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What does the term "digital dentistry" mean for the future of dentistry today? In my opinion, digital dentistry has become all-encompassing and without question represents the most important technology that will drive our industry for the next 25 years. Many clinicians think of digital dentistry only as the ability to create a virtual model of a patient's dentition with an intra-oral scanner. While intra-oral scanning was one very important innovation, it is not new, having been developed and utilised for more than 25 years already!

Perhaps other clinicians relate the term "digital dentistry" to restorations that are fabricated utilising CAD/CAM technology rather than conventional techniques in laboratory-intensive wax-ups and casting, whether for natural teeth or for dental implants. Certainly, this methodology has also been around for many, many years. As machining technologies have improved, software applications have become exponentially more powerful and equipment costs have declined. Most major dental laboratories now speak the language of digital workflow and have invested in the proper hardware, software, and training to deliver CAD/CAM restorations for their clinician clients.

Yet, perhaps we are just discovering what digital dentistry really means and the way in which technology will continue to be fuelled by innovation. The advent of computed tomography, and now cone-beam computed tomography, scan devices has allowed clinicians an unparalleled ability to visually inspect a patient's individual 3-D anatomy, yielding information that can be utilised for preoperative diagnosis and treatment planning. The uses are limited only by our imagination. Patients who require orthognathic surgery, bone grafting, dental implants, third molar extractions, orthodontic intervention or endodontic therapy will all benefit from a more complete and accurate assessment of bone, soft tissue and adjacent vital structures, all provided by digital information.

Can we create a synergy between all facets of digital dentistry? As an example, intra-oral optical scanning data can now be merged with 3-D CBCT data, allowing dental implants to be planned with greater precision through interactive treatment planning software applications. The concepts of virtual teeth, virtual occlusion, virtual articulation and implant planning can now be directly married to CAD/CAM of custom abutments and restorations in zirconia, titanium or other materials. The same technology is now being applied to bone grafting through rapid prototyping manufacturing by creating either an anatomical model or virtual model of the defect, and milling or printing the donor graft from a variety of biocompatible materials.

Just as the smartphone revolutionised the manner in which we communicate, the digital workflow will serve as the foundation for improved methods to treat our patients. The industry is now moving toward a common vision, but we are only at the tip of the iceberg in our use of digital technology worldwide currently. Publications such as this provide a valuable service by showcasing the manner in which all phases of digital dentistry will continue to evolve and affect our industry in the next 25 years.

Keep reading these pages to witness the continued evolution!
Digital dentistry, our future?
Dr Scott D. Ganz

Projecting a new smile from a facial photograph:
A new way to plan multidisciplinary dental treatments
Drs Marco Del Corso, Italy, & Alain Méthot, Canada

Digital implant dentistry—a workflow in five steps
Dr Tim Joda & Prof. Daniel Buser, Switzerland

Restoring implants using lithium-disilicate,
CAD/CAM fabricated restorations
Dr Walter G. Renee, USA

The finesse of the pink and the power of IPS e.max
Rafael Santrich & Dr Larry Grillo, USA

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Projecting a new smile from a facial photograph: A new way to plan multidisciplinary dental treatments

Authors_ Drs Marco Del Corso, Italy, & Alain Méthot, Canada

Introduction

Aesthetic dentistry relies on professional trust, traditional wax-ups and artistic modifications of provisional restorations in the mouth to achieve the desired final result. Many of the published articles in aesthetic dentistry discuss the same principles in smile design: Golden Proportion, gingival architecture, emergence profile, and shape related to facial anatomy. These principles have been followed without any significant advances in technique or case presentation.

Many options are now available to predesign the most appropriate smile for the patient, such as computer imaging, diagnostic wax-ups on models or simply drawing on a patient photograph. For decades, dentists have been using various forms of software to preview, predict, and plan aesthetic procedures. Many of these programs lapsed into obsolescence because it took too long to develop proper diagnostic marketing or clinical guides.

In this article, we demonstrate the use of Dental GPS software, developed and proven over the last five years. The system uses the parameters captured by one digital preoperative full-face photograph to help clinicians with aesthetic diagnosis and automatically generates the best smile virtual wax-ups in only minutes. The smile prescription is then sent to the laboratory for technicians to create or transform a new aesthetic smile with precision (Fig. 1).

From diagnosis to the smile project

The system generates the virtual wax-up and laboratory prescription within minutes with the digital facebow, which captures the exact position of the dental and facial midline with the occlusal plane to prevent canting and shifting of patient cases. The diagnosis and treatment planning system also uses the M Ruler, an algorithm that analyses the best position of all maxillary teeth on a digital image to design the smile. Compared with the Golden Proportion, which offers only one ratio, 1:618, the M Ruler determines the patient’s own unique ratio for smile design.

The program is used for diagnosing, planning and executing changes in the position, shape, di-
mension, and proportion of the teeth. The first advantage of this tool is the rapidity in sharing the aesthetic proposal with the patient, making him or her an active participant in the treatment plan. The precision in transferring all the co-ordinates of the computer-simulated 2-D proposal into a 3-D wax-up allows the lead dentist, all associated specialists and the laboratory technician to access and share information regarding the treatment plan, ongoing procedural status, and the final results of the case. Should any midstream correction be necessary, it is relatively simple to inform and receive consent from all involved.

Diagnosis

Diagnosis is simply achieved by importing a facial photograph into the GPS software and the program then establishes the best smile parameters for the patient. A full-face photograph of the patient is taken directly from the front by placing the lens in line with the patient’s nose (Fig. 2a). The facial photograph is taken with the patient’s Frankfurt horizontal plane parallel to the floor. The inter-pupillary line is not important in this process because often one eye is lower than the other. The long axis of the face and the upper lip line are the reference planes for diagnosis and treatment planning.

The digital facebow provided by the software is adjusted by the operator to fit along the incisal edges and the dental midline of the patient. Then, the digital facebow is rotated to fit the long axis of the face on the vertical axis and the upper lip on the horizontal aspect (Fig. 3).

The photograph is automatically zoomed out to place the M Ruler over the face. This helps the clinician to diagnose facial or maxillary asymmetries, to provide the most aesthetic tooth position, shape, and smile design for the patient’s facial frame.

The digital facebow of the program is adjusted to fit along the incisal edges and the dental midline of the patient. When the digital facebow has been set, the system automatically zooms in on the mouth with the M Ruler over the patient’s teeth. The M Ruler helps to diagnose facial and dental asymmetries to provide the most aesthetic tooth position, shape, and smile design for the patient’s facial frame.

The photograph is automatically zoomed out to place the M Ruler over the face. This helps the clinician to diagnose facial or maxillary asymmetries, to provide the most aesthetic tooth position, shape, and smile design for the patient’s facial frame.

The result is precise because the image is calibrated to maxillary incisors dimensions.
malpositioned teeth, gingival architecture discrepancies, improper axial inclination, dental midline deviation, or indications for maxillofacial surgery and/or orthodontic treatment (Fig. 4).

Without the patient’s facial data, it is impossible to evaluate the smile and its harmony within the patient’s face properly. As part of the diagnosis, it is necessary to evaluate facial and dental asymmetries. As practitioners, we need to keep global aesthetics in mind by using a full facial view in the laboratory (Fig. 5). Close-up photographs of the patient’s smile aid smile design, but the complete facial photograph is required to evaluate the smile on the patient’s face.6

**Simulation**

Computer software creates a simulation as a virtual wax-up. The practitioner uses the virtual wax-up in the diagnostic process to determine the treatment options appropriate for the patient, such as orthodontics, crowns, implants, bridges, or full or partial dentures. This process aids the practitioner in presenting and discussing different options with the patient during a consultation (Fig. 6).

The diagnosis and treatment planning use the M Ruler. This diagnostic tool for smile design uses an algorithm based on maxillary central incisors width and the width of the patient’s maxillary arch to display an ideal arrangement of all the teeth shown in the smile (Fig. 7). Each patient has a unique maxillary arch width and upper central width. Maxillary teeth best position should be disposed between those lines in respect of the width of the upper arch and the width of the central incisors. These vertical lines guide professionals in determining the best position of the maxillary arch and teeth in relation to the patient’s face and in relation to the patient’s lips and gingiva for smile design.

The computer software simulation or virtual wax-up can be generated within minutes, and helps (or guides) the clinician in determining treatment options, which can be discussed with the patient during the same consultation.

In this particular clinical case, the simulation suggested longer central incisors to create a smile line that would follow the lower lip and lend a more pleasing proportion to the smile. Tooth whitening was also indicated (Fig. 8).

**Communicating with the laboratory**

After the virtual diagnostic wax-up, the patient was informed of the treatment options, including no treatment at all, and the risks, benefits, and costs of treatment. Informed consent was obtained for the treatment, which entailed placing ten veneers from the second premolar to the opposite second premolar on the maxillary arch and ten veneers on the mandibular arch.

Once the simulation (Fig. 8) had been accepted by the patient, alginate impressions of the maxillary and mandibular arches were poured with white stone and sent to the laboratory with a bite registration6, 7 taken using LuxaBite (DMG America). The aesthetic prescription was sent to a certified dental laboratory, which mounted the 3-D model on to an articulator in accordance with the GPS smile prescription and waxed up the final work following the future smile line (Figs. 9a & b). Because of the image’s calibration, the wax-up coordinates are very precise (Fig. 10).

Laboratory communication is a critical factor in the development of a diagnostic wax-up. In order to reproduce the simulation (virtual wax-up), the laboratory technician requires the position of soft
tissue on the articulator. After simulating the final outcome with respect to the rest of the face, the GPS digital facebow will position the maxillary cast on the articulator with the exact pitch, yaw and row of the photograph to reproduce the virtual wax-up on provisional and final restorations. The M ruler guides the wax-up of the future smile. This process is actually the easiest way to transmit the entire aesthetic data concerning the facial soft tissue to the laboratory.

Project realisation

The model's wax-up was used to fabricate a preparation guide to perform minimally invasive preparation, controlling ceramic thickness and maintaining the structural integrity of the tooth. A silicone impression of the wax-up was taken with Sil-Tech Putty (Ivoclar Vivadent) and the impression was filled with Luxatemp provisional material in shade A2 (Luxatemp, DMG, USA) and then relined to the prepared teeth in order to create a mock-up.

Once the wax-up had been used to create a precise mock-up, the mock-up was scanned and constituted the ghost guide for the CEREC system (Sirona) to project the final restorations. The final restorations were successively stained, glazed and cemented with shade A3 Variolink (Ivoclar Vivadent; Figs. 12a & b).

At the end of treatment, the smile line had been corrected to follow the lower lip line contour, and the final smile results were in harmony with the patient's face. The final aesthetic outcome fulfilled the patient's expectations, and an improved smile and facial appearance were achieved (Figs. 13a & b).

Discussion

By using a simple preoperative facial photograph of the patient, the dental practitioner can diagnose, create a treatment plan, and produce with precision a virtual wax-up and laboratory prescription in less than 10 minutes. The software in this case uses the M Ruler to determine the best smile for the patient.

The Golden Proportion Rule, or Divine Rule, represents a ratio of 1.618. This ratio has been used in a multitude of applications for many years, and is well known in the arts and architecture, dating back many centuries. Over the course of time, this Golden Proportion Rule has been applied to facial aesthetics and dentistry to provide mathematical guidelines for the creation of pleasing and aesthetic smiles by the determination of the appropriate proportions of the central and lateral incisors, and the canines in the smile. However, many authors have observed that natural teeth do not follow the Golden Proportion Rule for the display of teeth and this rule cannot be universally applied to all patients. In order to achieve a good aesthetic result, the ratio of the Golden Proportion Rule must be changed or adapted for each patient.

This modified Golden Proportion Rule is achieved by application of a mathematical formula relating to the inter-molar distance of each patient, representing the width of the arch and the width of the central incisors to determine the correct balance for the teeth displayed within that arch to create a pleasing smile.
special digital smile design

The virtual wax-up generated by the computer generates an electronic prescription that can be sent to the laboratory to create an accurate wax-up of the proposed smile. Once the position of the maxillary cast correlates to the smile prescription and the articulator, it is possible to fabricate provisional and final restorations that match the virtual wax-up with the software. This guides the laboratory technician in arranging each final restoration according to length, width and position to establish the new smile line, occlusal plane, and vertical dimension of occlusion (Figs. 13a & b). The ceramist simply follows the GPS digital prescription to create the final restorations.

This new concept allows practitioners to increase their cosmetic workflow in their practice. The visual simulation allows the patient to understand the treatment plan from the preoperative image through to the final cementation of the restorations. Several aesthetic projects can be simulated and discussed with the patient in the first consultation, whereas traditional laboratory wax-up allows the patient to visualise only one smile design possibility, often with no idea of the final aesthetic result with respect to the rest of the face. Traditional mock-ups also help practitioners and patients to evaluate the smile design; however, in many cases with diastemas or malpositioned teeth, the mock-up itself—derived from the traditional wax-up—still gives only one alternative and cannot simulate the final result accurately without reducing teeth. In addition, it entails a great deal of work to take an impression, create a wax-up and try the mock-up in the patient’s mouth for an evaluation. Even if a diagnostic wax-up is made by the dental laboratory and shown to the patient, or if a provisional is made from the wax-up and tried as a mock-up in the patient’s mouth, this single proposed wax-up may not be the optimal aesthetic solution for that particular patient.12

Conclusion

This article demonstrates the accuracy of imaging using the digital facebow, a 3-D cast positioning system that requires a single facial photograph of your patient, and the M Ruler, a diagnostic device for smile design. Practitioners are able to fit the best possible smiles in minutes to the patient’s face by trying different simulated smiles using morphing technology to create predictable and pleasing smiles for their patients. This simple protocol saves significant time and chairside adjustments. Moreover, patients receive better cosmetic dental treatment by seeing their best custom smiles, and can actively participate in the smile design process._

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

Fig. 12a & b The final restorations were realised with a CAD/CAM technique using IPS Empress CAD blocks milled with the CEREC system.

Figs. 13a & b The final smile and facial improvement. The smile design contributes to the changed facial appearance.

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The concept of digital dentistry is one that started out small and has progressively increased in momentum until its boundaries appear to have become endless. New technologies in dentistry will only be successful if they are combined with a complete understanding of basic comprehensive dentistry. While new technology and computerization can make procedures more efficient, less labor-intensive and more consistent, it will not replace education, practical experience and clinical/technical judgment.

The most exciting factor surrounding these technologies is not, however, only in the potential applications of the technology that are being hypothesized by dental professionals. The excitement truly lies in the fact that these "hypothetical" applications are currently being developed today, and some are even in the final stages.

In a relatively short time period, distal technology will revolutionize the quality of dental care that is being delivered in modern practice. Implants are now well documented for fulfilling the functional requirements in prosthetic tooth replacement. These new technologies, along with the evolution of surgical and prosthetic techniques, allow the dental team predictable, consistent results in implant rehabilitation. MicroDental is involved as a beta test area for many of these emerging technologies.

As dentistry evolves into the digital world, the successful incorporation of computerization and new technology will continue to provide more efficient methods of communication and fabrication, while at the same time retaining the individual creativity and artistry of the skilled dentist and dental technician. The utilization of new technology will be enhanced by a close cooperation and working relationship of the dentist/technician team.

The dental laboratory's primary role in restorative dentistry is to perfectly copy all of the functional and aesthetic parameters that have been defined by the dentist into a restorative solution. Throughout the entire restorative process, from the initial patient consultation, diagnosis and treatment planning to final restoration placement, the communication routes between the dentist and the laboratory technician require a complete transfer of information.

Functional components, occlusal parameters, phonetics and aesthetic requirements are just some of the essential types of information that are nec-
ecessary for the technician to complete the fabrication of successful, functional and aesthetic restorations.

Today, as in the past, the communication tools between the dentist and the technician are photography, written documentation and impressions of the patient’s existing dentition. The clinical models from these impressions are created and mounted on an articulator that simulates the jaw movements of the mandible (Fig. 2).

_The digital laboratory_

As restorative dentistry evolves into the digital world of image capture, computer design and the creation of dental restorations through robotics, the dental laboratory must evolve as well. To fully understand this concept, a laboratory must be clearly defined.

At first thought, it may seem that a laboratory is the place where a dentist sends his or her patient’s impressions to (Fig. 3) be processed into restorations, which are sent back to the dentist for adjustment and delivery. This definition fits well with the traditional concept of a laboratory/dentist workflow.

However, just as the Internet has forever changed the landscape of communication through related computer technology, the possibility to use CAD/CAM restoration files electronically has provided the catalyst for a significant change in the way we view and structure the dentist/laboratory relationship.

Imagine that the laboratory is not a physical place, but exists only in (Fig. 4) the talents of those performing the restorative process: the dentist and the technician. The equipment used to create the restoration may be located centrally, remotely or both. The laboratory is essentially a workflow, which is as flexible as the abilities of the dentist, the technician and the equipment will allow.

The primary decision becomes where the hand-off from one partner to another should occur. The dentist, who has the ability to optically scan teeth for impression making and chooses CAD/CAM restorations as the best treatment option for his or her patients, has enhanced freedom as to where the hand-off to the technician should occur. As a result, the laboratory is no longer a place, it is rather to a great degree, virtual.

_Communication is key_

The ability to facilitate communication between the dentist and the lab is of utmost importance and what makes the E4D system stand out. Tools such as the E4D Sky network enable E4D clinical operators to communicate and facilitate the transfer of data to technicians whenever laboratory involvement is required. With just a click, the entire case (whether scanned or completely designed) can be sent from chairside to the laboratory for fulfilment of the online prescription (Fig. 4).

_The digital process_

The new millennium has brought with it a change in digital dentistry as more than 20 different CAD/CAM systems have now been introduced as solutions for restorative dentistry. The introduction of digital laboratory laser scanning technology along with its accompanying software allowed the dental laboratory to create a digital dental environment to accurately present a real 3-D virtual model that automatically takes into consideration the occlusal effect of the opposing and adjacent dentition.

As well as the ability to design 16 individual full-contour, anatomically correct teeth at the same time (Fig. 5). It essentially takes a complex occlusal scheme and its parameters and condenses the information, displays it in an intuitive format that allows
dental professionals with basic knowledge of dental anatomy and occlusion to make modifications to the design, and then sends it through to the automated milling unit.

For the dental lab profession, the introduction of digital technology effectively automated or even eliminated some of the more mechanical and labor-intensive procedures (waxing, investing, burnout, casting, and/or pressing) involved in the conventional fabrication of a dental restoration, allowing the dentist and technician the ability to create functional dental restorations with a consistent, precise method.

Linear versus vertical manufacturing

The successful laboratory of the future will need to focus not just on the quality of the end product, but also more efficient production methods to reduce turnaround time within the laboratory process. Digital technology will allow the laboratory production to become vertical rather than linear.

The current laboratory fabrication process follows a very linear progression: model fabrication, day one; waxing, day two; finishing, day three; ceramics, day four, etc. Average production time for an all-ceramic or porcelain-fused-to-metal restoration is approximately five to seven working days based on this fabrication method.

In the digital laboratory, impressions will still be received from the client. Instead of taking days or weeks to go through several processes, we will be able to accomplish the same process in two to three days.

Once the impression is received at the laboratory, the impression can be scanned and data sent to several digital production stations at the same time. This will potentially allow the model, the restorations (both framework and waxup) and the final ceramic restoration to be completed at the same time (Fig. 6).

Digital diagnostic and treatment planning

The basis for all long-term success in restorative dentistry is a comprehensive diagnosis and treatment plan. The ability to preview a case from start to finish, communicate and co-diagnose with other specialists and specialties about dental patients via the virtual world is the true power and capability of digital dentistry.

About the author

Lee Culp, CDT, is the chief technology officer at DTI Technologies, where he guides the development of the DTI digital technologies program and its applied applications to restorative dentistry. Lee is also the editor in chief of Teamwork and associate editor of Spectrum. He is also on the editorial boards of Practical Procedures and Aesthetic Dentistry, Compendium and Inside Dentistry. Culp’s professional memberships include the American College of Prosthodontics, American Equilibration Society, American Academy of Cosmetic Dentistry, Academy of CAD/CAM Dentistry and the American Prosthodontic Society. Culp is an accredited member of the American Academy of Cosmetic Dentistry. He is a leading resource/inventor for many of the materials, products and techniques used in dentistry today and holds numerous patents for his ideas and products. Culp writes many articles per year, and his writing, photography and teaching style have brought him international recognition as one of today’s most exciting lecturers and innovative artisans in the specialties of digital dentistry, dental ceramics and functional aesthetics.
Digital implant dentistry—a workflow in five steps

Authors: Dr Tim Joda & Prof. Daniel Buser, Switzerland

Interdisciplinary Planning

CoDiagnostiX ensures the planning of the implant position using Cone Beam Computed Tomography (CBCT) with DICOM data (Digital Imaging and Communications in Medicine) and the subsequent transfer of the virtual situation into reality with an interdisciplinary team approach including the restorative dentist, the implant surgeon and the dental technologist.

The conventional workflow includes the fabrication of a dental set-up, a radiographic template and the secondary adaptation to a surgical template. Here, the fully digital process represents a further development: computer-assisted planning of the implant position by means of a virtually constructed prosthetic set-up and on-screen designing of an implant-guided template. The number of operational steps is shortened significantly compared to the conventional workflow.

Moreover, costly and time-intensive preparations can be avoided for the patient in advance of the CBCT. In addition, existing 3-D radiographic images should already be used, if possible.

The clinical case presentation demonstrates step-by-step the fully digital implant workflow with CAIS, including intraoral surface scanning and prosthetic rehabilitation in a five-step approach (Fig. 1).

Introduction

Restoration-driven implant placement is a key factor for successful implant therapy. In this context, Computer-assisted Implant Surgery (CAIS) offers an additional instrument for treatment planning, surgical placement and prosthetic rehabilitation in an interdisciplinary team approach.

The continuous technological progress in both the computer-based development and the dental manufacturing process ensures new opportunities in the clinical workflow. DWOS, in association with Straumann, offers a powerful combination of CAIS with the established GonyX System. In addition, a fully digital pathway in a model-free approach or a combination of these workflows is now possible.

This case presentation displays insights into the current processes of CAIS with an outlook on future improvements in the digital implant workflow.
Step 1

3-D radiographic diagnostics are performed without any template. An intraoral surface scan (iTero™) supplements the imaging sequence. The scan allows the generation of a high-resolution portable STL file (Surface Tessellation Language) of the intraoral patient situation (Figs. 2a–c).

Step 2

The DICOM data and the STL file are implemented and superimposed in the CoDiagnostiX planning software. A virtual set-up of the prosthetic reconstruction, as well as a surgical template with optimal 3-D implant positioning can be realized using a restoration-driven backward planning concept, whilst considering the individual anatomical situation (Fig. 3).

Once the planning phase is finished in CoDiagnostiX, a 3-D printer can plot the virtual construction of the surgical template with the rapid prototyping technique without the need of any physical model. Finally, CoDiagnostiX delivers an individual drilling protocol with sequenced CAIS instruments for a safe 3-D implant placement (Fig. 4a & b).

_Surgery_

Step 3

Prior to implant surgery, the plotted template is checked for a gap-free fit in the patient’s mouth. Built-in viewing windows adjacent to the implant site and in contralateral position improve the level of control that can be clinically achieved (Figs. 5a & b). After anesthesia and soft tissue punch, the cortical bone is perforated with a round bur in central position.
Afterwards, the preparation of the implant bed is made, successively using specialized guiding tools and corresponding spiral drills that could clinically be inserted into the slots of the sleeves. A flapless approach is only recommended if the local bone anatomy is adequate in volume, and if a wide band of keratinized mucosa is present at the implant site (Figs. 6a & b).

An implant depth gauge is placed after the first drilling to confirm accurate positioning of the osteotomy. Early error detection can be noticed at this initial stage and a possible deviation of the proposed implant position must be corrected manually (Figs. 7a & b).

Afterwards, the guided drill sequence can then be continued. The present bone density will determine, if thread cutting is necessary, or not (Figs. 8a–c). The placement of up to RN/RC-diameter-implants can be made directly, guided via the integrated 5 mm drill sleeve. Implants with larger diameters must be inserted manually by guidance of the finalized drill bed. The post-operative radiograph shows the correct prosthetic positioning of the implant with sufficient safety distance from the Nervus alveolaris interior and the adjacent dentition (Figs. 9a–c).

**Prosthodontics**

**Step 4**

Based on an additional intraoral optical impression using an implant scanbody, a second STL file can be created immediately after implant placement. This STL file is then also implemented into CoDiagnostiX. Differences between the actual implant location and the virtually planned position can be correlated and compared (Figs. 10a–c).

Moreover, the implant-supported prosthetic suprastructure can be designed and fabricated during the healing period. All the necessary information of the actual implant position is still included in
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the second STL file at this time. The CAD/CAM-fabricated monolithic implant crown can be finalized based on the virtually generated patient situation in a model-free technical approach.

**Step 5**

The full-contour reconstruction is tried out and reveals a functional treatment outcome without the need for any interproximal or occlusal corrections and a pleasing clinical appearance (Figs. 11a–c).

**Summary**

Further development in digital implant dentistry approximates the interfaces of surgical and prosthetic treatment steps: from the virtual planning, plotted on a guidance template manufacturing, to the CAD/CAM-based design, including production of the final prosthetic reconstruction.

As a part of the whole digital sequence, CAIS offers an additional tool in the interdisciplinary treatment planning. Precise and predictable treatment results can be implemented with this approach under consideration of the individual patient situation. In the full digital workflow, the overall treatment time is shortened and technical work steps can be saved in advance in a total of five stages with only three patient appointments. This novel process ensures the virtual construction and fabrication of surgical templates with a 3-D printer as well as the fabrication of monolithic implant-supported reconstructions using CAD/CAM-technology without the need for any physical models. This approach has the potential to further simplify clinical procedures in implant patients. The technique needs to be examined in clinical studies. In addition, clinical experience will demonstrate what percentage of the patient pool will benefit from this exciting technology.

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Restoring implants using lithium-disilicate, CAD/CAM fabricated restorations

Author: Dr Walter G. Renee, USA

Today’s consumers are always searching for the ultimate bargain, even when it comes to their dental care. They want high-quality results and minimally invasive treatments. The majority of modern dental procedures and techniques are trending toward satisfying these demands.

As a result, CAD/CAM technology has been incorporated into an increasing number of dental procedures, enabling dentists and their teams to offer state-of-the-art care to patients in half the time of traditional methods.

Moreover, when it comes to implant-supported restorations, CAD/CAM technology efficiently and effectively produces restorations that demonstrate high-strength properties for durable, long-lasting results that can withstand implant forces.

Research has shown that aesthetic, ceramic, CAD/CAM-fabricated molar crowns supported by implants gained high strength values when used in conjunction with adhesive cements, particularly in cases with titanium and zirconia implant abutments.1, 2

One of the most challenging aspects of a restorative case, however, is matching the abutment, restoration and adjacent dentition in perfect harmony. This is especially difficult with single-unit restoration cases because human dentition exhibits different colours, shades, tones and hues. It never presents one simple colour found on the standard shade guide.

Yet, using highly aesthetic lithium-disilicate value blocks (IPS e.max CAD, Ivoclar Vivadent) milled in the E4D in-office CAD/CAM system, dentists can create restorations that are durable, strong and indistinguishable from surrounding dentition, facilitating the highest level of aesthetics and function.

Material selection/fabrication

The E4D in-office CAD/CAM system enables clinicians to design, fabricate and place first-rate aesthetic restorations in a single visit. The high-quality ceramic restorations also demonstrate excellent strength, fit and longevity suitable for a broad range of indications and contribute to predictable outcomes.3, 4

Among the benefits of utilizing the E4D in-office CAD/CAM system to design and fabricate lithium-disilicate restorations is the ability to capture state-of-the-art, powder-free digital impressions. These can be taken from multiple angles for customized accuracy and optimal efficiency. Additionally, both hard and soft tissues can be scanned, depending on the case.

Preparation and margin assessment are completed simultaneously, and high-tech software fab-
icates multiple digital models at once. If needed, sculpting tools facilitate corrections by reimaging, eliminating the need for constructing multiple models or placing temporaries.

During the milling process, the unit’s robust design minimizes vibrations, resulting in micron-precise accuracy for enhanced fit and function of the final restoration.4

As dental practices have moved toward in-office CAD/CAM, innovative ceramic materials have been developed that address material issues regarding strength and aesthetics. These new and improved ceramics are designed to endure CAD/CAM processing without chipping or fracturing. They can be milled to full contour for improved fit and function.5

For example, there are many advantages to placing monolithic lithium-disilicate restorations (IPS e.max CAD). These restorations exhibit the same structural and esthetic properties of ceramic, yet demonstrate high-strength resistance to long-term mastication forces.4 They also blend seamlessly with natural dentition.

Additionally, these restorations are indicated for full-coverage posterior and anterior crowns, although the material itself may be milled for cases requiring thin veneers, minimally invasive inlays and onlays, partial crowns, implant superstructures and three-unit bridges.5, 6

Research shows that restorations fabricated with CAD/CAM perform better and are more durable compared to other available restorative options.4

Fig. 2 Pre-operative right buccal view of retained primary molars 55 and 65.
Fig. 3 Pre-operative mesial view of retained primary molars 55 and 65.
Fig. 4 The zirconium abutments (Astra OsseoSpeed, DENTSPLY) were placed and scanned using the E4D intraoral scanner.
Fig. 5 The zirconium abutment margins were marked in the buccal area.
Fig. 6 Viewing zirconium in subgingival locations was simplified using the E4D ICE system.
Fig. 7 Image of the final restoration design proposed by the E4D design software for milling using lithium-disilicate material.
The lithium-disilicate crystals in the IPS e.max material, in particular, deflect, branch or blunt cracks, increasing the flexural and overall strength of the material to a range of 360 to 400 MPa. These high-strength characteristics, capacity for milling to full-contour and placement with adhesive bonding or conventional cementation render IPS e.max CAD monolithic restorations practical for restoring in-office implant restorations. Additionally, a strong bond between the restoration and underlying tooth substrates can be achieved.

**Case presentation**

A 28-year-old patient presented with retained primary molars 55 and 65 (Figs. 1–3). These would be extracted and replaced with implant-supported crown restorations fabricated in-office using the E4D CAD/CAM system and a lithium-disilicate (IPS e.max CAD) material. The Value 1 Impulse blocks were selected because they are ideal for implant crowns, providing the ideal level of translucency. Implants were placed and the patient was provided with zirconium abutments (Astra OsseoSpeed, DENTSPLY). To fabricate the crown restorations, the abutments were scanned using the E4D intraoral scanner (Fig. 4), and the zirconium abutment margins were marked (Fig. 5).

The E4D ICE software enabled easy viewing of the zirconium margins in subgingival locations (Fig. 6). The restoration’s material thickness was verified using the E4D Autogenesis software. The blue areas equaled 2 mm and the green 1.5 mm, which was ideal for the selected IPS e.max CAD lithium-disilicate material. The E4D Autogenesis software resulted in appropriate anatomical contours. The IPS e.max CAD Value 1 Impulse blocks were milled and fired in one cycle, producing highly aesthetic monolithic crown restorations. The E4D Autogenesis software resulted in appropriate anatomical contours. The IPS e.max CAD Value 1 Impulse blocks were milled and fired in one cycle, producing highly aesthetic monolithic crown restorations.

**Fig. 8** The restoration’s material thickness was verified using the E4D Autogenesis software. The blue areas equaled 2 mm and the green 1.5 mm, which was ideal for the selected IPS e.max CAD lithium-disilicate material.

**Fig. 9** The E4D Autogenesis software resulted in appropriate anatomical contours.

**Fig. 10** The IPS e.max CAD Value 1 Impulse blocks were milled and fired in one cycle, producing highly aesthetic monolithic crown restorations.

**Fig. 11** Postoperative view of the milled restorations.

**Fig. 12** Postoperative facial view of the completed restorations.

**Fig. 13** Postoperative view of the final monolithic crowns on the abutments to replace the retained primary teeth 55 and 65.
The E4D design software was used to virtually create the lithium-disilicate crown restorations for the two premolars (Fig. 7). The software also enabled verification of material thickness (Fig. 8). In particular, the E4D Autogenesis software was used to create ideal tooth anatomy and contours, with the buccal area 2 mm thick and the distal area 1.5 mm thick, which was perfect for the lithium-disilicate (IPS e.max CAD) material (Fig. 9).

The Value 1 Impulse blocks (IPS e.max) were milled and fired in one cycle, resulting in highly esthetic and monolithic crown restorations (Fig. 10).

The implant screw access canals were sealed using a provisional inlay material (Systemp.inlay, Ivoclar Vivadent). To prepare the lithium-disilicate crowns for placement, the internal aspects were etched with 5 per cent hydrofluoric acid (IPS Ceramic Etching Gel) for 20 seconds, then rinsed and dried.

Then, a silane primer (Monobond Plus) was placed inside the crowns for 60 seconds and also on the zirconium abutments as a zirconium primer for 60 seconds, using the phosphoric acid methacrylate and sulfide methacrylate to bond to zirconium. The restorations were then cemented using a universal resin cement (Multilink, Ivoclar Vivadent).

**Conclusion**

IPS e.max CAD restorations provide predictable results for restoring implants (Figs. 11–14). The Value Impulse blocks lend to the creation of restorations that blend seamlessly with the adjacent natural dentition, yet they provide the ideal level of translucency to mask zirconium abutments.

In this case, the patient was pleased with the natural looking treatment results that were achieved by combining the IPS e.max CAD material with E4D in-office fabrication technology.

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The finesse of the pink and the power of IPS e.max

Authors: Rafael Santrich & Dr Larry Grillo, USA

Introduction

When damage to dentition is too severe for restorative treatment to be feasible, conventional dentures have been the treatment of choice. Conventional dentures, however, can be foul smelling and uncomfortable. Additionally, jawbone resorption causes the dentures to become loose over time requiring readjustment of the jaw to ensure a proper fit.

In some cases, if resorption has already occurred, the patient will no longer have sufficient bone structure to support dentures. To overcome the disadvantages associated with conventional dentures, new implant materials and techniques have been developed, providing the growing edentulous population with more opportunities for functional, stable and comfortable treatments as well as decreased bone loss.

Due to the amount of masticatory forces placed on the prostheses as a result of implant support, stronger, more durable substructures and denture teeth are necessary to accommodate wear.

Zirconia is one of the strongest materials available in the dental industry today demonstrating a flexural strength of approximately 900–1,100 MPa. Ideal for high-stress restorations, including implant dentures, zirconia restorations boast a failure-free reputation according to current research. Designed and fabricated using CAD/CAM technology, zirconia substructures are stronger and more durable than traditional denture prostheses. Innovative techniques provide long-term and patient-pleasing results.

When fitted with customised lithium disilicate dentition, fixed implant prosthetics will not develop a foul smell, require no realignment and provide a predictable, highly aesthetic and lifelong solution. In addition, CAD/CAM technology can be used in the office or laboratory for indications including full-mouth restorations, fixed partial dentures, implant abutments, crowns, veneers, inlays, and onlays, contributing to faster and easier restorative treatments.

Suitable for restorations requiring high strength and exceptional durability, IPS e.max ZirCAD (Ivoclar Vivadent) is a yttrium-stabilised zirconia demonstrating a flexural strength of more than 900 MPa, and a fracture toughness of more than twice that of glass-ceramic materials.

With approximately 50 percent porosity, the pre-sintered blocks allow easy processing. Yet, once sintered to full density, its superior strength and inertness make it an ideal material for dental restorations. IPS e.max ZirCAD blocks (Ivoclar Vivadent) meet the functional requirements demanded by posterior masticatory forces.

Despite the use of different IPS e.max framework materials (lithium disilicate or zirconium oxide), aesthetic results can still be achieved due to a selection of natural and shaded pre-sintered zirconium oxide blocks for colour versatility, and when layered with aesthetic ceramic materials,
Figs. 1 & 2. Preoperative images of the patient’s dentition.
Fig. 3. Panoramic X-ray of the patient’s mouth.
Fig. 4. Immediate dentures were placed the day of surgery.
Fig. 5. A face-bow transfer was performed.
Fig. 6. A zirconia-hybrid prosthesis would be fabricated for the upper arch and an acrylic prosthesis for the lower.
Fig. 7. Image of the duplicate denture.
Fig. 8. Plastic temporary abutment placed over the multi-unit abutment.
Fig. 9. Part A and B of the resin is mixed together.
Fig. 10. The resin is applied to the denture.
Fig. 11. Image of the resin denture.
Fig. 12. The frame was designed and scanned.
Fig. 13. The zirconia frame was tried in.
Fig. 14. IPS e.max Ceram pink colours were chosen from the shade guide.
Fig. 15. The frame was characterised with Zirliner 1 and fired.
Figs. 16 & 17. A full-contour wax-up was completed.
Fig. 18. The frame was masked by layering IPS e.max Ceram in intensive pink porcelain, opal enamel white and opal violet.
Fig. 19. Characterisation of the porcelain was finalised using Essence stains.
industry report  aesthetic dentures

such as IPS e.max Ceram (Ivoclar Vivadent), good aesthetics can be attained.\(^9\)

The lithium disilicate ingots are specifically designed for press-on procedures indicated for zirconium oxide-supported gingiva portions, single-tooth restorations, anterior and posterior bridges, inlay-retained bridges, and implant superstructures.\(^10\)

Manufactured in nine block sizes, the larger ones suitable for long-span bridge frameworks or for stack milling and the smaller ones for coping, zirconia substructures can satisfy patient’s demands for high-strength, highly aesthetic, functional, fixed prosthetic results.\(^10\)

The All-on-4 treatment concept (Nobel Biocare) includes fixed and removable prosthesis and can be used in combination with a full-arch zirconia substructure as well as a variety of implants (Nobel Active, Nobel Biocare). The ability to screw a provisional prosthesis onto the implants directly after surgery provides edentulous patients with an immediate implant-supported restoration.\(^1\) - 15 Accommodating a wide range of abutments and prosthetics, this technique benefits patients by providing an aesthetically pleasing, comfortable, stable and functional prosthesis.\(^1\) - 16

**Clinical Protocol**

The patient presented with severely worn and damaged dentition (Figs. 1 & 2). After performing a panoramic X-ray of the patient’s mouth, it was decided that the complete removal of all remaining teeth was necessary (Fig. 3). The treatment agreed upon was the application of the All-in-4 technique (Nobel Biocare).

Therefore, the first step was to guide the placement of the four RP Nobel Active implants, and the multi-unit transmucosal abutments used to facilitate tissue level emergence by creating a precision surgical implant guide. Once the implants were placed, impression copings were inserted, an impression was taken from which to create the master cast and immediate dentures were placed (Fig. 4).

A face-bow transfer was performed to idealise the parameters for a precision restoration (Fig. 5). At this point, the decision was made to fabricate a zirconia-hybrid prosthesis for the upper arch and an acrylic prosthesis for the lower (Fig. 6). A laboratory verification jig was created from the master cast to guarantee the accuracy of the final fit. To set tooth arrangement and function, an occlusal wax rim was created. The set-up was then screwed in, the bite verified, and phonetics, function, and aesthetics approved.

**Laboratory Protocol**

A full-contour wax crow design was completed (Figs. 16 & 17). Intensive pink porcelain (IPS e.max Ceram) was built up to mask the frame and mixed with opal enamel white (OE4) and opal violet in specific areas to create a natural look. The bake speed was lowered to 35 °C per minute, held for one minute at 760 °C, cooled at a rate of 25 °C per minute and held at 350 °C for 15 minutes (Fig. 18).

Characterisation of the pink porcelain was finalised using Essence stains (Ivoclar Vivadent). Low speed rates were used to fire the glaze. Fired at 35 °C to 730 °C for one minute, the glaze was then slowly cooled at 25 °C per minute and finally held at 350 °C for 15 minutes (Fig. 19). Next, the crowns were glazed with shades one and two of copper, white, cream, profundo, mahogany, ocean and sunset, then baked at 775 °C per one minute hold (Figs. 20–25).

**Seating**

Once the patient was satisfied with the colour, phonetics, and smile line (Fig. 26), the case was prepared for bonding. The zirconia and titanium were primed (Monobond, Ivoclar Vivadent) to create mechanical and chemical retention in both materials. The case was then cemented using universal adhesive implant cement (Multilink Implant, Ivoclar Vivadent, Figs. 27–29).
Figs. 20–25. The crowns were characterised with shades one and two of copper, white, cream, profundo, mahogany, ocean and sunset, then fired.

Fig. 26. The case was ready for bonding.

Figs. 27–29. The case was primed with Monobond.

Fig. 30. The IPS e.max crowns were etched with 5 per cent hydrofluoric acid.

Fig. 31. The crowns were cemented into place, leaving the screw holds vacant.

Fig. 32. Image of the healthy soft tissue and the angulation of the multiunit abutments.

Fig. 33. The case was torqued into place.

Fig. 34. Image of upper arch with IPS e.max crowns and the Phonares acrylic teeth in the lower arch.

Fig. 35. Postoperative occlusal view verifying balance and occlusion.
Prior to cementing the crowns in place, they were etched with a 5 per cent hydrofluoric acid for 20 seconds (Fig. 30). All crowns were cemented into place except those that fit over the screw holds (Fig. 31), which would be cemented once the case was seated (Fig. 32). Finally, the dentures were torqued into place (Fig. 33). IPS e.max crowns were used in the upper arch and Phonares acrylic teeth in the lower (Fig. 34) to equipoise the forces and achieve a balanced occlusion providing the patient with the highest quality of function and phonetics (Fig. 35).

Conclusion

Previously limited to sometimes ill-fitting and painful false teeth, edentulous patients today have a variety of sophisticated treatment options. Due to their ease of use, predictability and its many advantages, CAD/CAM technology, pressable and milled ceramic materials and new implant structures enable dentists and laboratories to provide comfortable, stable and aesthetic treatments to edentulous patients. Newly developed, innovative alternatives are more durable, aesthetic and last longer compared to conventional options. Implant-supported dentures fabricated with materials such as zirconia and IPS e.max ZirPress not only demonstrate superior characteristics, but are stronger and more durable. Modern procedures and materials can satisfy patient demands by providing denture treatments that are long-lasting, strong and aesthetically pleasing._

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

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Diode laser application optimises the clinical outcomes of digital workflow

Authors: Drs Frank Liebaug & Ning Wu, Germany

Introduction

"Digital Workflow" has become an established term in present-day dentistry, helping to solve problems in dental technology which would have been rejected due to an unwarranted high analogous effort some years ago.

With digital procedures entering the realms of diagnosis, therapy and production, the workflow of dentists and dental technicians has changed considerably over the past years. Today, all dental disciplines rely on digital technologies to achieve exact diagnosis, modelling and production. The broad spectrum of technologies reaches from intraoral scanners for three-dimensional scanning of the stomatognathic system to the production of models via CAD-data by 3-D printers. Dentists and dental technicians make use of these technologies as well as of manual procedure steps. Digital technologies have improved the highly demanding work of today’s dental technicians in terms of reliability in planning and treatment. Now, neighbouring teeth, roots and nerves can be captured precisely via digital volume tomography, with the data being visualised three-dimensionally. These options result in a significant risk reduction of implant placement in the jaw bone. Furthermore, digitalisation has achieved a fundamental change in patient communication. Dental technicians and dentists are thus no longer demanded exclusively as clinicians and craftsmen. For instance, CAD/CAM technology and intraoral cameras allow for presenting transparent solutions for an improvement of the aesthetic situation to the patient already in the practice. Therefore, the patient is informed more soundly and can be included in decisions on treatment planning.

The production of restorations has undergone a tremendous change in the past years. All-ceramic crowns have replaced porcelain fused to metal as the standard. The properties of materials such as zirconium...
Diode lasers have been improved to deliver perfect aesthetic results.

Dentistry without digital technology and CAD/CAM procedures has become inconceivable. Intraoral and extraoral measurement, scanning of antagonists and registration, three-dimensional construction on screen (Fig. 7), applying a large variety of tooth shapes from the database, designing anatomical occlusal surfaces, the functional articulation in the virtual model, the subtractive processing of high-performance ceramics—all of this would be impossible without computers.

New procedures influence established steps of the process, and advances simplify workflows. Thus, virtual construction models, the articulation via Windows interface, biogeneric design of occlusal surfaces via intelligent software, rapid-prototyping and 3-D printing are only a small sample of the topics which are discussed in scientific publications with regard to CAD/CAM dentistry. Small and medium-sized dental laboratories or, as in my case, larger practice laboratories will acknowledge their core competence of producing high-class aesthetic restorations as well as individually designed partial dentures and implant dentures.

It has thus become a prevailing trend to produce inlays, onlays, partial dentures and single-tooth restorations as well as large-span bridges and suprastructure assisted by computer. In addition, the computer-assisted production of long-term temporary restorations according to functional criteria has become an established method in our practice for implantology and its superstructures.

Exact transfer of the oral situation as the base

Without an impression of the actual patient situation, modern dentistry is unthinkable. For decades, not much has changed with regard to impression technique, except for the development of impression materials. Already in the 1980s, the first trials in digital impression taking were conducted in the form of intraoral optical scans and then introduced as a new technique. By now, this technique is so well-developed that it can be applied in a multitude of indications.

However, an exact transfer of the oral situation on the virtual or physically present model is the foundation and the beginning of digital workflow. Whether analogous impression taking or digital scanning by optical procedures is applied, the mode of preparation, especially the preparation margin, must be depicted exactly.

Although sometimes the soft tissues can be pushed away from the subgingival preparation margin because of the viscosity of the impression material, opti-
I industry report _ diode lasers

Fig. 10 Depiction of the form of the preparation, especially the level ranges on the monitor, after cutting less relevant aspects of the model situation image digitally.

Fig. 11 Checking of the minimum layer depth for the future ceramic restoration is more practical than via the analogous model.

Fig. 12 Articulation can be checked from various perspectives.

Fig. 13 Production and checking of the optimum occlusal configuration.

Fig. 14 Okklusal view of the digitally planned partial crowns.

Fig. 15 In the end of the digital planning phase, the restoration can be checked from all special dimensions even before the milling process.

cal impression taking via scanner systems does not allow for this option.

While optical impression taking systems make a contribution to standardization, direct control of the preparation outcome and thus to the quality of the impression, conventional as much as digital optical impression taking can only capture structures which are visible to the human eye. Optical impression taking cannot replace conventional impression taking techniques completely. This holds true especially for removable and complete dentures as well as circular implant suprastructures. In addition, the transfer of virtual data into real-life working models, which is often mandatory, has not yet been perfected.

However, the current trend is digital impression taking, although many obstacles have yet to be overcome.

A review of the literature and published reports shows that in most cases supragingival preparation margins are treated, which some colleagues might be able to take an impression from without any retraction cords. Extensive haemostasis measurements and tissue suppression can cause more trouble, since a camera will only be able to scan areas optimally which are easily accessible.

No optical system has been able to see through a pooling of saliva or offer usable data for an exact rendering of the preparation margin. Imprecision can accumulate between impression taking and final prosthesis. Thus, both the advantages and the precise results produced by digital workflow would be taken ad absurdum.

But the clinical, deeply subgingival preparation margin with bleeding of the adjacent gingiva (Fig. 2) can be a severe challenge for experienced clinicians using the traditional analogous impression technique. Without cord techniques or astringent auxiliaries, a good result is hard to achieve from impression taking. Or is it?

Twenty years ago, I have introduced high-frequency technology and shortly afterwards dental lasers to our praxis because of the high quality standards in solving prosthetic problems by our team of clinicians and dental technicians. Especially the compact diode lasers can be applied effectively in this field.

_Laser radiation

Not only is laser radiation absorbed by the tissue and then transformed into heat, but it is also partly transmitted through the tissue. This takes place independently from the respective dental laser and determines the indication. The cutting speed of the laser radiation is limited by the tissue, which can only be ablated in layers. Laser radiation produced by the dental laser is led to the application site in the oral cavity by fibre optic systems consisting of mirror joint arms and flexible glass fibres. Here, laser radiation from the anterior fibre heats the surface layer of the tissue in a closely-defined area, thus ablatating the tissue. In order to reach deeper layers, the tissue must be ablated layer by layer. Although some authors see this as a disadvantage, this minimally invasive and tissue-conserving procedure is especially helpful in the sensitive cervical areas and in sulcus extension previous to impression taking.

_Clinical Procedure

The handpiece of the diode laser device (Fig. 1) is placed in the hand like a fountain pen (Fig. 1). With the thin fibre tip, the preparation margin is traced circularly around the anchor tooth, either over its total circumference or only the gingival level range of the partial crown (Figs. 3–5), by using it like a fine fibre pen of a diameter of only 0.3 mm.
Thus, uneven gingival areas or gingival areas damaged iatrogenically during abutment preparation are removed and haemostasis is achieved. If light oozing bleeding occurs, haemostasis is achieved punctually via laser fibre by increasing the pulse energy (Fig. 4). For this, only little anaesthesia is necessary and the procedure is much more pleasant for the patient. If a scanning system demands the use of powder in order to improve optical impression taking, special care must be taken to ensure that the powder does not bind with blood or cervical fluid. Otherwise, optical impression taken could provide imprecise results and thus cannot be used as the starting point of the digital process chain.

After the working field was prepared as described and the complete preparation level range is easily accessible by the clinician and can be prepared dryly (Fig. 5), the impression taking technique favoured by the dentist can be performed.

Laser application is seen as part of the prosthetic quality management in my practice and is thus a standardised aspect of every preparation. Immediately before the drainage, precision impressions are taken. For this, I often use individual impression trays and Impregnum (3M ESPE, Seefeld, Germany), as can be seen from Figure 6. The dental technicians in our team check the impression by stereo magnifying glasses and release it for further processing. After the classical production of the model from superhard plaster, the digital process chain starts with the strip light scanner S600 ARTI (Fig. 7).

**Strip light scanner S600 ARTI**

The all-automatic, optical strip light scanner S600 ARTI (Zirkonzahn) with two cameras, precision gears without tooth belt and 360° rotation and 100° swivel axis, digital model scanning of almost any object is possible with a precision of about seven micron. Differences can thus be registered easily. The oversized measuring field of 95 x 75 x 100 mm allows for complete scans of the articulator or the whole arch (Figs. 8 & 9). Combined with the software Zirkonzahn.Scan, it is the only scanning system by which the dental technician can register his own laboratory articulator with the scanner and measure its axes. This is necessary for rendering realistic articulator situations with regard to the facial arch in the three-dimensional system of coordinates of the software. When the model situation is depicted on the monitor, the result of the dental preparation after exposure of the levels via laser can be depicted in detail (Fig. 10). This is another opportunity for the treatment team to check for errors. Articulation and layer depths of the planned ceramic restoration can be depicted as seen in Figures 11 and 12. Then, the optimum occlusal planes as well as the form of crown or partial crown can be planned (Figs. 13 & 14). In addition to the milling machine M5, the scanner S600 ARTI forms a component of the CAD/CAM system 5-TEC (Zirkonzahn) that we use in our practice laboratory. Of course, every step of the process is guided by know-how and expertise in dental technology, which must not be underestimated during sintering process, individualization or veneering.

**Laser light in the placement of the prosthetic restoration**

After the dental laboratory fabrication, we have come full circle with the placement of the full ceramic restoration, for again we need cleanliness and a dry working field free of bleeding for this final dental treatment step. Often, localized gingivitis with an increased bleeding propensity can occur postoperatively or due to the temporary restoration, which often interlocks a number of prepared teeth to achieve stability. Furthermore, personal oral hygiene of the patients, especially flossing, is limited at this stage, which can cause localized gingivitis. Gingival hyperplasia also sometimes occurs, but it can be removed precisely and within seconds by diode laser. This holds especially true for the haemostasis of capillary bleeding and the drainage of the ginvival sulcus in close proximity to the preparation margin.

This is the only way to make sure that the various bonding cements or bonding systems are applied according to the manufacturer’s instructions.

**Conclusion**

Diode lasers are mandatory for an effective quality improvement in the beginning and at the end of the digital process chain. The form of the preparation, especially the preparation margin, must be depicted precisely, whether in analogous impression taking or digital scanning via optical techniques. The routinely application and consequent use of laser technique are the basis for clinical long-term success of the prosthetic restoration. It can therefore help to meet the high demands of the patients.

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

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MIS Dental Implants: When virtual becomes reality with the MGUIDE MORE

The MGUIDE MORE is an advanced virtual implant planning and guided implantology system developed by MIS to accurately transform DICOM data into 2-D and 3-D images that depict real cases in a virtual environment; enabling real-time 2-D and 3-D visualization for perfect implant planning.

The MGUIDE system features user friendly software, and incorporates the production of a fully validated drilling template; assuring accurate guided implantation with predictable prosthetic outcomes. The prosthetic-driven planning can be done either by the clinician, using simplified state-of-the-art MGUIDE software, or through the MIS network of MCENTERS, well-equipped facilities in over 20 countries and five languages that provide full technical support and guidance.

Implantology professionals using the MGUIDE software become members of an important online information hub that connects all software users; doctors, dental laboratories, periodontists, prosthodontists and the MCENTER. Users can share cases, take part in demonstrations, discussions or consultations, and use a remote access feature for direct interaction with another member’s MGUIDE MORE planning process.

How does the MGUIDE process begin? First a single patient Cone Beam CT scan is done. The DICOM data is then uploaded for a 3-D clinical evaluation. Next comes the implant planning and template design stage. Integration of a scanned wax-up and stone models enable virtual top-down planning as well as the template design. Then the stereolithographic templates are produced. The open wire-frame templates are made using advanced 3-D printing technologies to ensure optimum fit. Now the guided surgery can be performed. Restoration can be done via immediate provisional prosthetic solutions produced in advance, using MGUIDE MORE prosthetic tools for laboratory technicians.

There are many clear advantages to the MGUIDE MORE open wire-frame template. It allows an open field of view during surgery, where anaesthesia and irrigation are accessible from all angles without removing the template. Raised flap surgery can also be more easily performed. The template is constructed from a strong, durable biocompatible material and the 3-D CAD/CAM design ensures the highest level of accuracy. The lightweight template is an added benefit for patient comfort as well.

The MGUIDE MORE surgical kit not only enhances accuracy and safety for a smoother guided procedure, it also simplifies the implantology process by eliminating the need for traditional guidance keys. Specially designed sleeves and drills stop at the precise position and depth planned, freeing-up hands and saving valuable time. The MGUIDE MORE has been specially engineered to deliver a more accurate and streamlined minimally invasive implant placement and restoration procedure, resulting in less chair time and fewer patient appointments.

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New open CAD/CAM solutions for dentists and dental laboratories from Planmeca

Planmeca now introduces a full range of open CAD/CAM solutions for dentists and dental labs to complete its offering in industry-leading dental equipment and software. The dentist or lab can choose either the entire workflow solution or only certain parts, according to their needs. This is made possible with Planmeca’s unique and open interfaces between devices and software. From high-precision desktop milling units to sophisticated CAD software, this unique solution includes all necessary tools for open CAD/CAM dentistry.

Integrated workflow for dentists

Planmeca PlanScan is a digital impression scanner for ultra-fast, powder-free 3-D scanning. The quick and accurate scanner provides real-time digital impressions from one-tooth to full-arch scans. The open STL data output means that the scanned data can be sent to any dental lab for CAD work. Planmeca PlanScan is the first dental unit integrated impression scanner. Alternatively, it is available as a standalone version and can be connected e.g. to a laptop.

Planmeca also offers dentists a new open CAD software suite for easy 3-D design. Planmeca PlanCAD Easy is integrated in the Planmeca Romexis software and is a perfect tool for designing prosthetic works from individual inlays to full-arch bridges and abutments.

The ready design can then be sent to Planmeca PlanMill 40, a new milling unit targeted for dentists and designed for glass ceramic and other material works. The 4-axis milling unit is quick and accurate.

Integrated workflow for dental labs

For dental laboratories, Planmeca offers Planmeca PlanScan Lab, a fast and maintenance-free desktop lab scanner for scanning plaster casts. The design phase is done in the open Planmeca PlanCAD Premium lab software, after which the ready design is sent to Planmeca PlanMill 50, an accurate 5-axis milling machine designed for dental labs.

Alternatively, the laboratory can order fast and reliable milling services from Planmeca’s CAD/CAM milling centre PlanEasyMill, which offers a wide range of materials and fast deliveries.

“Our CAD/CAM solutions are truly unique, as the system is completely open and flexible”, explains Mr Jukka Kanerva, Director of Dental care units and CAD/CAM division at Planmeca Oy. “Dentists and laboratories can choose either the entire solution and benefit from the integrated workflow, or just pick the necessary parts and send the open data to their partners. This is truly digital perfection.”

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Compact 5 axis table-top machines for milling metal, zirconium dioxide, acrylics and wax

_Schütz Dental introduces_ the new Tizian Cut 5 smart milling machine which measures just 50 cm wide. It can master almost every milling task, almost any undercut with almost any material—even final non-precious metals.

Five simultaneous axes with an angle of up to thirty degrees make for a huge range of indications. With its separately available and retrofitted water cooling system, this machine becomes a milling machine for glass ceramics.

The automatic tool changer can take up to 16 milling and grinding tools. Adding to the basis machine Tizian Cut 5 smart, the model Tizian Cut 5 smart plus is available with a fully automated, 8-fold blank changer. Both machines can be fitted with a tool administrating module. With the help of this module, the user will always know when a tool needs replacing. All Tizian machines are license-free and import open STL data. This creates the core of a complete digital chain of work, which already begins for Schütz Dental from the first digital TMJ measurement.

The CAM family Tizian Cut 5 has been extended with the “smart” and now the new “smart plus” models (Fig. 1). In both simultaneous five-axis machines, the newest innovations in hardware and software ensure more precision, diversity, speed and comfort than ever before. Particularly impressive is how such a compact machine can be used for dry-machining of non-precious metals (Fig. 2). Due to the sinter-less process, precise fitting and high quality of materials, this machine produces bridges of up to 14 units and is also suitable for implant-supported objects with a passive fit. Production of frameworks is precise and time saving with the advanced construction software Tizian Creativ RT: Following a virtual design, the Tizian machine mills a framework in a modelling acrylics or wax. Thanks to an axis angle of up to 30 degrees, undercuts can be seamlessly produced.

Inside the Tizian Cut 5 smart plus machine, there is an additional automatic 8-fold blank changer (Fig. 3). Together with the previously integrated tool changing device, this gives you the opportunity for continuous operation. Both CNC versions can be upgraded with a water cooling system and a collecting tank. This means that lithium disilicate as well as zirconia reinforced glass ceramics can be milled using the wet-machining feature. This quick working, compact all-rounder and its “made in Germany” quality makes this machine truly stand out. Take the example of a three-unit metal bridge, milled in just 50 minutes.

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Straumann presents data and innovations that may change paradigms in implant dentistry

At the 22nd Annual Scientific Meeting of the European Association for Osseointegration in Dublin, Straumann provided an update on several initiatives that may lead to paradigm shifts in implant dentistry.

Roxolid SLActive—setting new standards, reducing invasiveness

The Group has just launched its Roxolid SLActive implants in a full range of sizes to help avoid bone augmentation procedures—saving patients trauma, discomfort, time and money, and thus increasing patient acceptance. Until now, only Straumann’s smallest diameter implants—which are designed for use in narrow spaces or where bone is limited—have been produced in Roxolid. But, based on extensive clinical evidence and with the goals of reducing invasiveness and making treatment possible for patients with insufficient bone, Straumann now offers all its implants in Roxolid together with the SLActive surface for accelerated osseous healing and the new Loxim Transfer piece for improved handling convenience.

Straumann’s new Roxolid 4 mm Tissue Level “Short Implant” was also presented in Dublin. This is the shortest implant Straumann has ever sold and it is designed to avoid extensive augmentation procedures in patients with insufficient vertical bone for conventional implants. It is backed by long-term clinical data, showing excellent performance over five years.

Speaking about Roxolid and SLActive at the Straumann Corporate Forum, Prof. David Cochran, Chairman of the Department of Periodontics at the University of Texas Health Science Center at San Antonio Dental School, noted: “These technologies will increase the clinician’s confidence to use shorter and narrower implants that reduce the invasiveness of implant treatment”.

New ceramic implant—an innovative evidence-based alternative

Clinical results were also published on Straumann’s new ceramic implant, which has now entered a controlled market release.

In terms of aesthetics, ceramic materials offer a significant advantage to metals in dental applications. Furthermore, ceramic provides a good biocompatible alternative for patients who ask for metal-free implants. However until now, the main drawback has been concern about mechanical predictability.

Straumann has overcome this hurdle through an innovative manufacturing process followed by a "proof-test", in which every implant is tested mechanically—a level of quality checking that is exceptional in the dental implant industry.

The aesthetic properties are also exceptional: unlike pure white ceramics, Straumann’s implant has a translucent ivory colour like natural tooth roots.
To further ensure reliability, Straumann has used a one-piece design (monotype), which integrates the implant and the abutment. In addition, the company has succeeded in creating a ceramic surface texture that is similar to, and performs like, the SLA surface used on its titanium implants to enhance and shorten the healing process.

The new implant is the result of a 7-year development program that has been driven by Straumann’s unique expertise in implant design and its 60 year heritage of material innovation. Typically, the company has chosen to test the product clinically before introducing it to the market. Initial results from the clinical program were published at the EAO: in a multicenter study with 41 patients, success and survival rates of 98% were reported with zero implant fractures after one year. Clinicians also reported pleasing aesthetic results and excellent gum tissue condition around the implant.

Based on the very positive results to date, a further 500 implants have been issued to clinics in a controlled market release. Providing the reports continue to be favourable, Straumann expects to launch the product on a broader scale in 2014.

Although the requirement for metal-free alternatives is not generally considered to be a major driver of the market, the availability of highly aesthetic ceramic implants with similar performance, flexibility and predictability to their metal predecessors would undoubtedly change implant dentistry. Straumann’s new ceramic implant may be a first step in this direction.

**Scientific update on new fully-synthetic bone regeneration material**

With the goal of developing an enhanced bone augmentation material that converts rapidly into vital bone and preserves volume, Straumann has been conducting research into synthetic bone substitutes focusing on innovative biphasic calcium phosphate ceramics. Good progress has been made in tailoring the composition to achieve optimal regenerative characteristics. Very encouraging pre-clinical results were presented in Dublin and clinical evaluation is underway.

**Collaboration agreement with 3Shape for CAD/CAM abutments with original Straumann connections**

Apart from the EAO news, Straumann announced a collaboration agreement with 3Shape, a leader in 3-D scanners and CAD/CAM software solutions, which makes it possible for users of 3Shape’s Dental System to produce customized restorations for Straumann Bone and Tissue Level implants with an original Straumann connection. To do this, 3Shape has integrated a Straumann library in its software, enabling dental technicians to model two-piece abutments using a pre-manufactured Straumann Variobase and a customized restoration that can be milled in the lab or a local milling centre.

Straumann firmly believes that using original components is in the patient’s best interest and its guarantee becomes invalid if systems are mixed. The Variobase implant kit offers labs a precise, reliable solution for producing their own abutments with an original Straumann connection. The agreement reflects Straumann’s efforts to offer the broadest range of prosthetic possibilities and flexibility with guaranteed precision and reliability.
Dental rehabilitation using implants has seen significant advancements in the last decade. Trends for the future of the specialty were discussed when the Convention Centre Dublin opened its doors last October for the 22nd Annual Scientific Meeting of the European Association for Osseointegration (EAO).

According to the organiser, over 2,000 dental professionals participated the three-day event, which was held in the Irish capital for the second time. In addition to current issues in the field, like peri-implantitis and the challenges linked to the treatment of an increasing elderly population, the congress reflected on new developments and methods, such as computer-assisted implant rehabilitation and tissue regeneration.

Moreover, a number of sessions focused on risk factors, treatment planning and the possibilities of virtual learning techniques.

Up to 70 experts from Europe and around the globe were speaking at the meeting. The latest research were presented in the form of short oral
sessions and poster presentations took place between the scientific sessions.

New products for treatment outcomes that are more predictable and an improved workflow in dental practices and laboratories were presented at the industry exhibition, which was supported by 87 sponsors this year. Among others, MIS and Henry Schein presented their latest tools for a complete digital workflow. Furthermore, Danish dental solutions provider 3Shape had its recently launched TRIOS intra-oral scanning system on display. New and improved implant systems were presented by Implant Direct and a number of other companies.

In 1995, the EAO held one of its earliest meetings in Dublin. Since then, the prestigious event has taken place at 17 locations in 15 countries throughout Europe. Last year’s anniversary meeting in Copenhagen saw more than 2,500 professionals participating, the number expected for the 2013 edition in Ireland. In addition to the Royal College of Surgeons in Ireland and the Oral Surgery Society of Ireland, the meeting has received support from the Irish Society of Periodontology and the Prosthodontic Society of Ireland.

“In 1995, implant treatment was provided by a fairly small number of specialists and access for patients was limited,” commented Dr Brian O’Connell, congress chairman and Professor of Restorative Dentistry at Trinity College Dublin’s dental school and hospital.

“Now implant treatment is available in every part of the country and is provided by a wide range of practitioners. As a result, awareness has really grown among the population. [...] Europe has a generally ageing population, who may have the greatest demand and need for dental implant treatment in the future. Evidence suggests that the majority remain healthy and active for much longer than we may have believed. We need to learn much more about the specific requirements of the older population and be aware of the risks as well. Often assumptions about older people are inaccurate. Although they may less demanding about their needs, they frequently respond well to implant treatment.”

Next year’s EAO annual congress will be held from 16 to 19 October in Rome. For details please visit EAO website.

All photos courtesy of EAO.
The 5th International CAMLOG Congress — the first CAMLOG Congress based on the new Consensus Reports

The 5th International CAMLOG Congress will be held from 26 to 28 June 2014 in Valencia, Spain. The meeting, with the motto: ‘The Ever Evolving World of Implant Dentistry’ will be based on the CAMLOG Consensus Reports, the congress will thus profoundly address the current developments in implant dentistry and the renowned scientific committee, chaired by Prof. Mariano Sanz (Spain) and Prof. Fernando Guerra (Portugal) will be responsible for the quality of the presentations.

The surgical and prosthetic concepts and recommendations are at the core of the program. According to organizers, these reports have been and will be worked out by a renowned team of experts from 18 countries during meetings in 2013 and 2014. The first CAMLOG Consensus Report has recently been accepted for publication by the renowned Clinical Oral Implant Research Journal. The CAMLOG Consensus Reports serve as a basis for questions relating to daily practice and these will be addressed at the Congress in Valencia both from academic and practical points of view.

The finishing touch at the end of the Congress will consist of case discussions on the controversial issue “Complications—what can we learn from them?” with a panel discussion also involving volunteers from the audience.

Several workshops, which will be held the day before the congress, aim at giving to participants excellent opportunities for further expanding practical experience and theoretical knowledge in implant dentistry. According to organizers these events are always booked out fast, so early registration is highly recommended.

In addition to the first class content of the congress, the extraordinary attractiveness of Valencia as a location should also be mentioned, in particular the Ciudad de las Artes y de las Ciencias, designed by the well-known architect Santiago Calatrava, where the Congress will be held in the spectacular Palau de les Arts.

Online registration for the congress is now open at: www.camlogcongress.com.

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Dubai, UAE
www.cappmea.com

EAED 28th Annual Meeting
29–31 May 2014
Athens, Greece
www.eaed.org

APDC 36th Asia Pacific Dental Congress
17–19 June 2014
Dubai, UAE
www.apdentalcongress.org

IACA 2014 Annual Meeting
24–26 July 2014
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www.theiaca.com

AAED 39th Annual Meeting
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www.estheticacademy.org

FDI Annual World Dental Congress
11–14 September 2014,
New Delhi, India
www.fdi2014.org.in

ESCD 11th Annual Meeting
9–11 October 2014
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www.escdonline.eu

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