer, up to 64 % of the hard dental tissue can be conserved.[1] In contrast, metal-supported full crowns consume at least 70 % in preparing the necessary retention surfaces.[2]

A sure positioning of the crown is facilitated by clear margins. It should be tactilely perceptible when the ceramic body has reached its correct position. Further, the advantage of adhesive

Fig. 2_Fracture of a veneered ZrO_2 bridge. The framework was ground in palatinally (pointed droplet shape) and did not support the veneer adequately. The over-dimensioned veneering layer became subject to tensile forces.
(Photograph courtesy of Prof Ulrich Lohbauer, Germany)

Fig. 3_Cusp-supporting coping form prevents veneering fractures.
(Photograph courtesy of Prof Joachim Tinschert, Germany)

Fig. 4_Embedding the CAD/CAM-milled wax-up in order to obtain a pressed veneer.
(Photograph courtesy of Volker Brosch, Germany)

Fig. 5_Pressed veneers (IPS e.max Press) with final firing on ZrO_2 framework.
(Photograph courtesy of Volker Brosch, Germany)

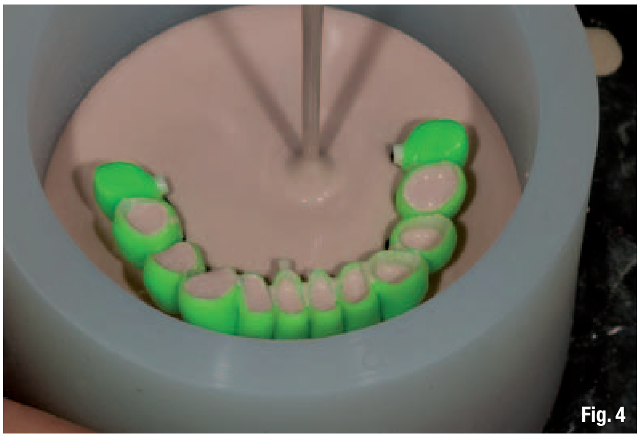

Fig. 4

Fig. 5

Table I _Failure rates of all-ceramic bridges. ZrO_2 frameworks remained largely fracture-free; chipping interfered with clinical success. (Table courtesy of Prof Matthias Kern, Germany)

Failure rates of all-ceramic fixed dental prosthesis

FIRST AUTHOR	N	CERAMIC	TIME (IN MONTHS)	FAILURE RATES (IN %) ANT.	PM	M
Pospiech 2004[c]	35	Lava	36	–	–	0°
Suárez 2004[c]	10	In-Ceram Zr	36	0°	5.5	
Raigrodski 2006[c]	20	Lava	31	–	0*	0*
Sailer 2007[a]	33	DCM	53	–	26.1°*	
Molin 2008[a/c]	19	Denzir	60	0	0	0
Tinschert 2008[a/c]	65	DSC	37	0°	0*	
Wolfart 2008[c]	24	Cercon	45	–	4*	
Wolfart 2008[c]	37	Cercon ext-br.	46	–	8.1°*	
Beuer 2009[c]	21	Cercon	40	–	9.5	
Eschbach 2009[c]	60	In-Ceram Zr	60	–	–	3.2*
Wolfart 2009[a/c]	36	e.max Press	86	0°	6.7*	

[a] adhesive luting [c] conventional luting ° up to 25 % additional fractures * 2.2–4.8 % structural fractures

luting is that no retention forms are necessary whatsoever. Depending on the type of material, ceramics have translucent properties; thus, according to Dr Kurbad, dark fillings can be a difficult foundation. Pronounced discolouration of the crown stump requires greater substance removal, in order to allow the ceramic a greater thickness.

_Toughness versus resistance

"The fracture toughness of the ceramic is more important than its resistance," explained Prof Ulrich Lohbauer (University of Erlangen-Nürnberg, Germany) in his talk on *Fracture mechanics of all-ceramic restorations*. Hence, it is an important accomplishment that in the structure of zirconium dioxide ceramic (ZrO_2), volume-expanding compressive forces block the propagation of micro-cracks. The fracture toughness explains the high survival probability of crown and FDP frameworks of ZrO_2 in clinical long-term studies. However, there has been recent discussion about veneering fractures on ZrO_2 frameworks[3] because the veneer ceramic (feldspar) has a much lower crack toughness than ZrO_2. In designing the crown copings, it is therefore important to ensure that cusps support the veneering layer (Figs. 2 & 3). After grinding (fine diamond), Prof Lohbauer recommended polishing the restoration's surface (check with loupes) during insertion or, better yet, sending it back to the dental laboratory for final firing. In selecting the ZrO_2 blank, Prof Lohbauer advised using only original materials from quality-conscious ceramic manufacturers and with proven clinical suitability, and adhering to the procedure for the veneers. This is to ensure that framework and veneering materials match.

_From wax knife to mouse

Master Dental Technician Volker Brosch (Germany) demonstrated the switch from wax knife to electronic framework design, comparing the workflow in conventional dental engineering with the CAD/CAM technique. The digitally constructed datasets can be used to construct both the temporary and definitive restorations. Fully anatomical anterior and posterior crowns can be made from the millable LS_2 blanks, and multi-unit bridges up to the second premolar can also be manufactured from this pressable ceramic of increased strength. Where aesthetic demands are particularly high, the cut-back procedure is used—the fully anatomical crown is anatomically ground down by the thickness of the enamel layer and then fuse-on veneered. Recently, Brosch has made singly designed veneers of fluorapatite pressable ceramic, digitally modelled and then sintered onto the ZrO_2 frameworks (Figs. 4 & 5).

Unique in dentistry is the multi-centre field study by the SDC, in which dentists in private practice can compare their findings/results on all-ceramic restorations anonymously and individually with other participating practices. At the time, over 5,700 restorations from more than 200 practices constituted the basis of the results. After evaluating over 3,000 follow-up examinations, Dr Reiss, who heads this quality-control study, recapitulated that the survival rate of inlays, onlays, partial crowns, and crowns of silicate ceramic lies at 83 % after 13 years of observation, putting them on par with cast restorations as described in the literature.[4] He explained that participating dentists enter their results online on the platform www.csa-online.net and receive an individual, graphic treatment profile.

_ZrO_2 not always necessary

Speaking on the *Clinical testing of all-ceramic restorations*, Prof Matthias Kern (University of Kiel, Germany) made it clear that ceramics must measure up to the survival rates of metal-supported restorations. The literature demonstrates that ceramic inlays and onlays have a clinical durability similar to that of cast restorations. CAD/CAM restorations demonstrate a longer service life than pressed or laboratory-constructed restorations.[5] Owing to its semi-translucency, Al_2O_3 is particularly well suited for crowns in the aesthetically sensitive anterior dentition. According to Prof Kern, it is thus not necessary to manufacture single crowns from ZrO_2. FDPs with ZrO_2 frameworks have demonstrated encouraging results; in observation periods of up to five years, framework fractures occurred rarely, even in multi-unit FDPs. However, some studies described veneering fractures (chipping; Table I). The reason for this is that originally, trusting in the high fracture-flexural strength of the material, ZrO_2 frameworks were delicate constructions, milled out with thin walls onto which thick veneering layers were applied, which became subject to tensile force. Prof Kern recommended wall thicknesses of no less than 0.8 mm for ZrO_2 frameworks and advised designing them anatomically, so that the veneering is supported by the cusps.

From the papers submitted for this year's Research Award in All-Ceramics, the jury selected three studies of equal merit. The presenter of the award thus decided to recognise all three researchers: Dr Frank Nothdurft (Germany) for his study *Clinical testing of a prefabricated all-ceramic implant build-up of zirconium dioxide in the posterior dentition*, Dr Andreas Rathke (Germany) for his *In vitro examination of the effectiveness of the dentin bond of ceramic inlays using different luting concepts*, and Falk Becker (Germany) for his study *Press-on and layering technique, chipping behaviour of all-ceramic anterior crowns.*

_CAD/CAM workshop reflects practical experience

During the concluding CAD/CAM workshop at the Clinic for Dental Prosthetics in Munich, Prof Daniel Edelhoff, Dr Florian Beuer, dentist Peter Neumeier, dental technician Marlis Eichberger and dental technician Josef Schweiger helped familiarise participants with the functioning of CAD/CAM systems. The clinic is equipped with representative CAD/CAM systems (C.O.S., 3M ESPE; Cercon, DeguDent; DigiDent, Girrbach-Amann; etkon, Straumann; Everest, KaVo; inLab, Sirona Dental Systems; Lava, 3M ESPE; Procera, Nobel Biocare; ZENOTEC, Wieland), which are used in scientific projects and for practical work in patient treatment.

In terms of the achievable quality and precision of fit of the milled all-ceramic frame-works, Prof Edelhoff emphasised that these are of a high level in every respect. Schweiger pointed out that the computerised milling systems for all-ceramic restorations employ various grinding strategies that are especially designed for the original blanks of the manufacturer. ZrO_2 frameworks that were manufactured in manual copy-milling processes (pantograph) had a worse fit and a critical structure, according to Schweiger. Prof Beuer and Schweiger demonstrated a new way to avoid veneering fractures: sinter veneering (Fig. 6). In this, single veneer structures of feldspathic ceramic are computer milled and sintered onto the ZrO_2 framework._

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

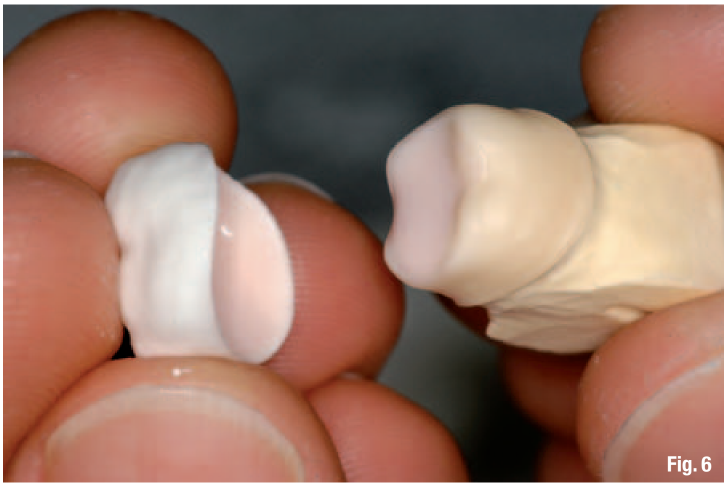
Fig. 6

Fig. 6_The feldspathic veneer, ground with CAD/CAM, was ceramic sintered to the ZrO_2 crown framework. (Photograph courtesy of Josef Schweiger, Germany)

_contact CAD/CAM

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International Events

2010

4th CAD/CAM & Computerized Dentistry International Conference
Where: Dubai, UAE
Date: 13 & 14 May 2010
E-mail: info@cappmea.com
Website: www.cappmea.com

EAED Spring Meeting
Where: London, UK
Date: 27–29 May 2010
E-mail: info@eaed.org
Website: www.eaed.org

3rd International Congress for Aesthetic Surgery & Cosmetic Dentistry
Where: Lindau, Germany
Date: 17–19 June 2010
E-mail: event@oemus-media.de
Website: www.oemus-media.de

IADR 88th General Session & Exhibition
Where: Barcelona, Spain
Date: 14–17 July 2010
E-mail: sherren@iadr.org
Website: www.iadr.org

IACA Annual Meeting
Where: Boston, MA, USA
Date: 22–24 July 2010
E-mail: info@theIACA.com
Website: www.theiaca.com

AAED 35th Annual Meeting
Where: Kapalua, HI, USA
Date: 3–6 August 2010
E-mail: meetings@estheticacademy.org
Website: www.estheticacademy.org

CEREC 25th Anniversary Celebration
Where: Las Vegas, NV, USA
Date: 26–28 August 2010
E-mail: jennifer.kist@sirona.com
Website: www.CEREC25.com

FDI Annual World Dental Congress
Where: Salvador da Bahia, Brazil
Date: 2–5 September 2010
E-mail: congress@fdiworldental.org
Website: www.fdiworldental.org

AACD & ESCD Joint Meeting
Where: London, UK
Date: 23–25 September 2010
E-mail: info@aacd.com
Website: www.aacd.com

ACCD Scientific Meeting
Where: Orlando, FL, USA
Date: 8 & 9 October 2010
E-mail: wanda@cmai.pro
Website: www.acadcamdent.com

Greater New York Dental Meeting
Where: New York, NY, USA
Date: 26 November–1 December 2010
E-mail: info@gnydm.com
Website: www.gnydm.org

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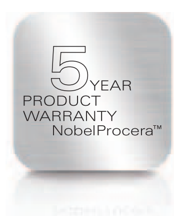

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