CE article
Interdisciplinary approach in aesthetic dentistry

Case report
Non-invasive reconstruction with ceramic veneers—Art or compromise?

Review
Ceramics overview: Classification by microstructure and processing methods
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Welcome to this year's first edition of cosmetic dentistry!

In general dental practice, simple to moderate restorative cases dominate the total workload in the practice and the financial gain ratio is comparatively high in simple cases compared with full mouth rehabilitation or other complex treatment. However, it is interesting to note that our young dentists in dental practice are focusing on complex case management and not giving due priority to Class V restorations, inlays, onlays, mild anterior crowding, maintaining optimal oral hygiene, enhancing tooth colour, etc. Globally, the focus is on implant and full mouth restorations, which requires in-depth clinical knowledge and skills in simple case management first. Personally, I always advise my trainees to develop hand skills in direct composite resin restorations, as a good dentist must have artistic hands. Once we understand the minute details (texture, colour, anatomy and effects) of natural teeth using direct restorations, it is easy to obtain quality work from the laboratory and achieve high clinical results. In order to treat complex cases, such as cosmetic full mouth rehabilitation, temporomandibular joint dysfunction (TMD) and sleep medicine, one must complete the required continuing education and learn clinical skills at quality training centres.

During 2013, my team was busy establishing a "regional training centre" for minimally invasive cosmetic dentistry (MiCD) and teeth, muscle, joint and airway (TMJA) harmony dentistry. Cosmetic dentistry, occlusion, TMD and dental sleep medicine are the areas on which the team is focusing. MiCD and TMJA harmony dentistry are becoming quite popular because of their do no harm approach to clinical practice and simplicity in training approach that focuses on skill acquisition.

We have established training centres at Thammasat University in Thailand, the International Center of Dental Excellence in India and the Bangladesh Institute of Advanced Dentistry, and more are coming in Asia.

Our first regional five-day skill training programme is being organised in Thailand on TMJA harmony dentistry and more than 70 senior clinicians from the Philippines, India, Indonesia, Vietnam, Cambodia, Nepal, Thailand, Canada and the US will be participating.

As a practising clinician and presenter of various international training programmes, I feel that every good clinician should participate in a clinical teaching programme, if possible, because this will help clinicians to remain updated and promote personal happiness by sharing their knowledge and skills for better patient care around the world.

We present various clinical articles in this issue and hope you will enjoy reading them.

Yours faithfully,

Dr Sushil Koirala
Editor-in-Chief
President of the Vedic Institute of Smile Aesthetics, Kathmandu, Nepal
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Interdisciplinary approach in aesthetic dentistry

Author: Dr Sebastian Ercus, Belgium

In today’s dentistry, for rendering the best comprehensive dental services to our aesthetically driven patients, the paradigm has shifted to an interdisciplinary team of specialists that work together steered by a clinical co-ordinator. This person should be either a multi-competence general dentist or a specialist with additional training outside his or her specialty area. This gives him or her the ability to bring the surgical, orthodontic, restorative and technical teams together as a whole, following treatment sequences customised especially for the patients’ best interests and expectations.

The challenge is making the correct diagnosis and selecting the appropriate treatment regimen. In order to achieve that, the clinician has to follow certain guidelines and understand the relations between teeth and the adjacent structures. Establishing the correct position of the incisal edge of a maxillary central incisor in relation to the lower lip, the correct ratios between the tooth’s width and length, and the level of gingival margin when smiling are very powerful diagnostic tools.

In order to aid memory, one may remember it as the 42.2 rule:

(a) a maximum of 4 mm of maxillary central incisor display when the lips are at rest (a minimum of 2 mm; Fig. 1);
(b) a maximum of 2 mm of gingival display during smiling;
(c) a maximum of 2 mm from the incisal edge of the maxillary central incisor to the lower lip during smiling (Figs. 2 & 3); and
(d) the middle third of the maxillary central incisor should be perpendicular to the occlusal plane and the incisal edge should touch the plane (± 0.5 mm; Fig. 4).

The correct ratio between the width and length of a maxillary central incisor is 78 to 80 per cent. With the incisal edge position already determined, we can identify the position of the gingival margin (Figs. 5 & 6).

Gingival margin positioning should be in accordance with the understanding of six conditions present in the oral cavity with different aetiologies and treatment regimens:

1. Altered passive eruption when the gingival margin does not recede to a level near the cemento-enamel junction (CEJ) during tooth eruption. Diagnostically, the gingival margin is located...
incisal to the CEJ. Treatment options depend on the amount of attached gingiva and the position of the bone relative to the CEJ (as a general rule, the biologic width should be a minimum of 2 mm):

(a) gingivectomy;
(b) osseous resection (ostectomy) with or without flap surgery (without a flap, it is difficult to control the osseous contour driven by the new gingival margin);
(c) apically repositioned flap.

2. Altered active eruption when the osseous crest does not resorb to a level 2 mm apical to the CEJ. The gingival margin is still located incisal to the CEJ. This is treated with periodontal surgery with osseous resection.

3. Compensatory eruption when the tooth surface is lost, with the reduction in facial height or vertical dimension of occlusion unaffected (short tooth syndrome). Treatment is either restorative or, in the case of hypermobility of the lip, combined with a coronally positioned mucosal flap.

4. Delayed eruption followed by early loss of primary maxillary incisors, delayed eruption of maxillary permanent incisors or overeruption of mandibular incisors. Diagnostic features are short maxillary incisors, over-erupted mandibular incisors or a Class III maxillomandibular relation. Bearing the 42.2 rule in mind, treatment should follow incisal reduction done selectively with crown lengthening only or crown lengthening combined with orthodontic intrusion of mandibular incisors and possible minimally invasive restoration of maxillary teeth.

5. Vertical maxillary excess described as a hyperplastic growth of the maxillary skeletal base where teeth are positioned farther from the skeletal base, an increased facial lower third and excessive gingival display, which is classified according to three categories:

(a) Category 1: 2–4 mm of gingival display, treated with only orthodontic intrusion, orthodontics and periodontics, or periodontics with restorative therapy;
(b) Category 2: 4–8 mm of gingival display, treated with periodontics and restorative or orthognathic surgery (Le Fort type I); and

Fig. 6. Altered passive eruption. The enamel could be exposed by a gingivectomy in one appointment.
Fig. 7. Lower third smile showing altered passive eruption.
Fig. 8. Delayed eruption.
Fig. 9. A hypermobile lip and a slight vertical maxillary excess.
Fig. 10. Lower third full smiling.
Fig. 11. Relaxed position / mouth sound – "ehhh".
Fig. 12. Superimposed photographs 10 & 11. The red arrow indicates the distance from the incisal edge to the upper lip in the relaxed position. The yellow arrow indicates the height of the upper lip in the relaxed position (~ 21 mm). The white arrow indicates mobility of the upper lip from the relaxed to smile position.
Fig. 13. Initial lower third when smiling.
Fig. 14. Findings in order of importance after establishing the incisal edge position on the full smile photograph.
Fig. 15. The wax-up duplicated in a stone model.
(c) Category 3: more than 8 mm of gingival display, treated with orthognathic surgery with or without periodontal and restorative treatment.

6. Hypermobile upper lip—the average mobility of the upper lip is from 6 to 8 mm from the rest position. More than 8 mm represents hypermobility. Considering that the average distance from the lower margin of the upper lip and the base of the nose (sub-nasion) is 21 mm, one could take two superimposed photographs with the patient at rest and the patient smiling fully to calculate the lip mobility very easily using the 42.2 rule. Generally normal tooth length is present and dental labial aesthetics is good to ideal.

The treatment regimen could entail a coronally positioned mucosal flap, crown lengthening with osseous resection or a combination of both (Figs. 8 & 9).

Example: Photographs captured at the same magnification opened in Adobe Photoshop:

Picture 10: Full smile—length of the central exposed edge to the lower margin of the upper lip in full smile.

Picture 11: Lips at rest – 2 mm central incisor reveal + 21 mm distance lower lip to base of the nose. Incisal edge to base of the nose 23 mm (incisal edge at the correct position).

x = distance from the incisal edge to the lower margin of the upper lip in full smile

y = the amount of central incisor exposed at rest
Since the aetiology is generally multifactorial, by combining all the clinical data gathered during the initial examination, including facial, periodontal, orthodontic, endodontic and restorative data, as well as radiographs and diagnostic photographs, the clinician has the ability to compose a very detailed and comprehensive treatment plan especially for a patient with high aesthetic demands.

Following the digitally designed smile concept, balancing the relations between the teeth and adjacent structures will help the clinical co-ordinator and the specialty team propose treatment planning to the patient. Presenting the plan in Keynote (Apple) or Microsoft PowerPoint is a very powerful communication tool in obtaining treatment acceptance.

Case presentation

A 32-year-old female patient came to the dental office with her chief complaints being short teeth, an uncomfortable bite, too much gingiva showing when smiling, brown-coloured areas of her teeth and insufficient contact points. The patient was in good general health with a good periodontal status and probing depths of 2 to 3 mm. The aetiology of the excessive gingival display was multifactorial, a combination of delayed eruption, altered passive eruption and hypermobility of the upper lip. From an evaluation of the teeth, both clinically and from the diagnostic photographs, we made the findings given in Table 1 in order of importance (Figs. 13 & 14). We placed incisal edge position first in order of importance because, in the majority of cases, without proper placement whatever follows could result in a tooth that tries to mimic nature but is not properly exposed in a full smile.

Table 1

<table>
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<th>Incisal edge position</th>
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<td>Form</td>
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<td>Gummy smile evaluation</td>
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<td>Teeth ratios</td>
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<td>Contact points</td>
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<tr>
<td>Occlusal interferences</td>
<td>Present</td>
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Fig. 28. Controlled tooth reduction.
Fig. 29. Tooth preparation.
Fig. 30. Porcelain restorations on alveolar models.
Fig. 31. The try-in paste and organiser.
Fig. 32. Cementation.
Fig. 33. Situation before.
Fig. 34. Situation after.
(Ceramics performed by Edwing Chung, Canada.)
Based on the data gathered, the treatment plan was then presented to the patient in 3-D on models mounted in the articulator and in 2-D with a Keynote presentation, allowing her to understand the present situation, treatment proposed and simulated final outcome.

Following the treatment proposal and acceptance, the case was sent to the dental laboratory, where the dental ceramist fabricated a wax-up and a stone model based on the clinician’s diagnostic findings (Figs. 15–17). A crown-lengthening surgical guide (a vacuum-formed Essix appliance) was manufactured on a duplicate model of the wax-up for ideal osseous contouring during the surgical procedure (Fig. 18). The gingivectomy was performed following exactly the gingival margin of the wax-up and then used for guiding the osseous contouring, through which a biologic width of a minimum of 2 mm was maintained (Figs. 19–24).

The mock-up should be placed before the surgical appointment for an initial evaluation and then ideally six to eight weeks post-crown lengthening. If done earlier, a very well-adapted indirect acrylic prototype would be advised or the utmost care in adaptation of the bis-acrylic resin (Figs. 25–27).

For the ultimate control and when time management in a private office is not an issue, the osseous contouring is performed and the flap is closed, followed by guided gingivectomy and mock-up placement at the next appointment in two to three months’ time. With this approach, the risk of recession or invasion of biologic width is reduced to the minimum.

Controlled tooth preparation was performed through the mock-up using 0.6 mm depth-gauge burs (Figs. 28 & 29). In designing restorations, the diagnosis of the initial situation and underlying tooth structure, the new design proposal and the patient’s expectations play a very important role. The material of choice in this case was feldspathic porcelain (VITA Zahnfabrik) on a refractory die in the anterior zone combined with pressed lithium disilicate (IPS e.max, Ivoclar Vivadent) in the posterior zone (Figs. 30–33). As a rule of thumb, when a material like feldspathic porcelain is used, which filters the light through to the underlying structure, a space of 0.2–0.3 mm is needed per shade change. The restorations were adhesively cemented using a total-etch technique and initially tried in with a translucent try-in paste (CHOICE 2, BISCO, Inc.). The occlusion was checked after cementation and a processed acrylic night guard was delivered two weeks post-operatively. The final result is shown in Figures 34, 36 & 37.

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

Authors: Dr Marco Del Corso, Italy, & Dr 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, providing the most aesthetic tooth position, shape, and smile design for the patient's facial frame.

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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 guide8 to perform minimally invasive preparation, controlling ceramic thickness and maintaining the structural integrity of the tooth.8, 9 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 (Figs. 11a–c) and produce chairside Empress CAD blocks (Ivoclar Vivadent). 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. Both maxillary central incisors were dominant and had been designed to the specific width and length by the GPS program to suit 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 1:1.618. 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 teeth8, 10, 11 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.5
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.

Figs. 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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Non-invasive reconstruction with ceramic veneers—Art or compromise?

Authors_ Dr Magdalena Jaszczak-Małkowska & Robert Michalik, Poland

_My professional evolution_proceeded in parallel with the change of the concept of "aesthetics" and the accompanying technological revolutions. By nature, humans are open to novelties, regardless of the correctness of their application. Over time, my professional experience has confirmed the principle that the key to success is thorough planning of each case, detailed diagnostics before commencing work, and the resulting proper selection of materials and procedures. Success is created by efficient communication between the patient, the dentist and the dental technician. Nowadays, patients can use all kinds of media (mostly online) to learn about dental problems they have. In many cases, patient education helps to establish expectations regarding a prosthetic solution. However, we should not forget that we should always realistically assess our reconstructive capabilities in a given case. My experience has taught me that one should not submit to the patient's desires if this interferes with a treatment plan or our feelings. The challenge for the whole team is to achieve a compromise between aesthetics, functionality and the technological possibilities. Achieving a common vision for the restoration ensures ultimate success and satisfaction.

From the beginning of my professional career, I have sought to find a happy medium between my expectations, those of the patient and medical indications, to achieve full health and harmony of the smile. Contrary to appearances, it is an extremely difficult task, and the higher the sense of aesthetics the dentist possesses, the more difficult the task. Patients often come to me with a request to improve their smile and create beautiful teeth. As I have already mentioned, media and often dentists themselves have accustomed patients to the idea that beauty is defined by the whiteness of one's teeth. As a result, the patient does not receive beautiful, natural and functional dentition, but a set of white dentures, often made in a way that does not allow him or her to function efficiently and perform basic hygiene. Frequently, in order to achieve such an effect, tooth tissue
is permanently lost, which, as we know, can lead to many, even long-term, complications. We are primarily doctors and, in achieving patient satisfaction, we must not forget the overarching objective, which is treatment, and this must be achieved by avoiding any harm to our patients. Of course, "aesthetics" is a relative notion, but it is we who, from the perspective of our profession and experience, should shape the aesthetic desires of our patients and present the best solutions to them. Our activity in this respect is an art and it should be treated as such.

In order to attain success in treatment, we have at our disposal an increasing choice of modern equipment, technologies and materials. Each technology requires human input. Contact with a person of similar sensibility and sense of aesthetics is essential; with a person who is able to understand and meet the often-high demands of the patient and the dentist. This person is the dental technician, who contributes equally to our success, the achievement of which is not possible without complete understanding. His or her work should also be considered an art.

In the cases presented, the primary objective was to achieve the maximum aesthetic effect with minimally invasive treatment, especially because the cases concerned young patients. We wanted our work to be a harmonious and functional addition to the patient's smile, adapted to the individual case and not a replica of a standard matrix. In order to choose a method of treatment to achieve this goal, we considered each case according to the following:

(a) case description;
(b) analysis of the white and red aesthetics (analysis of the planned restoration aesthetics in the context of facial features, lip shape, smile lines and characteristics of the patient's own teeth);
(c) analysis of occlusion and articulation;
(d) treatment plan and choice of material.

Figs. 3a–c. Prepared stumps from teeth 12 to 22. Visible minimally invasive preparation of the enamel and no chamfer preparation of the gingival area.

Figs. 4a–c. Fitting of the finished veneers showing visible ceramic shading around the gingival zone to about 0.1–0.2 mm.

Figs. 5a–f. Comparison of the veneers before and after cementation. No visible veneer–stump junction after placement. The colour is the result of the colours of the veneers, cement and stumps.
I case report _ceramic veneers

Case 1

Case description

A 24-year-old male patient came to the practice for improvement of the aesthetics of his anterior teeth. During the anamnesis, he reported dissatisfaction with the discolouration and shape of his maxillary incisors, but was satisfied with the colour of the rest of his teeth. The patient confirmed endogenous application of fluoride during childhood, which may have been the aetiology of the existing discoloration. The patient's priority was the least invasive prosthetic treatment with a natural and aesthetic restoration.

Analysis of white and red aesthetics

Smile and intra-oral images (Figs. 1a & b) were taken, and diagnostic models were prepared. With the lips in rest position, 2–3 mm of the maxillary incisors was visible. The full length of the maxillary incisors and the anterior gingival margin were visible in a smile. The contour of the maxillary incisors appeared excessively rounded in relation to the patient's masculine facial features.

Analysis of occlusion

Diagnostic models were mounted in an articulator after facebow registration and centric relation (CR) registration (Dawson’s technique). In CR, the first contacts occurred on the palatal cusps of the premolars on the right side. Preliminary equilibration on the models was performed. The correction concerned the premolar palatal cusps (medial slopes) on the right side and then in the same way on the left side, and the buccal cusps of the premolars on both sides (medial slopes) with lateral movements. Equilibration was performed until CR was in accordance with the maximum intercuspal position (CR = MIP) with preserved occlusion and until canine guidance on both sides during lateral movements was obtained. Then intra-oral equilibration was performed similar to the models. The equilibration...
was performed using 14 µm-thick articulating paper with a fine, pear-shaped drill bit (red-coated) mounted on a 1:5 increasing handpiece on a micromotor.

Subsequent to completion of equilibration, the corrected surfaces were polished. Again, diagnostic models were created for the wax-up, and for planning the final scope and type of restoration. On the basis of the wax-up, a mock-up was made in the patient’s mouth to check the function and acceptance of the shape of the restoration (Figs. 2a & b).

Treatment plan

The preparation of feldspathic ceramic veneers on the maxillary incisors (teeth 12, 11, 21 and 22) was planned in order to alter the shape of the incisors, while maintaining the original length and colour of the teeth. Preserving the natural colour of the teeth allowed for application of a more transparent and thus more aesthetically favourable ceramic, since fluoride discolouration is present only within the superficial layer of enamel, which can be removed during preparation.

After another clinical analysis, based on the diagnostic mock-up and consultation with the patient and dental technician, it was decided to perform power whitening of the maxillary canines (teeth 13 and 23) in order to make the existing discolouration on the labial surfaces the same colour as the rest of the teeth. This was made possible by predetermining the aetiology of the discolouration to be dental fluorosis. Discolouration caused by demineralisation of enamel would have become even more visible after the whitening treatment.

Maxillary canine whitening was performed selectively using a 16 % BriteSmile preparation (Philips Oral Healthcare) activated by a dedicated light (two sessions of 20 minutes each). The key issue for the mechanics and durability of ceramic veneers is not to cross the amelodentinal junction. Preparation of the stumps was limited to alignment and rounding of the incisal edges and to elimination of the most visible discolouration (Figs. 3a–c). The gingival area was not subjected to chamfer preparation owing to the possibility of shading the feldspathic veneers even up to 0.1 mm. The preparation was performed using a red-coated tip on a 1:5 increasing handpiece on a micromotor with water-cooling. After preparation, the enamel surface was polished with Sof-Lex discs (3M ESPE). Then a double-layer one-step impression was taken with polyvinyl siloxane material (BISCO, Inc.). Because the enamel surface preparation was performed supragingivally, no retraction cord was placed before taking the impression.

Fig. 11 Preparled stumps from teeth 13 to 23. Stump preparation was limited to smoothing the surface of the enamel and the removal of existing composite restorations.

Fig. 12 The finished veneers after being released from the refractory mass.

Figs. 13a–c Comparison of the teeth before and after treatment.
Laboratory procedure

After receiving the restorations from the laboratory, their tightness and adherence to the stumps were checked (Figs. 4a–c). In the case of veneers, it is not possible to check the contact surface and articulation before cementation. Therefore, the cementing of each veneer should be carried out separately, while checking the passivity of fit of the adjacent veneer.

It should also be remembered that the final colour of restoration is the combination of the colour of the veneer and of the underlying stump (Figs. 5a–f). Its initial assessment is possible with Variolink Try-in Paste (Ivoclar Vivadent), but the final selection of the colour of the adhesive material depends on the dentist’s experience.

Under rubber dam isolation, the stump surfaces were cleaned with pumice paste, rinsed thoroughly with water and etched with 37% orthophosphoric acid for 45 seconds. Then they were rinsed with a water spray for the same period. After that, the Variolink Veneer light-curing luting composite system was applied. Each time, the contact surfaces of the adjacent teeth were isolated using Teflon insulation tape. In the meantime, the inner surface of the veneers was etched with 7% hydrofluoric acid for one minute, the etching agent was pre-rinsed with a water spray and the veneers were placed in an ultrasonic cleaner for two minutes. The etched surface of the veneers was covered with silane (Monobond Plus, Ivoclar Vivadent), dried and covered with a bonding agent (Heliobond, Ivoclar Vivadent). Variolink Veneer in shade High Value +1 was applied to the etched surface of the veneers, which were placed on the stumps. After excess material had been removed, the veneers were cured for about ten seconds. The restoration edges were smeared with glycerine gel to prevent the formation of an oxygen inhibition layer in the composite. Each surface was irradiated with a curing light at 800 mW/cm² for 60 seconds. Excess composite was removed with a #12 scalpel blade, and polished with strips and bands for polishing composites. Finally, the veneers were checked for occlusion and articulation with 14 µm-thick articulating paper. Corrections were made with a 45 µm smooth diamond-coated tip on a 1:5 increasing handpiece on a micromotor. If any adjustments to the intra-oral ceramics are necessary, it is important to avoid the use of a turbine owing to its very fast speed and the ability to cause chipping or microcracks in the porcelain structure. Finally, the stump–veneer interface was polished with rubber bands and strips for polishing composites (Figs. 6a–c). The outcome of prosthetic treatment was satisfactory to both the dentist and the patient, both immediately and in the long term (Figs. 7a–c).

Case 2

Case description

A 30-year-old female patient came for treatment because of the progressive wear of the masticatory surfaces of the teeth in both the maxillae and mandible. The patient complained about a stressful lifestyle and perceptible excessive masseter muscle strain, even after waking up. She also reported habitual nail biting in stressful situations.
Analysis of white and red aesthetics

The incisal edges of the maxillary incisors were not visible with the lips in rest position. There was a reverse smile line. The gingival margin of the maxillary incisors and canines was unbalanced (Figs. 8a & b).

Analysis of occlusion and articulation

A slight tenderness of the masseter muscles and medial pterygoid muscles was observed. There were no audible symptoms during abduction and adduction, or during lateral movements. Mandibular movements were within the normal range. During load testing of the mandible according to Dawson’s technique, no pain was observed. There was generalised abrasion of the teeth in both the maxillae and the mandible. No evident points of first contact in CR were present. There were enamel defects on the vestibular surfaces of the maxillary incisors. Initially, bruxism was diagnosed without lesions in the temporomandibular joint.

Treatment plan

An increase in the height of occlusion in CR, a correction of the gingival margin in the anterior zone, and feldspathic ceramic veneers for the maxillary canines and incisors were planned.

CR registration was performed with Dawson’s technique using a wax plate (Bite Registration Wax wafer, Delal) after 15-minute deprogramming by means of a deprogrammer (Lucia Jig) with a flat surface on the incisors and no contact between the lateral teeth. Facial arch registration was performed and the models were placed in a partially adjustable Artex articulator. A diagnostic wax-up was made, partly reconstructing the worn tissue of the lateral teeth. Incisal and canine guidance was obtained in the anterior section. On the basis of the wax-up, a mock-up was made in the patient’s mouth to obtain acceptance of the shape and length of the incisors and canines, and to check the function (Figs. 9a & b).

Occlusal conditions planned on models were reconstructed in the patient’s mouth with temporary restorations retained for a period of four weeks, and adjustments to occlusion and lateral movements at weekly intervals. After the adaptation period, the temporary restorations were replaced with final ones. Pressed ceramic onlays, crowns with a zirconium dioxide core and direct composite restorations were fabricated for the posterior section. Adjustments to the gingival margin of the maxillary incisors and canines were done with a #15 scalpel blade (Figs. 10a & b) and the effect was maintained by appropriate shaping of the temporary restorations.

Two weeks after correction of the gingival margin, the final preparation for feldspathic ceramic veneers on the maxillary incisors and canines was performed. The preparation was carried out with a red-coated drill in the shape of a rounded cylinder, followed by smoothing with fine Sof-Lex discs (Fig. 11). The preparation was limited to the removal of old composite restorations of Black’s Class V, and to smoothing the facial surface and the incisal edges.
The impressions were taken according to a double-layer one-step method with polyvinyl siloxane material of two different resiliences (BISCO, Inc.). Gingival retraction was performed using Ultrapak #0 retraction cord (Ultradent).

**Laboratory procedure**

The modern concept of “aesthetics” constitutes a significant challenge in the work of both the dentist and the dental technician. Society's desire to be trendy means not only being associated with fashionable brands, but also emanating a healthy lifestyle. We want our design to attract the attention of others; we want others to perceive the beauty in us. The concept of “beauty” is difficult to define. But it is certain that beauty results from the harmony of shape and colour.

The progressive development of technology in dentistry and dental techniques aids the ongoing elimination of errors and increase in predictability in every area of dentistry. However, many treatments still depend on the artistic work of the dentist and the dental technician.

One area of work in which the technology has remained unchanged for many years is the feldspathic technique of the direct application of ceramics to a refractory mass followed by fusion. This technique offers the best cosmetic results. If we combine it with an artistic shape, we can achieve the full harmony of beauty.

This technique requires above all a perfect initial diagnosis. Why? The feldspathic technology is based on a homogenous structure of fused ceramics. There is no intermediate foundation between the patient's tooth stump and the veneer ceramics as is the case with crowns fused to zirconium dioxide or metal. This means that there are no intermediate steps of control in the patient's mouth. The feldspathic veneer or crown is removed from the refractory mass after sintering. If the diagnosis was not correct and the patient is not satisfied with the work, there is no opportunity for any correction. Therefore, as we have mentioned, this technique, which mimics the beauty of nature, will yield satisfying results if the initial analysis and preparation are accurately performed before the fabrication of the veneers.

Although the physical parameters of the material are unfavourable, restorations made from it—after correct adhesive application—are the least defective type of ceramic restoration. Of course, their application requires the fulfillment of many conditions, in the absence of which the work would fail. Feldspathic restoration can be performed only on incisors with straight chamfer preparation around the perimeter of the tooth. It is important that the patient demonstrate correct incisal and canine guidance, as well as lateral support.

This type of restoration allows a dramatic reduction in the amount of preparation of the patient's tooth. Therefore, we can use it to restore lost tissue and change colour, as well as to successfully correct diastemas and rotate teeth. The obtained values of veneer wall and crown
thickness range from 0.2 to 1 mm. Different wall thicknesses on the same veneer are not recommended with the foundation ceramic veneer technique.

The fabrication process begins with impression taking of the tooth stumps (Fig. 14) in silicone and obtaining duplicates of these stumps in plaster in a refractory mass (Figs. 15 & 16). It is important that the position of the plaster stumps in the model coincide perfectly with the position of the stumps in the refractory mass (Figs. 17 & 18). In order to achieve this, one should use an appropriate polymerisation vessel and removable pins (Fig. 18). Stumps produced in the refractory mass should be baked in a furnace according to the manufacturer’s instructions (Fig. 19). The next step is drawing preparation lines with a pencil designed for withstanding high temperatures (Fig. 20). Then the technician applies glaze to the stumps, creating a glossy surface owing to the ceramic microfilm, to protect them from possible damage. The prepared stumps are then ready for coating with an appropriate ceramic in layers, forming the desired veneer shape (Figs. 21–23).

The most complicated tasks are removing the refractory mass from the thin layer of ceramic and checking the marginal fit on the working model (Figs. 24 & 25). The process requires skill and attention from the dental technician. Structures of 0.2 mm in thickness are very brittle and even the slightest bending can break the veneer. The mass is removed by sandblasting at 0.1 MPa with 50 µm sand. The prepared veneers are then ready to be placed in the patient’s mouth. Careful work will be confirmed by marginal fit and colour compatibility.

After receiving the restorations from the laboratory, checking of the passivity of fit of the veneers on the stumps was performed. Cementation, adjustment and final polishing were carried out in the same way as in the first case. After cementation, the restorations were perfectly integrated with the gingival zone, and mimicked the characteristics and structure of the patient’s natural teeth. The outcome of prosthetic treatment was satisfactory to both the dentist and the patient, both immediately and in the long term (Figs. 26a–d).

**Conclusion**

In both of the cases presented, the patients came to the dental clinic to improve the aesthetics of their smiles with minimally invasive treatment. Owing to proper assessment of the conditions and to the selection of suitable material, the objective could be achieved for both patients. The patients received restorations perfectly harmonised with their own teeth and facial features. In addition, the application of the proper criteria for assessment of the cases and for indications for rehabilitation with feldspathic ceramic veneers ensured the functionality and durability of the restorations, which have been confirmed by several years of observation.

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Ceramics overview: Classification by microstructure and processing methods

Abstract

The plethora of ceramic systems available today for all types of indirect restorations can be confusing and overwhelming for the clinician. Having a better understanding of them is important. In this article, the authors use classification systems based on microstructural components of ceramics and the processing techniques to help illustrate the various properties.

Introduction

Many different types of ceramic systems have been introduced in recent years for all types of indirect restorations, from very conservative non-preparation veneers, to multi-unit posterior fixed partial dentures and everything in between. Understanding all the different nuances of materials and material processing systems is overwhelming and can be confusing. This article will cover what types of ceramics are available based on a classification of the microstructural components of the ceramic. A second, simpler classification system based on how the ceramics are processed will give the main guidelines for their use.

The term "ceramic" derives from the Greek "keramos", which means "a potter or a pottery". This word is related to a Sanskrit term meaning "burned earth", since the basic components were clays from the earth heated to form pottery. Ceramics are non-metallic, inorganic materials. Ceramics refer to numerous materials, including metal oxides, borides, carbides, nitrides and complex mixtures of these materials. The structure of these materials is crystalline, displaying a regular periodic arrangement of the component atoms, and may exhibit ionic or covalent bonding. Although ceramics can be very strong, they are also extremely brittle and...
will catastrophically fail after minor flexure. Thus, these materials are strong in compression but weak in tension.

Contrast that with metals: metals are non-brittle (display elastic behaviour) and ductile (display plastic behaviour). This is because of the nature of the interatomic bonding, which is called metallic bonds; a cloud of shared electrons that can easily move when energy is applied defines these bonds. This is what makes most metals excellent conductors.

Ceramics can be very translucent to very opaque. In general, the more glassy the microstructure (i.e. non-crystalline), the more translucent; and the more crystalline, the more opaque. Many other factors contribute to translucency, for example, particle size, particle density, refractive index and porosity to name a few.

Different types of ceramics used in dentistry

The term "ceramic" technically refers to a crystalline material. Porcelain is a mixture of glass and crystal components. A non-crystalline-containing material is simply a glass. However, dentistry typically refers to all three basic materials as dental ceramics. How ceramics are classified can be very confusing. Ceramics can be classified by their microstructure, (i.e. amount and type of crystalline phase and glass composition). They can also be classified by processing technique (powder/liquid, pressed or machined) and by their clinical application. We will give a classification based on the microstructure of ceramics, with the inclusion of how the ceramics are processed and the effect of this on durability, to help the reader better understand the ceramics available in dentistry.

Microstructural classification

At a microstructural level, we can define ceramics by the nature of their composition of glass-crystalline ratio. There can be infinite variability in the microstructures of materials but they can be broken down into four basic compositional categories with a few subgroups:

- Category 1: glass-based systems (mainly silica);
- Category 2: glass-based systems (mainly silica) with fillers, usually crystalline (typically leucite or a different high-fusing glass);
- Category 3: crystalline-based systems with glass fillers (mainly alumina); and
- Category 4: polycrystalline solids (alumina and zirconia).

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<th>Posterior crowns</th>
<th>Anterior bridges</th>
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Table 1: A clinical use selection guide.
1. Category 1: Glass-based systems

Glass-based systems are made from materials that contain mainly silicon dioxide (also known as silica or quartz) and various amounts of alumina (or aluminium oxide, chemical formula Al₂O₃). Aluminosilicates found in nature that contain various amounts of potassium and sodium are known as feldspars. Feldspars are modified in various ways to create the glasses used in dentistry. Synthetic forms of aluminosilicate glasses are also manufactured for dental ceramics. We could not find any documented references that demonstrated that naturally occurring aluminosilicate glasses perform better or worse than synthetic glasses, even though there have been claims to the contrary. These materials were first used in dentistry to make porcelain denture teeth.

The mechanical properties are low flexural strength, usually in the 60–70 MPa range. Thus, they tend to be used as veneer materials for metal or ceramic substructures, as well as for veneers using either a refractory die technique or a platinum foil. The microstructure of a glass is shown in Figure 1.

2. Category 2: Glass-based systems with crystalline second phase, porcelain

This category of materials has a very large range of glass–crystalline ratios and crystal types. The glass composition is similar to the pure glass of category 1. The difference is that varying amounts of different types of crystals have been either added or grown in the glass matrix. The primary crystal types today are leucite, lithium disilicate, and fluorapatite. Leucite is created in dental porcelain by increasing the potassium oxide (chemical formula K₂O) content of the aluminosilicate glass. Lithium disilicate crystals are created by adding lithium oxide (chemical formula Li₂O) to the aluminosilicate glass. It also acts as a flux, lowering the melting temperature of the material.

These materials have also been developed into very fine-grained machinable blocks, VITABLOCS Mark II (VITA Zahnfabrik), for use with the CEREC CAD/CAM system (Sirona Dental Systems). This material is the most clinically successful documented machinable glass for the fabrication of inlays and onlays, with all studies showing a less than 1 % per year failure rate, which compares favourably with metal–ceramic survival data. The benefit of a pre-manufactured block is that there is no residual porosity in the finished core that could act as a weak point, which could lead to catastrophic failure.

2.1 Subcategory 2.1: Low to moderate leucite-containing feldspathic glass

Even though other categories have a feldspathic-like glass, these materials have come to be called “feldspathic porcelains” by default. Leucite may alter the coefficient of thermal expansion (CTE) of the material, as well as inhibit crack propagation, which improves the strength of the material. The amount of leucite may be adjusted in the glass, based on the type of core and the required CTE. These materials are the typical powder/liquid materials that are used to veneer core systems and are the ideal materials for porcelain veneers.

The original materials had a fairly random size and distribution of leucite crystals, with the average particle size being around several hundred microns. This random distribution and large particle size contributed to the materials’ low fracture resistance and abrasive properties relative to enamel. Newer generations of materials (e.g. VITA VM 13, VITA Zahnfabrik) have been developed with much finer leucite crystals (10–20 µm) and very even particle distribution throughout the glass. These materials are less abrasive and have much higher flexural strengths. An electron micrograph of a typical feldspathic porcelain reveals a glass matrix surrounding leucite crystals (Fig. 3). The most common use of these materials is as veneer porcelains for metal–ceramic restorations (Fig. 4).
2.2 Subcategory 2.2: High leucite-containing (approximately 50%) glass, glass-ceramics

The microstructure of these materials consists of a glass matrix surrounding a second phase of individual crystals. The material starts out as a homogeneous glass. A secondary heat treatment nucleates and grows crystals that give this class of materials improved mechanical and physical properties owing to the physical presence of the crystals and generation of compressive stress around the crystals. Glass-ceramic materials may be ideally suited for use as dental restorative materials. Glass-ceramics generally have improved mechanical and physical properties, such as increased fracture resistance, improved thermal shock resistance, and resistance to erosion. Improvements in properties are dependent upon the interaction of the crystals and glass matrix, as well as on the crystal size and amount. Finer crystals generally produce stronger materials. Glass-ceramics are in widespread use for cookware, missile nose cones, and even heat shields on space vehicles. They may be opaque or translucent, depending upon the chemical composition and percentage of crystallinity. A fundamental method of improving strength and fracture resistance is to add a second phase to a glass material, causing dispersion strengthening. The crystals may act as roadblocks to crack propagation. A crack spreading from a defect must go through or around the crystal, which takes some energy away from the propagating crack and may stop its progress. Thus, the restoration may continue to function instead of being cracked in half. In addition to the roadblock effect, compressive stresses around the growing crystals may help pin cracks and further enhance fracture resistance.

The most widely used version is the original pressable ceramic, IPS Empress (Ivoclar Vivadent), but there are several other products in this category (Figs. 5, 6a & b). A number of pressable materials with properties and microstructures similar to IPS Empress are available. This include Finesse (DENTSPLY), Authentic (Jensen), PM9 (VITA) and OPC (Pentron). A machinable version, IPS Empress CAD (Ivoclar Vivadent), designed for both the CEREC (Sirona) and E4D Technologies (Planmeca) CAD/CAM systems for high-leucite ceramics, has performed well clinically when used for posterior inlays and onlays, as well as anterior veneer and crown restorations. Machinable and pressable systems have much higher fracture resistance than powder/liquid systems, and have shown excellent clinical results for posterior inlay and onlay applications, and anterior veneer and crown restorations.

2.3 Subcategory 2.3: Lithium disilicate glass-ceramic

This is a type of dental glass-ceramic originally introduced by Ivoclar Vivadent as IPS Empress II (and later in the form of IPS e.max pressable and machinable ceramics). Increasing the crystal content to about 70% and refining the crystal size achieved improvements in flexural strength. The glass matrix consists of a lithium silicate with micron-size lithium disilicate crystals in between submicron lithium orthophosphate crystals (Figs. 7, 8a & b). This creates a highly filled glass matrix. A veneer porcelain consisting of fluorapatite crystals in an aluminosilicate glass may be layered on to the core to create the final morphology and shade of the restoration. The shape and the volume of crystals increase the flexural strength to about 360 MPa, or about three times that of IPS Empress. This material can be very translucent even with the high crystalline content. This is due to the relatively low refractive index of the lithium disilicate crystals. This material is translucent enough that it can be used for full contour restorations or for the highest aesthetics and can be veneered with special porcelain. Veneer porcelain consisting of fluorapatite crystals in an aluminosilicate glass may be layered on the core to create the final morphology and shade of the restoration. Fluorapatite is a fluoride containing calcium phosphate (chemical formula \( Ca_5(PO_4)_3F \)). The fluorapatite crystals contribute to the veneering porcelain’s optical properties and CTE so that it matches the lithium disilicate pressable or machinable material. Both the veneering material and the lithium disilicate material are etchable.
review _ ceramics

owing to the glassy phase. Initial clinical data for single restorations with this material is excellent, especially if it is bonded.20

3. Category 3: Interpenetrating phase ceramic

VITA In-Ceram (VITA Zahnfabrik) consists of a family of all-ceramic restorative materials based on the same principle introduced in 1988. The family includes a range of strengths, translucencies and fabrication methodologies designed to cover the wide scope of all-ceramic restorations, including veneers, inlays, onlays, anterior and posterior crowns, and bridges. VITA In-Ceram SPINELL (alumina and magnesia matrix) is the most translucent, of a moderately high strength and used for anterior crowns. VITA In-Ceram ALUMINA (alumina matrix) is of high strength and moderate translucency, and is used for anterior and posterior crowns. VITA In-Ceram ZIRCONIA (alumina and zirconia matrix) has a very high strength and lower translucency, and is used primarily for three-unit posterior bridges. Additionally, these materials are supplied in a block form for producing milled restorations using a variety of machining systems.

VITA In-Ceram belongs to a class of materials known as interpenetrating phase composites.21 They consist of at least two phases that are intertwined and extend continuously from the internal to the external surface (Fig. 9). These materials possess improved mechanical and physical properties relative to the individual components owing to the geometrical and physical constraints that are placed on the path that a crack must follow to cause a fracture. A tortuous route through alternating layers of both components is required to break these materials.

Interpenetrating phase materials are generally fabricated by first creating a porous matrix, in the case of VITA In-Ceram a ceramic sponge. The pores are then filled by a second-phase material, a lanthanum aluminosilicate glass, using capillary action to draw a liquid or molten glass into all the pores to produce the dense interpenetrating material.

The system was developed as an alternative to conventional metal–ceramic restorations and has met with great clinical success.22, 23 The system utilises a sintered crystalline matrix of a high-modulus material (85 % of the volume), in which there is a junction of the particles in the crystalline phase. This is very different from glasses or glass–ceramic materials, in that these ceramics consist of a glass matrix with or without a crystalline filler in which there is no junction of particles (crystals). Slip casting24 may be used to fabricate the ceramic matrix or it can be milled from a pre-sintered block.25 Flexural strength ranges from 350 MPa for VITA In-Ceram SPINELL, 450 MPa for VITA In-Ceram ALUMINA and up to 650 MPa for VITA In-Ceram ZIRCONIA. Several clinical studies support the use VITA In-Ceram ALUMINA for single units anywhere in the mouth. In those studies, VITA In-Ceram ALUMINA had the same survival rate as porcelain fused to metal up to the first molar, with a slightly higher failure rate for the second molar.26–28 VITA In-Ceram ZIRCONIA should only be used on molars owing to its very high opacity, which is not ideal for anterior aesthetics. For anterior teeth, VITA In-Ceram SPINELL is ideal, owing to its higher translucency (Figs. 10 a–c).

4. Category 4: Polycrystalline solids

Solid sintered monophase ceramics are materials formed by directly sintering crystals together without any intervening matrix to form a dense, air-free, glass-free polycrystalline structure. There are several different processing techniques that allow the fabrication of solid sintered alumina or zirconia frameworks. The first fully dense polycrystalline material for dental applications was Procera AllCeram alumina (Nobel Biocare) with a strength of about 600 MPa.29 The alumina powder is pressed and milled on a die, and sintered at about 1,600 °C, leading to a dense coping but with about 20 % shrinkage (Figs. 11, 12a & b).

The use of what is commonly referred to as zirconia in dentistry has increased rapidly over the past few years. This is not pure zirconia; it is partially stabilised by the addition of small
amounts of other metal oxides. Partially stabilised zirconia is one of the materials that allow production of reliable multi-unit all-ceramic restorations for high-stress areas, such as the posterior region of the mouth. Zirconia (or zirconium dioxide, chemical formula \( \text{ZrO}_2 \)) may exist in several crystal types (phases), depending upon the addition of minor components, such as calcia (or calcium oxide, chemical formula \( \text{CaO} \)), magnesia (or magnesium oxide, chemical formula \( \text{MgO} \)), yttria (or yttrium oxide, chemical formula \( \text{Y}_2\text{O}_3 \)), and ceria (or cerium(iv) oxide, chemical formula \( \text{CeO}_2 \)). Specific phases are said be stabilised at room temperature by the minor components. Typically for dental applications, about 3 wt% of yttria is added to the pure zirconia (Figs. 13, 14a & b).

Zirconia has unique physical characteristics that make it twice as strong and tough as alumina-based ceramics. Values for flexural strength for this material range from about 900 to 1,100 MPa.\(^{30,31}\) It is important to note that there is no direct correlation between flexural strength (modulus of rupture) and clinical performance. Another important physical property is fracture toughness, which has been reported to lie between 8 and 10 MPa m\(^{1/2}\) for zirconia.\(^{30}\) This is significantly higher than any previous dental ceramic. Fracture toughness is a measure of a material’s ability to resist crack propagation. Zirconia has the apparent physical properties to be used for multi-unit anterior and posterior fixed partial dentures. Clinical reports on zirconia have not demonstrated problems with zirconia frameworks.\(^{32-34}\) The problems have been associated with chipping and cracking of porcelain. Using a slow-cooling protocol at the glaze bake to equalise the heat dissipation from the zirconia and porcelain increased the fracture resistance of the porcelain by 20%.

Within categories 2 and 3, there can be great variation of composition and there are several commercial materials in these groups. Glass-based systems (categories 1 and 2) are etchable and thus easily bondable. Crystalline-based systems (categories 3 and 4) are not etchable and thus much more difficult to bond. Categories 1–3 can exist in a powdered form that is then fabricated using a wet brush technique, or they can be preprocessed into a block form that can be pressed or machined. As a rule, powder/liquid systems have much lower strength than pre-manufactured blocks do owing to a much larger amount of bubbles and flaws in the finished restoration.

**Classification based on processing technique**

A more user-friendly and simplistic way to classify the ceramics used in dentistry is by how they are processed. It is important to note that all materials can be processed by various techniques but in general for dentistry they can be classified as:

- powder/liquid glass-based systems;
- machinable or pressable blocks of glass-based systems; and
- CAD/CAM or slurry, die-processed, mostly crystalline (alumina or zirconia) systems.

It is an important classification method, as there appears to be a greater correlation with clinical success (and thus failure) due to processing technique. Even though a material may have the same chemistry and microstructure, the processing methodology used to produce a restoration may improve or decrease the final properties and clinical success. Specifically, machined blocks of materials have performed better than powder/liquid versions of the same material.
I review ceramics

1. Powder/liquid

1.1 Conventional

These are typically veneer materials, which may be all glass or a mixture of glass and crystal components. These include veneers for all-ceramic and metal frameworks, and may also be used alone as anterior veneer restorations. Typically, these materials are mixed by hand with deionised water or a special modelling liquid supplied by the manufacturer. They are built up by hand and vibrated (condensed) to remove water and air. These are fired in a vacuum to help remove remaining air and improve the density and aesthetics of the veneer. Since these restorations are made by hand, there are often voids present in the fired material. This is inherent to the process and may be worse or better depending upon environmental conditions, the skill of the technician, and the firing cycle. Often, one sees bubbles remaining in the hand-layered veneer material.

1.2 Slip casting

The original VITA In-Ceram and some partially stabilised zirconia blocks are fabricated based on slip casting of alumina or zirconia. The slip is a homogenous dispersion of ceramic powder in water. The pH of the water is often adjusted to create a charge on the ceramic particles and the ceramic powder is coated with a polymer to cause the particles to be evenly suspended in the water. In the case of VITA In-Ceram, the slip is painted on a gypsum die with a brush to form the underlying core for the ceramic tooth. The water is removed via capillary action of the porous gypsum, which packs the particles into a rigid network (Fig. 15). The alumina core is then slightly sintered (0.2 % shrinkage) in a furnace to create an interconnected porous network. The lanthanum glass powder is placed on the core, and the glass becomes molten and flows into the pores by capillary action to produce the interpenetrating network. The last step in the fabrication of the restoration involves application of aluminous porcelain to the core to produce the final form of the restoration. Other powder dispersions, such as those created with zirconia, may be poured into a gypsum mould that withdraws the water and leads to a homogeneous block of zirconia being formed.

2. Pressable

Pressable ceramic restorations are fabricated using a method similar to injection moulding. Monochromatic porcelain or glass-ceramic ingots are heated to allow the material to flow under pressure into a mould formed using a conventional lost-wax technique. The restoration may be cast to its final contours and subsequently stained and glazed to provide an aesthetic match. Alternatively, a coping may be moulded upon which porcelain is added to achieve the final shape and shade of the restoration. IPS Empress restorations and other materials with a similar leucite/glass structure are fabricated in this manner. The glass-ceramic IPS e.max is also fabricated this way. Pressables may be used for inlays, onlays, veneers and single-unit crowns.

3. CAD/CAM

3.1 Subtractive (removal of excess material to fabricate the restoration, milling)

3.1.1 Full contour

Full contour restorations, such as inlays, onlays, crowns and veneers, may be fabricated from various blocks of materials. In general, these blocks are fabricated from starting powders that are mixed with a binder and then pressed into a mould or extruded like a sausage into a block form. The binder helps hold the powder together so that the shape is maintained after pressing or extrusion. The blocks are then transferred to a furnace to remove the binder and sintered to full density. As mentioned...
3.1.2 Glass/crystal

VITABLOCS Mark II are fabricated using fine-grained powders, which produce a nearly pore-free ceramic with fine crystals. This was the first material specifically produced for the CEREC system and has an excellent history of clinical success for inlays, onlays, and anterior and posterior crowns. The restoration may be characterised with external stains or porcelain may be added to produce a layered effect (Figs. 17a & b). These blocks are available as monochromatic, polychromatic with stacked shades as in a layer cake, and more recently in a form replicating the hand-fabricated crowns for which an enamel porcelain is layered on dentine porcelain.

3.1.3 Glass/leucite

IPS Empress CAD is based on the pressable IPS Empress and has the same microstructure, a feldspathic glass with about 45 % leucite crystal. These blocks also have a fine leucite crystal structure (about 5–10 µ) and may be further characterised using external stains or porcelain. IPS Empress CAD is available in monochromatic and polychromatic stacked shades. Its strength properties are similar to that of VITABLOCS Mark II. Common to all of these blocks is a microstructure with a fine particle size that helps resist machining damage, improve mechanical properties and decrease the polishing time of the finished restoration.

3.1.4 Lithium disilicate

The IPS e.max block (lithium disilicate) is not initially fully crystallised. This improves milling time and decreases chipping from milling. The milled restoration is then heat-treated for about 20–30 minutes to crystallise the glass, and produce the final shade and mechanical properties of the restoration. The crystallisation process changes the restoration from a blue colour to a tooth shade. The microstructure and chemical composition are essentially the same as those of IPS e.max Press. The IPS e.max block has several translucency levels, the least translucent used primarily as a framework material and the higher translucency blocks used for full contour restorations.

3.1.5 Framework

(a) Alumina: Interpenetrating phase or glass-infused

VITA In-Ceram blocks are fabricated by pressing the alumina-based powder into a block shape in a manner similar to that of VITABLOCS Mark II. However, these blocks are only fired to about 75 % dense. Porous blocks of VITA In-Ceram materials are milled to produce a framework. The blocks are then infused with a glass in different shades to produce a 100 % dense material, which is then veneered with porcelain. Glass infusion only requires about 20 minutes for a coping and 1.5 hours for a three-unit bridge. The microstructure is the same as that of slip-cast alumina. The blocks are available in all three types of VITA In-Ceram.

(b) Alumina: Porous

Alumina frameworks may be fabricated from porous blocks of material. Pressing the alumina powder with a binder into moulds produces the blocks. The blocks may be partially sintered to improve resistance to machining damage or used as pressed in a fully green state (unfired, with binder). The frameworks are milled from the blocks and then sintered to full density at about 1,500 °C for 4–6 hours. The alumina has a fine particle size of about 1 µ and a strength of about 600 MPa, and is designed for anterior and posterior single units, as well as anterior three-unit bridges.
Zirconia frameworks milled from porous blocks are fabricated in a similar fashion to those milled from alumina blocks. There are a variety of methods to press the powder into a mould. Uniaxial pressing involves pressing from one direction, biaxial pressing involves pressing from two equal and opposite directions, and isostatic pressing involves uniform pressing in all directions. There are advantages and disadvantages to all methods but the desired result is the same: to produce a homogeneous block that shrinks uniformly. As is the case with the alumina block, the milled zirconia framework shrinks about 25 % after a 4–6 hour cycle at around 1,300–1,500 °C. The particle size is about 0.1–0.5 µ.

Fully dense zirconia is produced by a method called hot isostatic pressing. The zirconia powder may be pre-pressed into a block or the powder itself may be packed into a flexible mould. Either the block or mould is then vacuum sealed in an airtight rubber or plastic bag and placed into a fluid-filled chamber. Pressure is then applied to the fluid and this pressure is transmitted evenly all around the zirconia. Heat is applied to the chamber, which sinters the zirconia to full density (Fig. 18). Zirconia blocks produced in this manner may achieve flexural strength values of about 1,200–1,400 MPa. However, it requires extended milling to produce the framework and the higher strength value does not generally justify the loss in productivity. The accuracy may be improved versus the porous block method and may be preferred for large frameworks that span the arch.

3.2 Additive

3.2.1 Electrodeposition

VITA In-Ceram powder dispersions used in the slip-casting technique have been applied to electrodeposition systems, which apply a current across the dispersion and deposit the powder particles automatically on the surface of a conductive die. This approach is efficient for single units, but becomes cumbersome and potentially unreliable for multi-unit frameworks.

Discussion and summary

Ceramics can be classified in many ways. Two classification systems were given to aid the reader in understanding the types of ceramics available for dental use. The processing technique has a very large impact on strength and thus clinical performance, and should be one of the primary considerations in choosing a material.

There are many clinical aspects that are important for success with all-ceramic materials that are not as critical with metal-based restorations that cannot be covered here (e.g. preparation design, management of stresses, and cementation techniques). The reader is advised that significant knowledge and training in these areas are requisite for success with all-ceramic materials.

Editorial note: A complete list of references is available from the publisher.
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Following previous investments in Brazil, Germany and Spain, Straumann recently announced that it has bought convertible bonds worth US$30 million from MegaGen, one of the largest dental implant solution providers in South Korea. At the recent World Symposium of the International Team for Implantology in Geneva in Switzerland, on behalf of cosmetic dentistry, implants magazine Managing Editor Georg Isbaner had the opportunity to talk with Frank Hemm, a member of Straumann’s executive management board, about the investment and how it will affect his company’s position in the Asia Pacific region.

According to analysts, South Korean manufacturers are expected to dominate the market for dental implants in Asia in the years to come. Is this projected development the main reason for your investment in MegaGen?

Frank Hemm: South Korea is one of the largest markets for implants in terms of volume. More than two million implants are placed every year and local manufacturers are looking to expand into other Asian markets with high potential. China is a good example, where the market is still comparatively small but under-penetrated and growing quickly.

In these markets, the premium implant segment, where Straumann has been and still is very active, is growing less dynamically than the medium- and low-price segments are. We see the same trend in other markets, like Brazil, where companies like Neodent sell higher volumes than premium providers do. Two years ago, we had to ask ourselves whether we could address the non-premium segment with our existing brand or whether we needed a second brand. We decided on the latter and purchased a 49 per cent stake in Neodent. As an established brand in the region, MegaGen gives us a foothold in the Asian “value” (medium-price) segment. The convertible bond approach means that we have the option to gain a majority stake in 2016 with a managed low risk.

Straumann has always provided premium dental implants backed by solid scientific evidence and service excellence. These key differentiators make it necessary to use a separate brand strategy to address customers who are willing to accept lower standards and who want to pay less for implants. The value segment is growing exponentially and developing a new brand from scratch would simply take too much time and too many resources, which is the reason we chose to invest in other established companies.

Both companies have said that they will continue to operate separately. Still, do you expect any synergies to arise from this partnership?

It is important to keep both businesses completely separate to ensure that customers do not think that Straumann is MegaGen and vice versa. The only synergies we see are in supporting the value brand companies to enter selective markets, and in sharing back-office functions, like infrastructure, information technology or accounting. Everything else is handled by each company independently. Straumann products are certainly produced in Straumann facilities and this will continue to be the case in the future.
Is there the risk that you might be creating more competition for yourself with this investment?

We would not have taken this step if the market situation had not required it. The trend towards products in the medium-price range has accelerated and there is already strong competition, even without MegaGen. We are not adding more competition; rather, we are competing where we could not compete as Straumann.

What position is your company generally aiming for in the Asia Pacific region?

We aspire to market leadership in the region. We are not there yet, partly because our Roxolid implants with the SLActive surface are not yet available in the larger markets. We recently received approval for SLActive Tissue Level implants in Japan and the sales figures demonstrate the extent of the potential of our innovative technologies.

Achieving a leading position in Asia will certainly have a positive influence on our global position.

What requirements will have to be fulfilled for you to exercise the option to convert and acquire a majority stake in MegaGen in 2016?

We are keeping a close eye on the company’s development. MegaGen is a relatively new enterprise. It is growing dynamically and has many ambitions that still have to be realised. We also want to see how the market develops and the extent to which MegaGen can penetrate certain areas. The company’s valuation is another item on our radar. If our expectations are met, we can convert the bonds into shares in 2016 or require repayment with interest. That is the flexibility that this option allows us.

Should you decide to convert the bonds into stock, another large international implant conglomerate would be created. Is it only possible to survive in the long run as a large market player?

The implant market is still very fragmented and the market share of larger corporations is actually declining. There are hundreds and hundreds of smaller providers, often founded by dental clinicians, that come and go because they do not have the capability to expand internationally. Few companies succeed in making this jump and remaining in the market for a longer period.

Unlike in some industries, scale in the dental implant industry does not have inherent returns. What we are seeing is a consolidation in a larger context, as many distributors have started to include implants in their portfolios with the aim of becoming one-stop shops. This development needs careful scrutiny because implants involve other factors that only we as specialists can deliver.

Thank you very much for the interview.
Maximal aesthetics in the periodontally compromised anterior maxilla

Immediate implantation

Introduction

In addition to habits, systemic diseases and bruxism, periodontal diseases are challenging problems in oral implantology. Here, surgeons have to deal with tooth loss, prolonged epithelia, bone resorption and loss of periodontal ligament. In the following case, we could clearly see at the preclinical analysis that major bone resorption had occurred horizontally as well as vertically. The bony defects referred to more than one wall, the bone resorption around the root was like a crater, infiltrated with soft tissue. Primary stability was difficult to achieve for the implant.

The periodontal treatment was the primary focus, accompanied by fillings and extraction therapy to cure acute inflammations and achieve oral health. Nevertheless, periodontal treatments result in regular to functionally and aesthetically compromised situations and unsatisfied patients. Further, periodontal treatment does not secure the adequate prosthetic treatment of the patient. Depending on the art of the restoration, teeth often have to be extracted, in spite of successful periodontal treatment. So the question to be asked is whether and when a periodontal treatment makes sense as a definite treatment or if it should be a tool that enhances later surgical and restorative procedures.

Clinical and radiological findings

The clinical examination showed a severe periodontal defect, screening index of Grade IV, pockets of up to 6 mm, tooth mobility grade II–III and a bleeding index of 3–4. The functionality was very limited and the aesthetic situation unsatisfactory. The existing prosthetics on the central incisors were too long to cover the recessions, resulting in further attachment loss. The aesthetics also were compromised, following periodontal fibre loss and bone support. Especially the lateral incisors suffered severely from loss of interproximal bone, followed by mesiorotations and ante-inclination (Figs. 1 & 2). Radiological findings confirmed that all four upper incisors needed to be extracted.
technique _ periodontally compromised situation _

_Treatment plan_

Taking into consideration that the goal of surgical periodontal treatments is a screening index of 2–3 mm and that they almost always result in recessions, the outcome of these procedures is aesthetically poor. Especially in highly scalloped biotypes, patients are rarely satisfied. Longer prosthetics to cover the free root surface do not improve this outcome. On the other hand, these procedures are not always successful, resulting additionally in thermal sensitivities and persisting tooth mobility. Because of the high costs of surgical periodontology and the previous arguments, patients increasingly ask for alternative procedures. In the case discussed in this article, periodontal treatment would further neither aesthetic nor functional improvement, but only maintain the teeth for some months or years. The risk would be additional loss of bone and soft tissue, compromising future plans and prosthetic possibilities. The treatment plan for this case included conservative periodontal treatment and recall to treat inflammations, tooth extraction and immediate implantation with guided bone and tissue regeneration.

_Surgery_

Before extracting the incisors, the crowns 13 and 23 were removed and the teeth were prepared to receive temporary bridgework. With a wax-up on the situation model and pontics, an optimal form was created to support and manipulate soft tissue during the healing phase. At the same time the temporary bridge functions as wound coverage if primary closure is not possible (Figs. 3–6).

In the next step, the teeth 12 to 22 were extracted. The flap outline spared the middle papilla and mesial ones on 12 and 22. Due to interproximal bone defects, raising of the papilla in this region would have led to severe recessions. The vertical bone defects, especially between 11 and 12, were obvious after raising a full-thickness flap. Releasing incisions were placed distally at the canines and only in the attached gingiva to prohibit scar formation through vertical cuts in the mucosa. The low vestibule made a split thickness or periosteal pocket flap less logical. Mobilizing soft tissue from the lips by other flap designs would provoke functional limitations, suture tension and a secondary gum plastic to reposition the coronal transpositioned soft tissue. The wound margins were freshened to remove prolonged epithelia and the bone defects freed from soft tissue ingrowth (Figs. 7–10). The horizontal bone loss was moderate. Implants were placed slightly subcrestally. Although the gap between implants and the buccal plate was approximately 1–1.5 mm and the buccal plate thickness 1–1.5 mm due to the resorption, we decided for 3.8 mm implants, leaving a 1.5 mm gap to the buccal plate.

The interimplant space and the buccal plate were augmented with a combination of allograft and xenograft. Xenograft was also placed on the buccal plate so as to manipulate buccal plate resorption. A pericardium membrane was used as barrier (Fig. 11).
The anatomy of the upper jaw and the low vestibule did not allow primary closure. To protect the membrane from proteolytical resorption and the augmentation, we placed two layers of tissue fleece above the membrane. Through the collagen fleece and the protection of the provisional bridge, free granulation of the extraction socket cover was expected after two weeks (Fig. 12). The patient received a weekly recall with prophylaxis and hygiene instructions. Three weeks postoperatively, sutures were removed. The clinical situation showed no irritation and the wound healing and closure ideal (Fig. 13).

**Re-entry and prosthetics**

The re-entry was performed after three months with minimally invasive crestal cuts. A papilloplastic adjusted the wound margins between 11-12 and 21-22 (Fig. 14). After three additional weeks, impression was performed. The healed situation showed optimal soft tissue quality and adequate attached gingiva quantity. We measured 2–2.5 mm soft tissue height above the implant necks, enough for the necessary emergence profile. With the help of convex or concave formed prosthetics, soft tissue can be manipulated to the direction needed for esthetics (Figs. 15 & 16).

The final crowns show great results. The papillas and pseudopapillas fill up the approximal space. The approximal contact had to be longer and wider than normally in order to compensate the former vertical bone loss, especially in the region 11-12. Nevertheless, there were no black triangles, the patient was satisfied and with the proper hygiene, the aesthetic outcome will be optimized in the next months. Therefore, there was no need to work with rose ceramics (Figs. 17–19).

**Discussion**

In the periodontally compromised situation, it is important to decide on whether a curative periodontal treatment offers satisfactory long term results. As in this occasion, the extraction in a crucial moment helps us preserve what we have, use it to the maximum for the implant surgery and risk no further bone loss or recessions. Any other procedure would have led to a two-stages surgical approach and probably to removable prosthetics. Very favourable was the thick biotype of the patient, such as the low lip line. The soft tissue quantity was evident. Tension on the flap closure was prohibited by the surgical protocol and the free granulation of the wound. The bone quantity insured a primary stable implant insertion. Immediate implantation provided stability for the augmentation and less material. The positioning of the implant allowed us to create an optimal emergence profile, making complicated soft tissue procedures unnecessary.

The clinical situation and the bony defects made clear during surgery that we would have to make an aesthetic compromise in region 11-12. The bony support of the interproximal soft tissue is difficult to regenerate and the pseudopapilla formation not predictable. Immediate implantation in these regions preserve hard and soft tissue. Through the positioning of the implants and the free granulation of the extraction wound, we enhance the soft tissue, a major advantage for the re-entry and prosthetics.
technique

The implants placed feature micro grooves at the implant neck in a height of 1 mm. This laser manufactured design imitates biology and promises an improved cell adhesion on this surface. These modern designs, combined with the advantages of platform switching, result in high tech products. Modern crestal bone maintenance functions because of the protection of the crestal bone. When implants are placed subcrestally or crestally, a soft tissue ring builds on the platform and protects the bone beneath. When implants are placed supracrestally, implant neck options secure the crestal bone beneath, through soft tissue fibre attachment of their necks.23, 24

In cases in which primary closure is not possible or mobilization of neighbouring soft tissue through other flap designs is not wanted, temporary prosthetics are essential. The soft tissue manipulation begins from the very first moment and decides about the aesthetic outcome.25-27

The clinical situation after three weeks with healing abutments needed to be altered buccally at 11 and 21 and manipulated 0.5 mm apically. This was achieved via individualized abutments with convex base and breadth of 1 mm. In contrast, the gingiva margins at the lateral incisors needed to be corrected coronally. Therefore, we used narrow abutments to give soft tissue more space to head coronally.13-15

The combination of the biomaterials belongs to our standard augmentation protocol and is well documented. The results of guided bone regeneration are predictable and can be planned, even in major defects. In addition to the combined biomaterials, their structure is very important. Rocky and edgy particles help internal stabilisation at the augmentation area. Often is an external stabilization with pins or screws unnecessary. The porosity of the particles is defined through their biology. This is the reason why we prefer no alloplastic biomaterials and take advantage of the pros of combined allografts and xenografts. At the same time, these are the requirements of modern biomaterials, accompanied by induc tivity and conductivity.28-30 Periodontal diseases are a regular limitation factor in oral implantology. Thus, there are situations in which periodontal disease pose no contraindication to implantology. Preconditions for similar procedures are understanding and knowledge of biology, surgery and prosthetics. These procedures underlie no algorithms but proper diagnosis, analysis and planning of every individual patient and the choice of the appropriate implant system and biomaterials. Modern implantology provides all tools for successful implant treatment. Complications are, however, severe and can hardly be solved without compromises.

Editorial note: A complete list of references is available from the publisher.
Planmeca makes CAD/CAM easier than ever

Planmeca’s open-interface CAD/CAM solutions introduce, above all, quality, cost efficiency and precision to the daily workflow at dental clinics or laboratories. Petri Kajander, product manager of Planmeca’s CAD/CAM solutions, explains the revolutionary features of these new products in this article.

State-of-the-art solutions for dentists: Superfast Planmeca PlanScan

The new Planmeca PlanScan is a digital and powder-free intra-oral scanner that scans the patient’s dentition quickly and accurately. The scanner produces real-time digital impressions from one-tooth to full arch scans. Thanks to the open STL data, the scanned files can be sent to any dental laboratory for design work. This is the world’s first dental unit-integrated intra-oral scanner that can also be connected to a laptop.

"The scanner has only one cable, so it is extremely easy to move from one place to another, for example between different treatment rooms or clinics," said Kajander. "In addition, the scanner is delivered with a laptop, so the device can be flexibly shared between different users. In other words, Planmeca PlanScan offers value for your investment: it is not a device for just one dentist but can be used by the entire clinic."

The scanner uses the blue-laser technique. It projects a pattern on the surface of the teeth and then analyses it from different directions to calculate distances. In this way, the device is able to calculate a model that is extremely accurate. "You can view the result as a real-time video image. The video recording and the dental surface identification algorithm make the device extremely flexible to use. Thanks to these features, you can pause the scanning at any time and continue later on at any point from where data is already available."

The scanner includes a range of exchangeable tips in various sizes, the smallest of which facilitates access to the posterior areas, particularly in small children and trauma patients. The tips can be autoclaved for efficient infection control. In addition, the scanner is extremely durable, since it has no internal moving parts other than a fan that removes warm air. "Thus, the device stays calibrated and is not subject to mechanical wear," explained Kajander.

Planmeca PlanCAD Easy, an efficient design tool for prostheses

Planmeca also offers dentists a new kind of open software solution for 3-D design. Planmeca PlanCAD Easy is seamlessly integrated into Planmeca Romexis software, and it is a user-friendly design tool for the design of inlays, onlays, veneers, crowns and bridges.

"The software runs on a floating licence basis. This means that it is not tied to just one computer or workstation, but the work is saved on the Planmeca Romexis server. In this way, the scanning station can be used only for scanning, while another workstation is used for the actual design work. This is a truly unique feature, which allows work to be continued straight away on another computer, while the scanner is freed for more productive operation," said Kajander.

Every dentist who designs his or her own prostheses will also face cases that require assistance from a dental laboratory. For this reason, Planmeca’s system utilises an open STL file format that allows the work to be sent immediately to a partner via the Planmeca Romexis Cloud service.

Since Planmeca PlanCAD Easy is integrated into Planmeca Romexis software, soft-tissue scans can also be conveniently paired with CBCT scans of the patient. This combined data provides valuable information for implant planning, for example, because it visualises the soft tissue and the crown that is designed for the occlusion. This facilitates the planning of the implant screw’s location.

The Planmeca PlanCAD Easy workflow, from preparation to the finished result, includes just five easy stages: work description, scanning, marking of the margin line, automatic design, and sending the work...
to the mill. “Once the work has been sent to the mill, it is transferred there in its entirety and the mill’s computer finishes the work. In this way, the software and scanner are immediately freed for a new assignment.”

The software is very user-friendly. All design phases are saved automatically and previous phases can be returned to flexibly if further impressions are needed. The design software automatically takes into account the cusps and marginal ridges of the adjacent teeth, in addition to the contact strengths defined by the user. This creates a design that blends into its surroundings well.

**Planmeca PlanMill 40, a fast and precise milling unit for dental clinics**

Planmeca PlanMill 40 is an extremely precise four-axis milling unit controlled by its own computer. The device is suitable for all single-tooth indications, in other words for the milling of crowns, inlays, onlays and veneers. The mill can manage bridges of up to five units in the posterior area and three units in the anterior area.

Since the mill handles the milled pieces completely independently, as many as several dozen pieces can be sent to the mill at a time. In addition, the device determines which block size, colour and material should be used, so any member of the staff can place the block in the mill. “This saves everyone working time. The dentist does not need to put the block in himself,” said Kajander.

Planmeca PlanMill 40 has a six-tool exchange mechanism, and it changes tools independently according to different job requirements. In addition, the device mills different materials according to their properties. For example, it knows how to handle delicate ceramics gently in work phases that require precision. "If you force the material, it may break prematurely. Even the smallest hairline crack in the material can lead to a cemented piece breaking when pressure is applied to it."

Also, the maintenance of the device is easy. The mill’s computer calculates the service life of the tools, monitors wear and reports on these via the user interface. It also calculates the time that milling will take and lets the user know when the tools or water should be replaced. “Similar to a car, a mill requires maintenance at certain intervals and notifies the user of this.”

**An ideal solution for laboratories too**

For dental laboratories, Planmeca offers a comprehensive solution that utilises the open STL file format. Planmeca PlanScan Lab is an accurate desktop scanner that uses blue light for scanning gypsum models and impressions. The device scans gypsum models quickly and effortlessly with an accuracy of 15 μm.

Design takes place in the open Planmeca PlanCAD Premium laboratory software, which can be used for the design of all prostheses, ranging from one-tooth units to full arch structures. The software can also be used to design for example individual abutments, night and sports guards, different crown and bridge work and implant bridges and bars for cement-retained and screw-retained solutions.

The software has an order manager page that lends efficiency to the workflow by reporting each stage of work. In this way, several work orders can be entered into the software in one go. The last phase is always saved in the memory so that work can be continued freely at the most convenient time. In addition, precise values can be set for each workpiece to allow for cement space and the milling unit’s blade.

An open STL file is created from the design, and the design can be manufactured with any milling unit that supports the open file format, including Planmeca PlanMill 50. This milling unit can mill any soft, wet and dry materials and for example glass ceramics. In addition, the file can be sent to a milling centre, such as Planmeca’s own PlanEasyMill milling centre, for manufacture.

**_Fig. 4_ Planmeca PlanMill 40.**

**Fig. 5_ Planmeca PlanScan Lab.**

**Fig. 6_ Planmeca PlanMill 50.**

**Fig. 7_ Planmeca PlanCAD Premium.**

**_Fig. 7_**

**_Fig. 5_**

**_Fig. 4_**

**_Fig. 6_**

**_Fig. 5_**

**_Fig. 4_**
IMAGINA Dental: Digital dentistry experts meet in Monaco

Fig. 1. At the congress, Dr Scott Ganz introduced cone beam, international magazine of cone beam dentistry. (Photo courtesy of Dr Scott Ganz)

In the middle of February, over 500 dental professionals from all over the world gathered at the Grimaldi Forum in Monaco for the third IMAGINA Dental congress. IMAGINA Dental is a prestigious international dental meeting entirely dedicated to 3-D and CAD/CAM technologies in dentistry and organised by MONACO MEDIAX, one of the world's most highly regarded event organisers.

The rapid development of 3-D and CAD/CAM technologies has necessitated essential changes for all dental practices and laboratories. The challenge is to keep up to date with this growing industry and implement this digital workflow in dental practices.

According to the organisers, the three-day conference featured educational content on digital dentistry relevant to every dental professional. Internationally well-known speakers, experts and trainers in the fields of implantology, CAD/CAM, prosthetic dentistry and laser shared their knowledge and experience with passion and enthusiasm. Participants learnt about the latest digital oral scanners, 3-D printers, 3-D diagnosis tools, treatment planning, guided surgery and aesthetic restoration in dentistry.

Parallel to the lectures, numerous workshops were organised, which offered dentists answers to many practical questions, clinical knowledge and tips on the latest technologies in dentistry.

According to the organisers, IMAGINA Dental is one of the few industry events to apply a policy of fairness towards all brands and thus does not favour one over another.

At the congress, Dental Tribune International launched cone beam international magazine of cone beam dentistry, a quarterly continuing education publication devoted entirely to CBCT in dentistry. Editor-in-Chief Dr Scott Ganz presented the first issue of the high-gloss English-language magazine.

The new magazine covers the most significant developments in the field and is targeted at experts who use CBCT, such as implantologists, orthodontists, prosthodontists and endodontists. It presents the latest research and case studies in the field,
as well as pertinent industry news, trends in procedures and techniques, and the newest education and events.

cone beam, which is the official publication of the International Cone Beam Institute and several other education providers in the field, will be distributed at all major international congresses, exhibitions and many specialty-specific events.

“The evolution of CBCT, which started with the introduction of 3-D imaging for dental applications in the 1980s, continues within the pages of the new cone beam international magazine. We will do our best to provide our readers with useful information by presenting a variety of clinical applications and state-of-the-art concepts that showcase CBCT technology and related applications. It is time to realise that there is a real danger when we are bound by 2-D concepts, when clearly today we live in a 3-D world,” Ganz said.

The first issue is available for free download in the e-paper archive of the Dental Tribune website (www.dental-tribune.com).

Press releases and videos from IMAGINA Dental, as well as interviews with the organisers, are already available online at www.youtube.com/user/IMAGINADental and www.imaginadental.org.

Fig. 3. During the breaks participants could see newest 3-D and CAD/CAM technologies. (Photo courtesy of MONACO MEDIAX)

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Roberto Canalis, CDT.
Prof. Bob Khanna
Leonardo Cavallo, CDT.
Dr. Andrea Chierico
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Alessandro Iorio, CDT.
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“Clinician education is critical to success”

An interview with AO Annual Meeting chairman Dr Lyndon Cooper

Author_Sierra Rendon, DT America

The Academy of Osseointegration is recognized as the premier association for professionals interested in implant dentistry. It has always been at the forefront of scientific advances in dental implant and tissue replacement therapy. In an interview, Annual Meeting chairmen Lyndon Cooper, DDS, PhD, and Donald Clem III, DDS, discuss this year’s meeting, which was held recently, and plans for the 2015 event.

_Sierra Rendon: How many people attended AO Annual Meeting 2014?

Dr Lyndon Cooper: More than 2,000 clinicians joined us for the 29th annual meeting of the Academy of Osseointegration (6–8 March 2014, Seattle, USA), which recorded the fourth largest attendance in its history. We had 624 international attendees representing 45 countries and more than 1,100 exhibitors who showcased products and services to support implant dentistry.

_Sierra Rendon: Why did AO choose the theme “Real Problems, Real Solutions”?

We have seen that implants are widely applicable and generally successful, and we recognize that clinician education is critical to success among our patients. This year, we sought to inform clinicians that a segment of our population will experience implant complications and failure, but emerging strategies can help them recover success. We encouraged the clinical team to examine implants carefully, address issues promptly and recognize when—and learn how to—intervene to preserve dental implant and patient health.

_Sierra Rendon: What were some highlights of the clinical sessions?

Leading experts led the program with insights on who experiences complications, why they occur and what evidence says about how well we address these complications. Consistent with the plan, a broad range of data was presented. The early focus on periimplantitis opened the minds of the audience, while the closing futuristic presentations certainly left everyone feeling inspired. Our clinical presentations anchored the meeting by demonstrating what good science offers great clinicians who adopt an evidence-based approach to caring for people.

_Sierra Rendon: Was research a big focus of the meeting?

Yes, presentations ranged from digital planning, new aesthetic techniques and prevention strategies to molecular strategies and stem cell biology. Abstract presentations explored original scientific and clinical research, clinical innovations and case presentations that could help shape the future of implant dentistry. We had a record number of more than 250 Scientific Posters as well.

_Sierra Rendon: The new board of directors was also announced in Seattle. How does the AO enjoy such a seamless transition in leadership?

Dr Lyndon Cooper: The 29th annual meeting of the Academy of Osseointegration.
Approaching its 30th year, the AO is fortunate to have organization leadership and leadership development that are very carefully managed. We are all very excited to announce that Dr. Joseph Gian-Grasso, a periodontist from Philadelphia, was elected to serve as the 2014–2015 president of AO. He will follow in the footsteps of a very successful president, Stephen Wheeler, DDS. Dr. Gian-Grasso—along with the rest of us—will remain committed to establishing a nexus where specialists and generalists from around the world can come together to learn and stay up-to-date on the rapidly advancing clinical research and innovations in the dental implant and tissue engineering industries.

Have you already started planning for AO 2015? Yes, because it's AO's 30th anniversary, we're all very excited about it. Mark the calendar now to join us in San Francisco from 12 to 14 March 2015, where we plan to on the power of collaboration to advance the art and science of dental implant therapy.

Can you give us a few glimpses at what's in store for next year?

The opening symposium will feature teams of doctors presenting on how they manage patients together for optimal results. The keynote speaker will be Dr. Daniel Alam, who was a member of the multi-disciplinary team of doctors and surgeons at Cleveland Clinic who performed the first near-total face transplant in the United States. He will speak to the critical importance of different disciplines coming together to support a patient's medical, surgical and emotional needs to make them whole again.

AO also will take a look at what the academy has learned throughout its 30-year history and summarize current recommendations to address the most challenging conditions in implant dentistry. AO has enlisted some of the foremost authorities in both surgical and restorative dentistry to share their knowledge and views to support this initiative.

Keeping with AO tradition, we also want to ensure the closing symposium doesn’t disappoint. It will be an interactive session where attendees can vote on keypads to give their opinion on various treatment options for presented cases. A panel of experts will also discuss and debate the options.

What are you most excited about for the meeting?

At the annual meeting, we are excited to build on AO's past and chart the way for its future. This will be done via top-notch surgical and restorative tracks, as well as a "Morning with the Masters," for which AO has put together an outstanding group of experts to give attendees pearls that can be used in the office on Monday morning. Ultimately, patient safety and benefit must be based on sound evidence—that’s what the academy is all about and our annual meetings are as well. To learn more about AO membership, please visit our website (www.osseo.org/NEWmembership.html).
International Events

2014

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

18th World Congress on Dental Traumatology
19–21 June 2014
Istanbul, Turkey
www.iadt-dentaltrauma.org

AAED 39th Annual Meeting
5–8 August 2014
Santa Barbara, CA, USA
www.estheticacademy.org

ICOI Summer Implant Prosthetic Symposium
21–23 August 2014
Chicago, USA
www.icoichicago2014.org

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

EAO 2014
25–27 September 2014
Rome, Italy
www.eao.org

EPA Annual Conference
25–27 September 2014
Istanbul, Turkey
www.epa2014.org

ICOI World Congress
3–5 October 2014
Tokyo, Japan
www.icoi.org

ESCD Annual Meeting
9–11 October 2014
Rome, Italy
www.escdonline.eu

155th ADA Annual Session
9–12 October 2014
San Antonio, USA
www.ada.org

Digital Dentistry Show
16–18 October 2014
At the International Expodental Milano, Italy
www.digitaldentistryshow.com

6th Dental Facial Cosmetic International Conference
14–15 November 2014
Dubai, UAE
www.cappmea.com/aesthetic2014

ADF Meeting
25–29 November 2014
Paris, France
www.adf.asso.fr

Great New York Dental Meeting
28 November–3 December 2014
New York, USA
www.gnydm.com
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Article lengths can vary greatly—from 1,500 to 5,500 words—depending on the subject matter. Our approach is that if you need more or less words to do the topic justice, then please make the article as long or as short as necessary.

We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

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Text formatting
We also ask that you forego any special formatting beyond the use of italics and boldface. If you would like to emphasise certain words within the text, please only use italics (do not use underlining or a larger font size). Boldface is reserved for article headers. Please do not use underlining.

Please use single spacing and make sure that the text is left justified. Please do not centre text on the page. Do not indent paragraphs, rather place a blank line between paragraphs. Please do not add tab stops.

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Any formatting contrary to stated above will require us to remove such formatting before layout, which is very time-consuming. Please consider this when formatting your document.

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Please number images consecutively throughout the article by using a new number for each image. If it is imperative that certain images are grouped together, then use lowercase letters to designate these in a group (for example, 2a, 2b, 2c).

Please place image references in your article wherever they are appropriate, whether in the middle or at the end of a sentence. If you do not directly refer to the image, place the reference at the end of the sentence to which it relates enclosed within brackets and before the period.

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Questions?
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