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4²⁰⁰⁹

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*Mouth Motion Fatigue and Durability Study

Petra C Guess, Ricardo Zavanelli, Nelson Silva and Van P Thompson,
New York University, March 2009

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Dear Reader,

_The end of 2009 is already drawing near, which is an opportune time to look back and evaluate what we have achieved as dental professionals: What accomplishments and changes have we been able to make thus far? How are we doing overall and what can we improve in the coming year?

A survey conducted by the American Academy of Cosmetic Dentistry (AACD) revealed that cosmetic-related income climbed to an average of US\$495,000 per practice in 2007, representing a 15 per cent increase over the previous year.

In August, the American Academy of Esthetic Dentistry hosted the International Federation of Esthetic Dentistry Las Vegas meeting with the theme *Passion, Esthetics and New Technology: The Future of Dentistry*. Leading lecturers from all over the world con-tributed to an exchange of invaluable information. The meeting confirmed that the future of dentistry is geared towards aesthetic dentistry with an emphasis on evidence-based dentistry. Cosmetic dentistry is a field of recognisable growth globally and this trend is likely to continue.

I was invited to present at the annual scientific meeting of the AACD in Hawaii and received much positive feedback on **cosmetic dentistry**. It is thus with great excitement and pleasure that I introduce this year's final edition. With the above-mentioned developments in mind, we bring you the latest on the most significant international developments and experiences. I am confident that this edition of **cosmetic dentistry** will satisfy your current needs by providing you with guidelines, instructions and visions for your future cosmetic dentistry procedures.

Please feel free to contact us with your valuable feedback, questions, concerns or suggestions.

Sincerely yours,



Dr So-Ran Kwon
Co-Editor-in-Chief
President of the Korean Bleaching Society
Seoul, Korea



Dr So-Ran Kwon
Co-Editor-in-Chief



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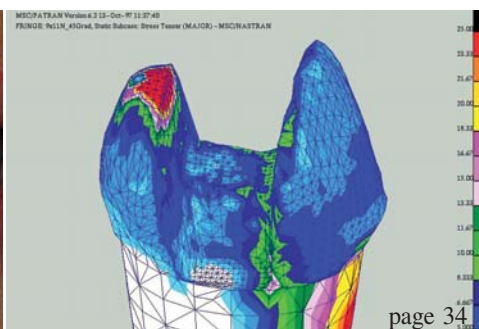
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Cosmetic periodontal surgery: Pre-prosthetic soft-tissue ridge augmentation (Part I)

Author _ Dr David L. Hoexter, USA



Fig. 1 Initial labial view of maxillary #9 edentulous area with a flipper.

Fig. 2 Labial view of maxillary #9 edentulous area.

Dentists understand that patients demand outstanding aesthetic, as well as physiological, results in all phases of dentistry today. This places an onus on dentists, who must therefore be able to apply the latest technologies and techniques to achieve each patient's unique aesthetic desires successfully. A successful aesthetic outcome requires knowing how to create the right illusion, which is subjective for each individual. Yet, it can be measured in objective and subjective standards. How then can practitioners evaluate and achieve these goals?

To begin, there are certain basic and objective characteristics of a healthy periodontia that must first be observed, respected and maintained. A healthy periodontia is essential for achieving and maintaining restorative aesthetics.

A reddish, inflamed periodontia immediately attracts negative attention to the area. In contrast, a healthy zone of pink attached gingiva acts as a subtle background, providing dentists with significantly more restorative options for teeth.

Similarly, exposed gold crowns, gingival margins, exposed gingival porcelain jackets or laminate margins will draw negative attention. Also, crowns placed sub-gingivally in an inflamed area are likely to lead to recession and an irregular gingival pattern, resulting in dissatisfied patients.

After healthy periodontia has been achieved, colour, hue, shape, form, symmetrical appearance and individual choice must then be discussed. At this point, the challenge of aesthetic dentistry is at its zenith.

Part I of this series discusses the role of pre-prosthetic, cosmetic periodontal surgery to achieve and maintain a healthy periodontia and to aesthetically improve shape, colour, form and appearance.

Clinicians should strive to achieve the appearance of a healthy symmetrical flow. For example, patients will not be satisfied with an oversized pontic placed in a large irregular edentulous area with a fixed bridge for long. It is unaesthetic and retains



Fig. 3



Fig. 4

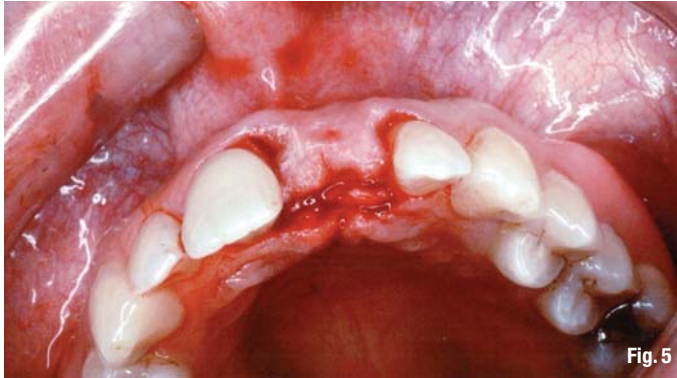


Fig. 5

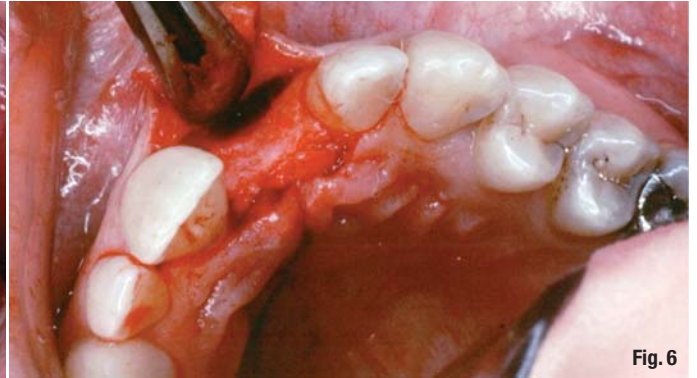


Fig. 6

food and plaque, which will lead to inflammation and periodontal disease. Often, a phonetic problem will also result. These patients will be thwarted and frustrated by their hygiene efforts, and dissatisfied with the illusion of health and aesthetics that they sought to achieve. Therefore, the relationship of a pontic and the abutment teeth to the gingival must be observed critically before the prostheses are fabricated.

By correcting the edentulous area aesthetically and physiologically with cosmetic periodontal surgery, a restorative dentist is able to fabricate a correctly shaped prosthesis that enhances aesthetics and function.

It is important to make an assessment prior to fabricating the prostheses. In the past, large pontics were made to fill voids created by irregularly shaped,

depressed edentulous ridges between abutments. The opportunity to build out and create a symmetrically harmonious bridge that blends in with the abutment's periodontia is currently available.

The following illustrates an example of treatment of one such case, resulting in a harmonious and aesthetically pleasing appearance.

Case 1

A 25-year-old woman presented to the office very interested in achieving ideal aesthetics with a non-removable appliance. For years, she had been wearing a flipper removable replacement for her maxillary left central incisor (Fig. 1), which was traumatically lost in an accident when she was 15 years old (Fig. 2). Following the accident, it was suggested by her restorative dentist (because of her young age)

Fig. 3 Lateral view showing labial concavity depression.

Fig. 4 Occlusal incisal edge view showing concave labial ridge.

Fig. 5 Occlusal view of flap outline.

Fig. 6 Reflected muco-gingival flap exposing osseous labial defect.

Fig. 7 Gingival connective tissue graft placed in correct position.

Fig. 8 The gingival graft is sutured to the flap, while the flap is repositioned and sutured for stability.

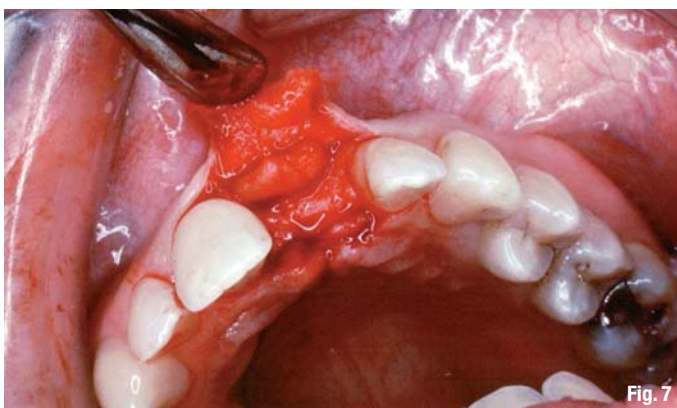


Fig. 7

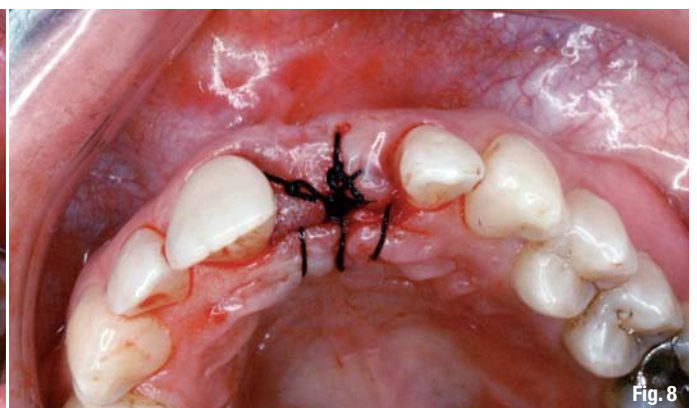


Fig. 8



Fig. 9a _Initial lateral view of depressed area.

Fig. 9b _Healed ridge augmentation, lateral view.

that she avoid a permanent splint and wait for the pulps of the adjacent teeth to mature. Years later, she was referred to me for pre-prosthetic cosmetic surgery that would allow for a non-removable, aesthetically pleasing and physiologically maintainable appliance.

Without the surgery, the permanent replacement would have been a large bulky pontic or physiologically sized pontic, which would have retained food and plaque because of a void between the gingival space of the pontic and the crest of the edentulous ridge. This void would then have created a dark and unaesthetic contrast. If the pontic had been smaller, there would have been a space between the pontic and the edentulous ridge in which food and plaque would also be retained.

If a removable appliance had been fabricated, the practitioner might have achieved an acrylic colour that somewhat resembled the pinkish gingival area, but it would have been discernible. If a clasp partial was used for the removable prostheses, the clasp would have been unsightly. An attachment-type partial would require crowns to be prepared on the remaining abutments, and the contrast of the replacement tooth would have been detected next to the adjacent abutments. Either partial would have been an obvious replacement that contrasted with the adjacent teeth.

After consultation, it was determined that by using a combination of periodontal surgery techniques, the shape, height and form of the ridge could be corrected, enabling the restorative dentist



Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 10 _Buccal view of a posterior maxillary area with an extreme depression defect.

Fig. 11 _Occlusal view of the same posterior defect without provisional prosthesis.

Fig. 12 _Anterior-buccal view of same defect.

Fig. 13 _Tissue ridge augmentation completed in posterior with new provisional; note the physiological and aesthetic enhancement.

to place a physiological crown. The edentulous ridge had a labial depression and an incisal edge that appeared concave (Figs. 3 & 4). The tissue had to be built up incisally and labially, and a harmonious flow of pink attached gingivally had to be maintained.

Following a thorough evaluation, an autogenous connective tissue graft was placed sub-epithelially in one surgical procedure to achieve a symmetrical look. After anaesthetising the patient, the flap outline and its reflection towards the labial were completed (Figs. 5 & 6). The connective tissue donor site could have been selected from various areas. In this particular case, the tuberosity area was used. The donor tissue was de-epithelialised, and the deformed edentulous area was sculpted to the desired shape. The original flap outline was designed to prevent recession on the adjacent teeth and provide a covering for the graft in order to avoid a keloid on the crest. During healing, a keloid would have been a different colour, which would have detracted from the goal of harmonious colour integration. The flap outline was then extended palatally to include more attached gingiva, which avoided a keloid and retained the graft. Once the autogenous free connective tissue graft was in the desired location, the flap was repositioned and sutured for stability (Figs. 7 & 8).

In this case, the patient had worn a flipper for years to replace a missing tooth. Following surgery, I reduced the existing flipper to allow space for the graft to heal.

After an uneventful post-operative period, the patient healed and continued with good oral hygiene. The referring dentist had a choice of several restorative techniques. In this case, a fixed splint was fabricated with an acceptable pontic (Figs. 9a & b).

In a one-stage procedure, we avoided creating a dark area of labial depression and/or an irregular, concave gingival crestal margin. A lengthy, unsightly pontic was replaced by a physiological, cosmetically acceptable, natural-looking pontic, and the patient was delighted.

_Case 2

The second case demonstrates the use of the same technique in the posterior segment of a patient's maxilla. An extreme buccal-incisal defect (Figs. 10 & 11) where an extraction was done is shown in a maxillary posterior area (Fig. 12). The soft-tissue ridge augmentation technique was used. A temporary provisional bridge shows the restored ridge enhancing the cleanliness and cosmetic appearance. The final prosthesis displays a prosthetic appliance



Fig. 14

that had been in the patient's oral cavity for 20 years. This shows the longevity, as well as the aesthetic enhancement of the technique and its ability to enhance the prosthesis. The finished prosthesis, which is easily maintained by the patient, shows that the unaesthetic, unphysiological defects were successfully corrected (Figs. 13 & 14).

Fig. 14_ With final prosthesis in place.

_Summary

In these presentations, depressed concave ridges—one example in the anterior and the other in the posterior—were corrected using soft-tissue grafts. The results eliminated unaesthetic, dark, depressed food-gathering areas. This technique provides a pre-prosthetic treatment, thus avoiding large pontics, which as illustrated make the area difficult to keep plaque free or cosmetically pleasing. The restorative dentist will then have a positive background to create the aesthetic and physiologic prosthesis.

There must be constant communication between the periodontist, restorative dentist and patient. Detailed techniques must be combined with artistic ideas and tempered with patience.

_about the author

cosmetic dentistry



Dr David L. Hoexter is director of the International Academy for Dental Facial Esthetics, an organisation that combines physicians and dentists with other related fields in research and relates its finding to clinical practice. He lectures throughout the world and has published internationally. He has been awarded 11 fellowships including FACD, FICD and Pierre Fauchard. He maintains a practice in New York City, limited to periodontics, implantology and aesthetic surgery. He can be reached at drdavidlh@aol.com.

Complete maxillary implant prosthodontic rehabilitation utilising a CAD/CAM fixed prosthesis

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

_Endosseous implant treatment has been widely reported as a highly predictable treatment modality with a low percentage of clinical complications. Prudent clinical judgement and careful consideration of the risks and benefits of various treatment options are essential for the treatment planning and long-term success of prosthodontic treatment.¹

Traditional implant prostheses are commonly fabricated using acrylic resin teeth supported by a metal framework. Significant space is designed at the tissue surface of the prosthesis to enhance oral hygiene maintenance. However, application of this prosthetic design in the maxillary arch is occasionally aesthetically inadequate and speech may be compromised.

Conventional porcelain-fused-to-metal restorations require the placement of labial restoration margins below the free gingival margin in order to mask the hue and value transition between the sub-gingival implant sub-structures and the supra-gingival crown restorations. From a periodontal point of view, sub-gingival placement of restoration margins

is related to adverse periodontal tissue response.²⁻⁵ As a result, restoration margins are best placed coronally from the free gingival margin.^{4,5}

Porcelain-fused-to-metal restorations are commonly used in the posterior teeth because of their well-documented long-term clinical track record.⁶⁻¹³ CAD/CAM ceramic-based materials are prescribed nowadays, owing to their demonstrated promising physical properties^{14,15} and clinical longevity.¹⁶

This article describes the clinical application of high-strength zirconium oxide restorations in the prosthodontic management of an edentulous maxilla with a failing implant prosthesis.

_Clinical report

A 62-year-old female with an implant-supported maxillary prosthesis was evaluated at the Specialist Dental Group in Singapore. She presented clinically with a maxillary fixed complete denture supported by six endosseous implants (NobelReplace, Tapered Groovy, Nobel Biocare). The prosthesis had acrylic

Fig. 1 Pre-treatment intra-oral frontal view: A large space was noted between the intaglio surface of the prosthesis and the maxillary tissue, and there was significant tissue resorption on the labial surface of the implant over the maxillary right canine area. The patient was asymptomatic.

Fig. 2 Full thickness flap revealed the advanced bone loss on the labial surface of the implant. In spite of the tissue damage, this implant was clinically firm.

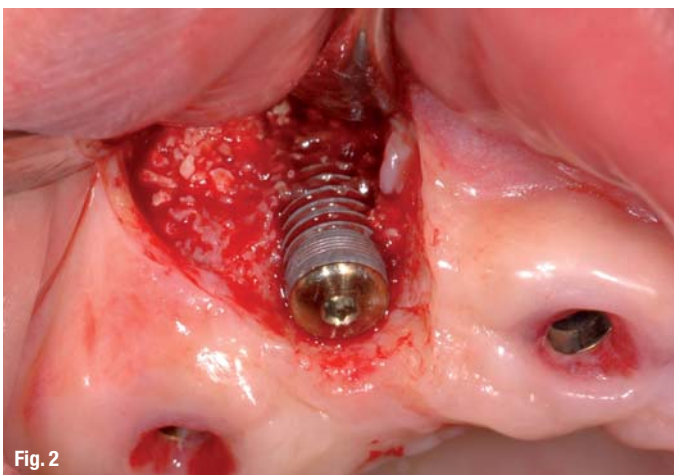




Fig. 3



Fig. 4

resin teeth supported by a gold alloy metal framework. The implant at the patient's maxillary right canine area was exposed. No symptoms were reported by the patient (Fig. 1).

An occlusal examination revealed a stable maximal inter-cuspatation position with insignificant centric relation to maximal inter-cuspatation slide at the teeth level. A canine-guided occlusal scheme was noted. No para-functional habits were reported. Sub-optimal maxillary lip support was noted. A significant amount of dead space was identified between the intaglio surface of the prosthesis and the maxillary soft tissue.

Upon removal of the maxillary prosthesis, all the maxillary implants were found to be osseointegrated. The patient desired to correct the failing implant, restore lip support, masticatory function and facial aesthetics.

The overall treatment plan included removal of the implant at the maxillary right canine area, replacement of a new implant at the maxillary right canine region and fabrication of a full-arch, zirconium oxide-based ceramic restoration in the maxilla.

Under local anaesthesia, the implant at the maxillary right canine area was removed surgically (Fig. 2) and a new 13 mm-long regular platform implant was placed (NobelReplace, Tapered Groovy). The new implant was submerged and primary wound closure achieved. Her existing prosthesis was re-inserted during the healing period to serve as a provisional prosthesis. Once osseointegration was achieved a few months later, the new implant was exposed and the maxilla was ready for prosthodontic rehabilitation after a few weeks of soft-tissue healing.

Six implant-level impression copings (Nobel-Replace) were placed onto the maxillary implants. High-viscosity, vinyl polysiloxane material (Aquasil Ultra Heavy, DENTSPLY DeTrey) was carefully injected around all the impression copings. A stock tray loaded with putty material (Aquasil Putty, DENTSPLY DeTrey) was seated over the entire maxillary arch to make the definitive impression. A jaw-relation record at the treatment vertical dimension was made with a vinyl polysiloxane material (Regisil PB, DENTSPLY DeTrey). The maxillary and mandibular definitive casts were mounted arbitrarily in the centre of a semi-adjustable articulator (Hanau Wide-vue, Teledyne Waterpik) using average settings.^{17,18} The custom zirconium oxide

Fig. 3 Maxillary prosthesis after the application of tooth-coloured porcelain: Excessive crown length was noted at this stage.

Fig. 4 Completed maxillary prosthesis with gingival-coloured porcelain applied to provide adequate lip support: Excessive crown height was reduced.

Fig. 5 Anterior view showing the CAD/CAM-fabricated full-ceramic implant abutments at the approximated vertical dimension of occlusion.

Fig. 6 Occlusal view of the maxillary arch before insertion of the maxillary prosthesis: Favourable anterior-posterior spread allowed the replacement of posterior teeth with distal cantilevering.



Fig. 5



Fig. 6



Fig. 7

Fig. 7 Completed maxillary implant-supported prosthesis; note the placement of the supra-gingival margins.

abutments with gold-alloy fitting surface (Procera, Nobel Biocare) were CAD/CAM fabricated according to the prosthesis design.

The development of the planned definitive maxillary restoration was carried out using a CAD/CAM process. The maxillary definitive cast with the custom full-ceramic abutments (Fig. 3) were scanned (Zeno Scan, Wieland Dental+Technik), and the prosthesis framework was designed using a software program (D700, 3Shape). The framework was milled in zirconium-base material (Zeno Zr Bridge, Wieland Dental+Technik) with a milling machine (Zeno 4030 M1, Wieland Dental+Technik). The prosthesis framework was sintered according to the manufacturer's recommendations. Subsequently, overlaying low-fusing, tooth-coloured porcelain material (IPS e.max, Ivoclar Vivadent) was manually applied onto the exterior to create proper anatomic form (Fig. 4). Low-fusing, gingival-coloured porcelain material (IPS e.max) was applied to create proper lip support (Fig. 5).

During the delivery clinical session, the old prosthesis was removed and the new custom abutments were torqued to 32 Ncm (Fig. 5). The new prosthesis was tried-in to verify colour, occlusion, lip support, teeth form, and comfort. Upon confirmation of the patient's acceptance, the implant abutments were sealed in gutta-percha (Fig. 6) and the prosthesis was cemented in resin-modified glass-ionomer luting agent (RelyX Unicem, ESPE).

The patient was evaluated two weeks post-operatively. Anterior guided occlusal schemes were verified intra-orally before and after prosthesis cementation (Fig. 7). The patient reported no discomfort and she had been functioning well with the new restorations. No abnormal clinical signs were noted.

Discussion

Osseo-integration is a well-documented and predictable clinical treatment option. On the other hand,

management of implant failure is also a clinical reality. In this clinical report, the failure of one implant at a crucial location indicated the need for re-fabrication of the whole implant prosthesis.

As the patient desired a high level of aesthetics, full-ceramic restorations were selected. By prescribing tooth-coloured ceramic abutments and full-ceramic restorations, prosthesis margins were made at the gingival level and gingival retraction procedures were eliminated during impression and prosthesis insertion.

Full-arch prosthodontic rehabilitation using fixed prostheses usually requires longer-term provisional restoration in order to facilitate a predictable treatment outcome. In this patient, the existing maxillary prosthesis served as a long-term provisional restoration for verifying her adaptability and multiple professional clinical adjustments of provisional restorations was not required. This treatment sequence increased the margin of safety in the execution of the definitive full-ceramic restoration. Intra-oral verification of the new treatment occlusal scheme and detailed *in situ* clinical adjustment of the restorations on the day of prostheses insertion still formed the essential foundation for proper treatment execution. In any major prosthodontic treatment, the patient should be informed of the potential financial and time implications should the need for re-fabrication of the restorations arise.

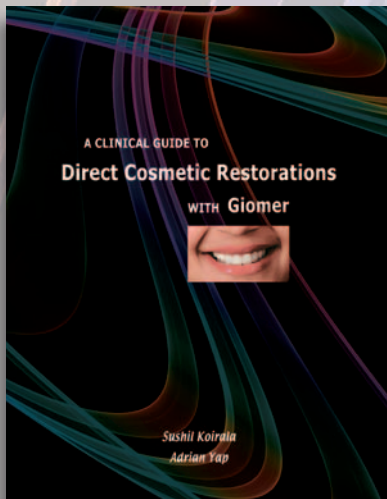
Conclusion

The functional management of an edentulous maxilla using a full-ceramic implant-supported maxillary prosthesis has been reported. New CAD/CAM-based restorative materials were used in treating this case. The use of high-strength full-ceramic restorations enhances overall aesthetic predictability and long-term functional outcome.

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

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Aesthetic functional veneers in patients with habitual dysfunctions?

Author_ Prof Martin Jörgens, Germany

Presently, numerous options for non-preparation veneers are available on the market. These have been proven to be effective and serve as an excellent marketing tool in the dental practice specialising in aesthetics. However, these types of veneers are not applicable for patients with individual colour or shape requests or those suffering from a habitual dysfunction. For such patients, a standardised veneer preparation is generally excluded.

In such cases, an extensive functional analysis is indispensable for the preparation of the veneers in order to facilitate harmonious occlusion and, most importantly, to enable smooth articulation. The aim of each veneer case should always be to achieve health, aesthetics and longevity of the veneers while minimising the risk of fractures.

Accurate clinical examination and documentation of the basic functional parameters is essential in order to identify where overloading exists or where it can occur. State-of-the-art diagnostic instruments, like CADIAX and Free-corder, provide comprehensive functional analysis and are extremely helpful. The articulator is programmed according to the patient's articulation and allows the dental technician to reproduce functional occlusion surfaces corresponding to the natural dentition. Functional disorders resulting from imbalanced prosthetic treatment and dysfunction can be avoided.

Smooth articulation should also be achieved in the molar region where old fillings, inlays/onlays or crowns may result in malocclusion and cause para-function. If necessary, retained wisdom teeth should be removed and orthodontic pre-therapies used to correct existing malfunctions. In addition, pre-prosthetic orthodontics may result in minor material removal in a planned preparation.

Case study

The following case study demonstrates the interaction between aesthetics and function in the preparation of veneers in a patient with severely advanced habitual dysfunction. The patient also had severely damaged upper anterior teeth due to extreme latero-trusion habits.

Figs. 1–3 Initial situation with pronounced habitual dysfunction.





The case was documented according to the European Society for Cosmetic Dentistry (ESCD) guidelines as a requirement for obtaining certification as a specialist in Cosmetic Dentistry ESCD (these guidelines are available from the author upon request). An integral part of documentation is the use of identical camera settings for all photographs that have to be taken before and after any reconstruction.

In addition to the correction of the damage, the following were especially important to the patient: longevity of the reconstruction, ability to select shape and colour of the veneers, use of all-ceramics, minimally invasive preparation, and harmonious aesthetics. Furthermore, the patient desired a purely cosmetic optimisation of the lower central incisors with slight contouring and, if needed, BRITESMILE bleaching after the application of the upper veneers.

First, an aesthetic functional wax-up of the six upper teeth was created in order to facilitate optimal communication between patient, dentist and dental technician throughout each stage of the veneer preparation. The patient's history revealed that four premolars had been extracted in his youth, followed by orthodontic therapy. Over the years, all teeth had been treated conservatively and the wisdom teeth were well adjusted. All upper and lower premolars and molars had been treated with all-ceramic zirconia crowns. The patient did not desire a complete makeover with overbite reduction. Therefore, we focused on the design of perfect and fracture-free veneers for the mandibular central incisors. Thus, all interfering factors had to be minimised.

The aesthetic contouring of the lower central incisors naturally leads to a harmonious overall appearance. In addition, one of the main causes of veneer fracturing can be eliminated: patients with extreme mandibular mobility are able to shift into extreme areas of protrusion and latero-trusion, often going much beyond the cutting edge of the maxilla. However, fracturing and failure of a veneer are not merely caused by forward movement. Problems often occur during the backwards movement of the mandible when the teeth slide back into retrusion and become stuck and, owing to the extreme forces, a veneer fracture can result. These extreme retrusions can be imitated in the articulator only if the technician registers a bite situation of this position. If the technician only considers standard mandible movements, he will not be able to reach the extreme areas of the existing habitual dysfunction.

Fig. 4 Preparation without gingival correction.
Fig. 5 Crown elongation.
Fig. 6 Preparation.
Fig. 7 Final preparation.
Fig. 8 Sulcus demonstration with diode laser.
Fig. 9 Functional temporaries according to wax-up.

Patient-oriented articulation adjustments

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| R ANGLE | 51 | 53 | - | R ANGLE | 6 | 6 | 6 |
| L INSERT | BLACK | BLACK | BLUE | L INSERT | WHITE | WHITE | WHITE |
| L ANGLE | 41 | 47 | - | L ANGLE | 12 | 8 | 5 |
| SEQUENTIAL | PROTRUSIVE | | LATERAL RIGHT | | LATERAL LEFT | | |
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Fig. 10



Fig. 11



Fig. 12

Fig. 10_Veneers on the model.

Fig. 11_Bleaching.

Figs. 12 & 13a-d_New harmonised incisal guidance.

In such patients, the aim of the contouring should be the removal of all uneven surfaces that could cause dysfunction of mandible protrusions and retrusions. This must be done prior to the initial veneer preparation. All possible movements of the mandible in the palatal surfaces of the maxilla and beyond the incisal edge have to be marked accurately.

Owing to the clear overbite of 3 mm, the first step was to shorten the maxillary teeth sufficiently. This creates significantly less static leverage forces in the veneer, which is thus subsequently shorter, than in veneers with normal or greater length. Thus, even in habitual dysfunctions, a better force distribution can result within the veneer.

Figs. 14_Post-op situation from multiple angles.

Patients with extreme overbite and crowded anterior teeth are especially exposed to veneer

In order to achieve an optimal aesthetic result, crown elongation was performed during



Fig. 14

fractures. In such cases, orthodontic pre-treatment is often essential but refused by many patients. Should this be the case, all edges must be smoothed and rounded so that the veneers created subsequently have a chance of survival.

Thorough functional analysis and subsequent documentation were performed. The wax-up demonstrated that for the removal of the old vestibular composite reconstructions and for optimal veneer construction, this case required preparation in order to achieve an aesthetic result. The main concern in this case was to identify which basic static design possibilities were achievable.

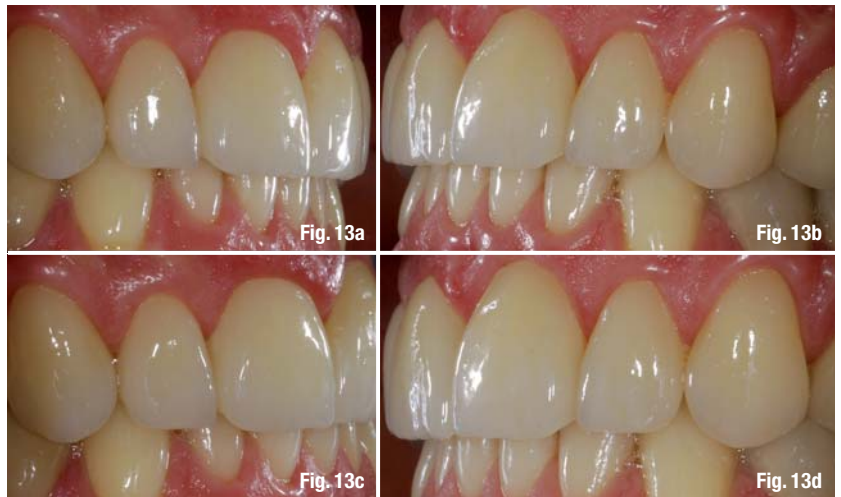
preparation using ELEXION's diode laser system. On the one hand, length disparities between the individual teeth can be balanced and on the other hand, a general lengthening of the clinical crowns of all the anterior teeth can be achieved to create a harmonious smile. These measures can always be carried out safely when a sufficient amount of attached gingival exists and an excision with subsequent relocation of the preparation edge does not lead to insufficient biological width.

In this case, a prominent mesio-proximal defect of the cervical aspect of tooth 11 led to a significant length disharmony of tooth 21. The teeth appeared to be of the same length after laser cor-

rection and were prepared accurately. For indexing, the preparation margin was exposed through minimal invasion using with the diode laser.

While preparing the temporaries, it has to be ensured that they support the healing of the gingiva after the excisions through optimal, anatomic convexity. The new outer contours created in the wax-up need to be considered and with the silicon key they may serve as model of the new contour and thickness of the temporaries. With this procedure, excellent healing results can be achieved that create optimal conditions for cementing. Photographs taken from all angles facilitate comparison with the initial situation and significantly aid the technician in creating the veneers. The more extensive and precise the photographs, the more accurately and beautifully the veneers can be prepared.

At this point, which technical parameters can be of use in patients with habitual dysfunctions?



Ao+Pressbody was applied followed by multiple layers of Authentic. After the form of the veneers had been modelled, they were pressed and coated. The perfect result was achieved after four firings. The durability of the veneers is a significant advantage of this multiple-layering technique.

We were able to fulfil our patient's aesthetic and functional desires from try-in. The patient was highly enthusiastic and immediately approved of his improved smile. He was given a night guard to prevent possible problems due to bruxism. In our opinion, a night guard should always be used after the completion of reconstructions in habitual dysfunction cases, in order to protect the veneers.

_Conclusion

Direct comparison of the preoperative and post-operative situations demonstrates the new, stress-free situation in the upper anterior teeth, which is the aim in patients with habitual dysfunction. Accurate planning and careful consideration of the veneer type—prepared or non-prepared—is highly recommended.



For one, the above-mentioned static design data of the veneer length play a significant role. Protrusion and latero-trusion forces can easily be compensated when the sagittal incisor guiding angle is levelled. Optimal function surfaces can be created through fine adjustments. Thus, the result of the treatment is not only a careful alteration of the overbite-overjet relation, but also a fine adjustment of the pathological anterior and lateral guidance.

Furthermore, the selection and quality of the veneer ceramic plays a significant role. Ceramics that are more elastic and abrasion resistant should be preferred. In the present case, our team decided to use the following combination: initially

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Prof Martin Jörgens

DentalSpecialists
Kaiserswerther Markt 25
40489 Düsseldorf-Kaiserswerth, Germany
www.dentalspecialists.de

ZTM Olaf van Iperen

Siebengebirgsblick 12
53343 Bonn-Wachtberg, Germany
www.vaniperen.de

A new approach for patient acceptance and appreciation

Authors_ Dr Lorin Berland & Dr Sarah Kong, USA



Fig. 1_ Pre-op full face.

the severe tetracycline staining, she felt her teeth were worn from years of grinding. Moreover, she had old resin bonding on her lower front teeth that was not only discoloured, but also mismatched from years of patching and re-patching each time something broke off.

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

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

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

When the patient came for her first visit, she wished to address a number of dental concerns. In addition to

Fig. 2_ Smile Style Guide.

Fig. 3_ P-3, pointed canines with square centrals and round laterals.

Fig. 4_ Length code L-2, laterals slightly shorter than centrals and cuspids.



Fig. 2 The tool you need to create the smile you want



Fig. 3



Fig. 4



Fig. 5_Cosmetic image.

Fig. 6_Diagnostic wax-up and putty matrices.

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

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

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

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

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



Fig. 7_Slip-On Smile full face.

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



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

In order to prepare the gingiva for the final impressions, Expasy! (Kerr) was placed around the gum line. Final impressions with a PVS material (examples are Take 1 Advanced, Kerr; and Virtual, Ivoclar Vivadent) were then taken in custom trays. A slow-setting material was used to record her bite registration (SuperDent). In order to cement the provisionals, the same bis-acryl was placed in the temporaries and seated in the mouth. The excess was removed with a microbrush before the material set. The patient loved the way her provisionals looked and fitted (Fig. 11).

There were no surprises, as she had chosen the smile design she liked best before any work had even begun.

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

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



Fig. 11_Provisionals full face.

Fig. 12_Post-op full face.

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

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

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

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

Although the mix-to-match method is an extra step that requires more chair time, the results justify the

means. And for this patient, this meant a beautiful new smile with minimal tooth reduction to achieve the most natural aesthetics. Each step of this process gained more of the patient's acceptance of the proposed treatment, which determined her appreciation of the results.

_ about the authors

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Dr Lorin Berland, an accredited Fellow of the AACD, is one of the most sought-after speakers and published authors on cosmetic dentistry in America. He has featured in national and regional magazines and major dental journals, and recently on NBC News,

Fox News, and ABC's 20/20. For more information on *The Lorin Library Smile Style Guide*, the 8-AGD credit DVD, www.denturewearers.com, and The One Appointment Inlay/Onlay Kit and complimentary 8-AGD credit CD/ROM, call +1 214 999 0110 or visit www.dallasdentalspa.com.



Dr Sarah Kong graduated from Baylor College of Dentistry where she served as a professor in restorative dentistry. She focuses on preventive and restorative dentistry, transitionals, anaesthesia, and periodontal care. Dr Kong has worked with

a master ceramist in one of the world's finest dental laboratories. She is an active member of numerous professional organisations, which include The American Dental Association, The Academy of General Dentistry, The American Academy of Cosmetic Dentistry, The Texas Dental Association, and The Dallas County Dental Society.

Maintenance of periodontally compromised teeth with **direct splinting**—current materials and options

Author _ Dr Ajay Kakar, India

- Fig. 1** _ A common periodontal situation with mobile anterior maxillary teeth causing discomfort.
- Fig. 2** _ Grooves prepared on the buccal surface of the incisors at the incisal third to enable placement of the fibre.
- Fig. 3** _ The fibre in place and polymerised after being coated with flowable composite.
- Fig. 4** _ The completed splint with direct bonding composite build-up to achieve a pleasing aesthetic result.
- Fig. 5** _ A case of migration of the central incisors.
- Fig. 6** _ A splint done followed by recontouring of the tooth and direct bonding composite build-ups.

_Periodontal disease is initiated in the main as gingivitis, which in a smaller subset of individuals progresses to the more advanced form referred to as periodontitis. Gingivitis is restricted to the marginal gingival area and does not lead to destruction of osseous tissue. Gingivitis is the progression to *periodontitis*, which encompasses extensive loss of bone surrounding the tooth. Modern-day therapy can generally ensure the arrest of the progression of periodontal destruction and, in favourable situations, even the regeneration of all the components of the periodontal apparatus, albeit to a much lesser extent than the original. Of the periodontal structures, the loss of soft tissue makes the process of complete regeneration much more difficult.

In such circumstances, wherein the inflammation and infection has been controlled and the disease activity has been curbed, it becomes imperative that the dentition, which is definitely compromised owing to the pre-existing damage, be supported and additional aids provided to create the optimum function, coupled with aesthetics. One of the key issues in such dentitions is the mobility of the teeth. Such mobility may be localised to certain teeth and in a specific path of motion or may be much more generalised and afflict many teeth. In either case, the benefits of immobilisation are multiple. The comfort level of the patient is sufficient reason to use this treatment option for mobile teeth. Additionally, this also leads to tremendous patient motivation and compliance in maintaining oral hygiene, which



directly translates into better periodontal health. Furthermore, an immobile tooth will heal much faster and better than a mobile one. Any regenerative therapy carried out around afflicted mobile teeth will have better results than would have been the case had the teeth been immobilised (Figs. 1–4).

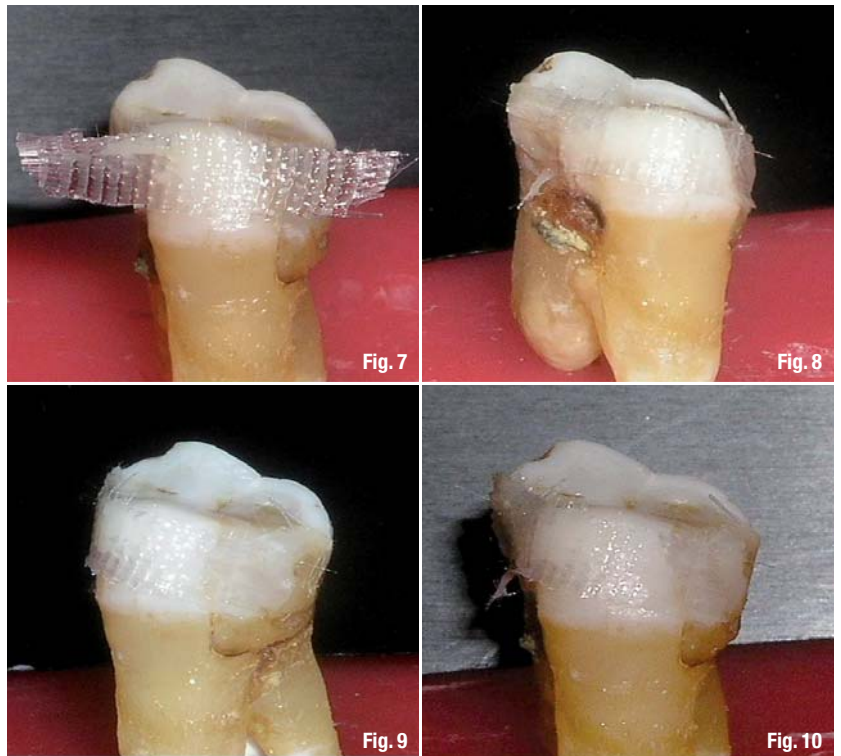
Another critical manifestation of periodontal disease, when coupled with imbalanced occlusal loads, is the sequel of migration that results from such a clinical situation. Migration, an extremely slowly developing phenomenon, leads to drastic consequences that can usually be optimally corrected only by using orthodontic appliances. But even this correction requires a permanent splinting procedure to ensure that the concerned teeth remain in place and do not migrate away once again. This same technique can be used routinely by orthodontists to place permanent non-invasive quartz splints. Another possible use of quartz glass fibre splints is in cases of alveolar fractures. The advent of bonding dentistry and the easy-to-use quartz splint fibre make it a very strong contender for the stabilisation and immobilisation of anterior alveolar fractures.

A key factor towards achieving the end point of a good and long-lasting splint is the base material used in conjunction with the composite restorative material for building and applying the splint. It is very important that the splint functions like a monobloc and bonds optimally to the enamel and dentine. In order to provide this monobloc effect, the substructure has to chemically bond and be in unison with composite restorative material. In order to provide near-optimum bonding, the substructure and the entire monobloc, which has to be built-up, have to be very closely adapted to the teeth around all the curves, right into the interproximal spaces. This means that the fibre material should have physical properties that allow curving and very easy manipulation into any shape (Figs. 5 & 6).

The required materials for achieving a high quality functional and aesthetic splint are:

- _ a pre-impregnated glass fibre-based splinting material;
- _ a restorative micro/nano-filled composite material;
- _ a flowable composite material; and
- _ a bonding agent.

The above only highlights the materials required and does not list the armamentarium, which would consist of a number of special hand instruments to achieve a high quality result and



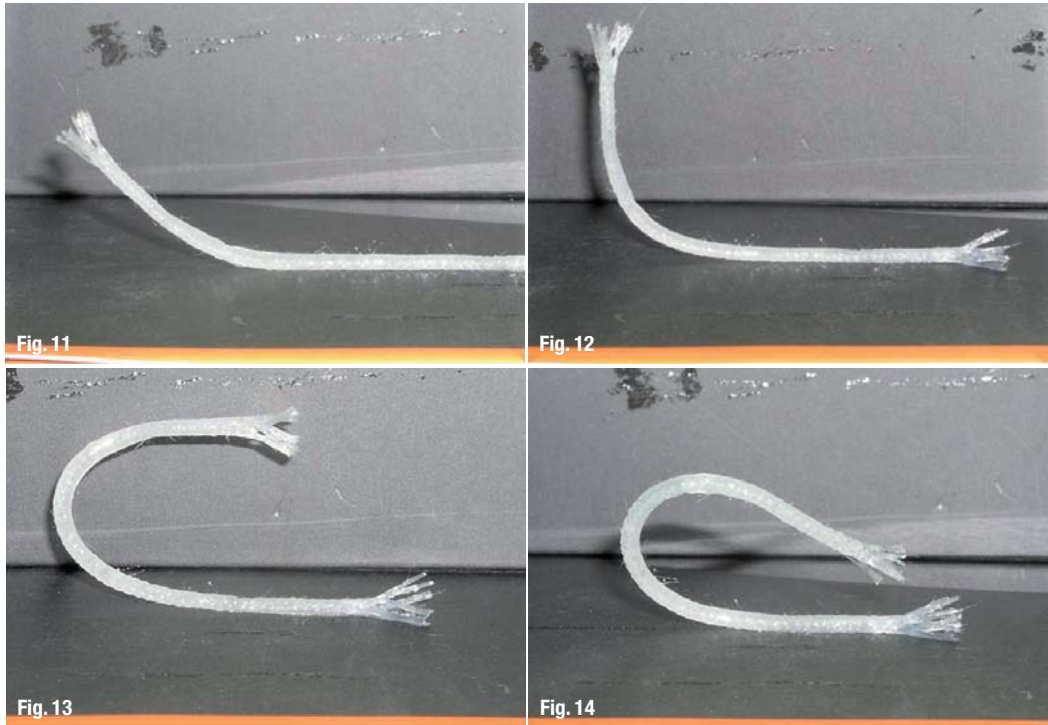
finish. Amongst the materials, the bonding agent and the composite restorative material are dependent on the clinician's preference. The micro- or nano-filled range of products from any of the industry leaders in restorative materials are most appropriate. A good flowable material is also required to create a close fit of the splint material to the tooth surface, while a sixth or seventh generation bonding agent would be able to achieve the desired bond strength.

The most critical aspect in achieving the ideal splint outcome is the selection of the fibre used as the substructure. There are a number of options available on the market. I have tested different splinting fibres throughout my career and quite a number of them has given very good results and lasted for years. Available materials have some favourable properties at the cost of some other undesirable elements and at times the clinician has to choose between sacrificing several of the desired elements in order to gain the others. The ideal substructure fibre material has the following properties:

- _ high strength subsequent to polymerisation;
- _ chemically bondable with composite resin material;
- _ available in a pre-impregnated state;
- _ no thicker than 0.2 mm;
- _ available in varying widths;
- _ easy to trim and cut; and
- _ no memory as regards its form.

Figs. 7–10 The clinical zero memory effect of the woven quartz splint demonstrated by adaptation around the entire curvature of the crown of an extracted molar. The material is not polymerised but stays in the newly adapted position.

Figs. 11–14_The near zero memory property of the rope quartz splint demonstrated by distortion into various shapes; the material maintains its distorted position without any polymerisation.



Of the above, the last property is a critical one. Because of the difficult handling properties of the fibre splint, splinting has been a very technique-sensitive procedure thus far. Unless the clinician was extremely conversant with all the requisite steps and also extremely skilful and dexterous in the handling of the fibre and composite, the likelihood of a long-term success would be reduced.

Many splint materials have a tendency to a memory, that is the property of returning to original shape if deformed under load. This memory of a material makes it resistant to being shaped around curves, especially curves that double-back, for example the interproximal areas around the linguals of lower anterior teeth or around the curvature of a maxillary premolar. If the material can be fabricated in such a way that it bends and adapts around curves without bouncing back, it

makes adapting and placing the splint in the oral cavity a far simpler and more accurate task.

Glass-based fibres have an inherent tendency to maintain their longitudinal direction. This can easily be observed in any unidirectional fibre splint material. The only way to negate this property of the fibre is to interweave the fibres in a cross-stitch pattern. This creates a kind of mesh framework, thereby making the material almost free of memory. The term *zero memory* can then be applied to such a material, which will only minimally maintain any form to which it is subjected (Figs. 7–10). Although the material does possess a certain amount of memory, it becomes practically insignificant as regards clinical application. For all practical purposes, the material would then have zero memory.

My best experience thus far has been with a very new entry in the splinting fibre market: Quartz

Fig. 15_Buccal view of a patient with mobile lower central incisors.

Fig. 16_Lingual view of the same patient with mobile lower central incisors.





Fig. 17



Fig. 18

Fig. 17_A tin foil template used to measure the size of the required splint.

Fig. 18_Buccal view of the splint done with the woven quartz splint.

Splint (Recherches Techniques Dentaires). The basic raw material used in this product is quartz glass, unlike regular glass fibre. This is the same quartz used to develop endodontic posts, which demonstrate cyclic fatigue resistance values that are much higher than desired in the oral cavity. Quartz glass is also homogenous with the Bis-GMA range of unfilled resin, which makes it ideal for use with restorative composite material, allowing it to become a monobloc with the composite. The quartz splint is developed as a woven fibre using extremely thin strands of glass fibres.

The weave pattern imbues certain physical attributes to the material. It allows force distribution in such a manner that it creates the previously mentioned clinical zero memory effect and does not resist and inhibit crack propagation. All of the above-mentioned effects are achieved without any compromise to the strength of the material. In fact, the quartz fibre will enhance and strengthen the monobloc that is created with the amalgamation of the unfilled resin, quartz fibre, flowable composite, and micro-/nano-filled composite material. Since the material is available pre-impregnated and is soaked in unfilled resin, it becomes all the more easier to use the splint right out of the box. The zero memory allows it to be adapted extremely easily around a curved arch without polymerisation. Once ideal adaptation

has been achieved, it can be polymerised in that position and then layered with micro/nano composite to complete the splint (Figs. 11–14).

Another critical factor in the variety of situations for which a splint is indicated is the width and thickness of the material. Too thick a material can be an encumbrance for placement and final positioning. An ideal thickness is between 0.1 and 0.25 mm. The thinner the material becomes, the lower its ability to reinforce and strengthen will be. The quartz splint is in the 0.2 mm thickness range, making it useful in almost all clinical situations.

The quartz splint is available in a variety of patterns and widths. The recommended pattern for intra-oral splinting is the woven pattern. This is available in widths of 1.5 mm, 2.5 mm and 4 mm. Of these three, the 1 mm design is most suited for use as a retention splint in post-orthodontic cases in which the teeth are neither extremely mobile nor do they exhibit gingival recession and loss of the supporting structures. The 2 mm fibres are most ideally suited for teeth afflicted with previous periodontal disease. When the teeth are large in size and exhibit clinical crowns larger than the anatomical crowns, the 3 mm fibre may be used in lieu of the 2 mm fibre.

The quartz splint has a unique design—much like a braided rope—giving it extremely high flex-



Fig. 19



Fig. 20

Fig. 19_Lingual view of the splint done with the woven quartz splint.

Fig. 20_A case requiring post-orthodontic retention of the upper incisors; the splint is to be placed on the palatal surface of the maxillary anteriors.

Fig. 21 Preparations done on the palatal surface; the area where the splint is to be placed has been grooved.

Fig. 22 A tin foil template placed on the grooved area to measure the size of the required splint.

Fig. 23 The woven quartz splint placed in the prepared area on the palatal surface of the maxillary anteriors.

Fig. 24 The completed splint.



Fig. 21



Fig. 22



Fig. 23



Fig. 24

ural strength values after complete polymerisation. The design of the material requires it to be between 1 and 2 mm in diameter. A deep groove has to be cut into the teeth where the splint is being placed to enable it to be adapted optimally. This design can be utilised when in cases in which an occlusal splint design is used to stabilise maxillary or mandibular premolars. Other than the woven and rope patterns, the quartz splint is available as a unidirectional fibre. This is not to be applied in clinical situations, but rather as a laboratory reinforcement material used to develop poly-ceramic prostheses. The quartz splint also has a 4 cm x 4 cm mesh that can be applied in denture repairs, for example.

With material benefits aiding and improving the functional aspect of splints, there has been a newer approach possible owing to the enhance-

ment of bonding dentistry technology. Shade matching, polishability, enhanced bond strength and much longer-lasting composites have all contributed to a much greater usage of direct bonding procedures in everyday dentistry. The emphasis this has given to aesthetic procedures has been tremendous. Similarly, the quartz fibre-based composite splint in a dentition with pre-existing periodontal damage can be enhanced to achieve a much better aesthetic result (Figs. 15–19).

Although function has been the paramount and most critical issue when placing a periodontal splint, aesthetics now also play an important role. The patient and the clinician may not be completely satisfied with function. It is quite easy to apply standard bonding principles of a diastema closure to ensure that the basic substructure is appropriately located and thereby enable an excellent aesthetic outcome with longevity. This modification of a functional splint to an aesthetic splint can be easily applied for anterior teeth exhibiting extensive mobility or migration. Several of these cases can be seen in the following figures, in which the maxillary anterior teeth presented with diastemas and proclinations coupled with mobility. The results have been very satisfactory.

This article has only touched on the fundamental concepts of splints and the new improvisations available in terms of material technology.

_about the author

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Dr Ajay Kakar is in private practice specialising in periodontics and implantology in Mumbai in India. He is the secretary of both the International Academy of Periodontology and the Indian Academy of Aesthetic & Cosmetic Dentistry. He lectures extensively in India and abroad and runs a web portal for Indian dentistry at www.bitein.com. Dr Kakar can be contacted at ajay@bitein.com or at +91 98210 15579.



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Minimally invasive cosmetic dentistry—Concept and treatment protocol

Author_ Dr Sushil Koirala, Nepal

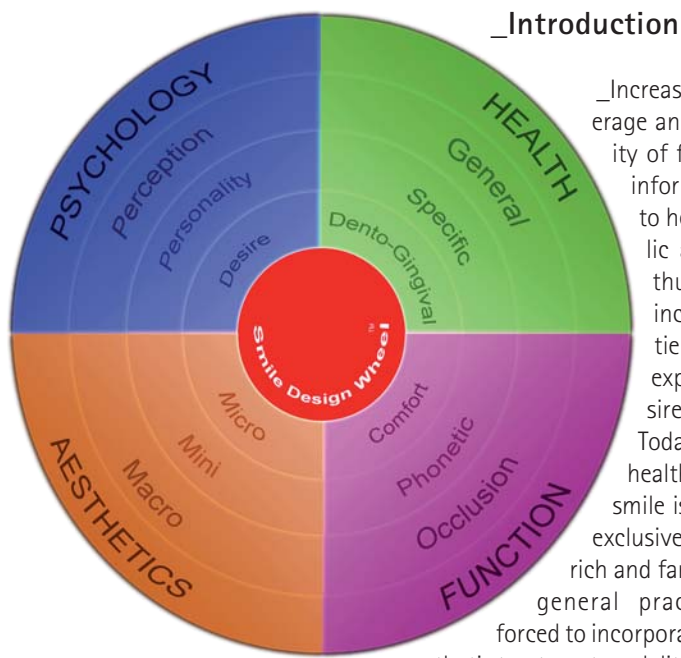


Fig. 1 practices to meet this growing demand.

_Introduction

_Increased media coverage and the availability of free web-based information has led to heightened public awareness and thus to a dramatic increase in patients' aesthetic expectations, desires and demands. Today, a glowing, healthy and vibrant smile is no longer the exclusive domain of the rich and famous and most general practitioners are forced to incorporate various aesthetic treatment modalities in their daily practices to meet this growing demand.

The treatment modalities of any health-care service are aimed at the establishment of health and the conservation of the human body with its natural function and aesthetics. The concept of minimally invasive (MI) treatment was initially introduced in the medical field and was adapted in dentistry in the early 1970s with the application of diamine silver fluoride.¹ This was followed by the development of preventive resin restorations (PRR)² in the 1980s and the atraumatic restorative treatment (ART) approach³ and Carisolv⁴ in the 1990s. The major components of MI dentistry are the risk assessment of the disease with a focus on early detection and prevention; external and internal re-mineralisation; use of a range of restorations, bio-compatible dental materials and equipment; and surgical intervention only when required and only after any existing disease has been controlled.⁵⁻¹¹

Current basic treatment protocols (TPs) and approaches in MI dentistry are the use of air abrasion, laser treatment or sono abrasion to gain cavity access and excavate infected carious tooth tissue through selective caries removal or laser treatment;^{12,13} cavity restoration by applying ART, PRR, or sandwich restoration; and the use of computer controlled local anaesthesia delivery systems¹⁴ with emphasis on the repair of a failed restoration rather than its replacement.¹⁵ Thus far, the focus of MI dentistry has been on caries-related topics¹⁶ and has not been comprehensively adopted in other fields of dentistry. Dr Miles Markley, one of the great leaders of preventive dentistry, advocated that the loss of even a part of a human tooth should be considered a serious injury and that dentistry's goal should be to preserve healthy and natural tooth structure. His words are much more relevant in today's cosmetic dental practice, in which the demand for cosmetic procedures is rapidly increasing. With the treatment approach trend towards the more invasive protocols, millions of healthy teeth are aggressively prepared each year in the name of smile makeovers and instant orthodontics, neglecting the long-term health, function and aesthetics of the oral tissues.

_The need for a new concept

Contemporary aesthetic dentistry demands well-considered concepts and TPs that provide a simple, comprehensive, patient-friendly and MI approach with an emphasis on psychology, health, function and aesthetics (PHFA; Fig. 1). The need for a holistic concept and basic treatment guidelines was expressed by concerned practitioners, aesthetic dentistry associations and academics around the world for the following basic reasons:

_Owing to an increased aesthetic demand, aesthetic dentistry is becoming an integral part

of general dentistry. The aesthetic outcome of any dental treatment plays a vital role in the patient's treatment satisfaction criteria.

MI dentistry currently focuses on prevention, remineralisation and minimal dental intervention in the management of dental carious lesions. It has failed to give the necessary attention to the problems that negatively affect smile aesthetics, for example non-carious dental lesions, or developmental defects and malocclusion.

The treatment modalities of contemporary cosmetic dentistry are trending towards more invasive procedures with an over-utilisation of crowns, bridges, thick full veneers, and invasive periodontal aesthetic surgeries, while neglecting long-term oral health, actual aesthetic needs and the characteristics of the patient.

Social trust in dentistry is degrading, owing to the trend of fulfilling the cosmetic demands of patients without ethical consideration and sufficient scientific background (the more you replace, the more you earn; more is more mentality).

In this article, I introduce a concept and TP for minimally invasive cosmetic dentistry (MICD), in order to address these facts properly and integrate the evidence-based MI philosophy and its application into aesthetic dentistry.

Defining MICD

As the perception of aesthetics and beauty is extremely subjective and largely influenced by personal beliefs, trends, fashion, and input from the media, a universally applicable definition is not available. Hence, smile aesthetics is a multi-factorial issue that needs to be adequately addressed during aesthetic treatment.¹⁷ MICD deals both with subjective and objective issues. Therefore, in this article I define MICD as "a holistic approach that explores the smile defects and aesthetic desires of a patient at an early stage and treats them using the least intervention options in diagnosis and treatment technology by considering the psychology, health, function and aesthetics of the patient."¹⁸

The core MICD principles are:

1. application of *the-sooner-the-better* approach and exploration of the patient's smile defects and aesthetics desires at an early stage in order to minimise invasive treatments in the future;
2. smile design in consideration of the psychology, health, function and aesthetics (Smile Design Wheel¹⁸) of the patient;

3. adoption of the *do-no-harm* strategy in the selection of treatment procedures and the maximum possible preservation of healthy oral tissues;
4. selection of dental materials and equipment that support MI treatment options in an evidence-based approach;
5. encouragement of the *keep-in-touch* relationship with the patient to facilitate regular maintenance, timely repair and strict evaluation of the aesthetic work performed.

The main MICD benefits include:

1. promotion of health, function and aesthetics of the oral tissues and positive impact on the quality of life of the patient;
2. preservation of sound tooth structures (banking the tooth structure), while achieving the desired aesthetic result;
3. reduction of treatment fear and increased patient confidence;
4. promotion of trust and enhancement of professional image.

The MICD treatment protocol

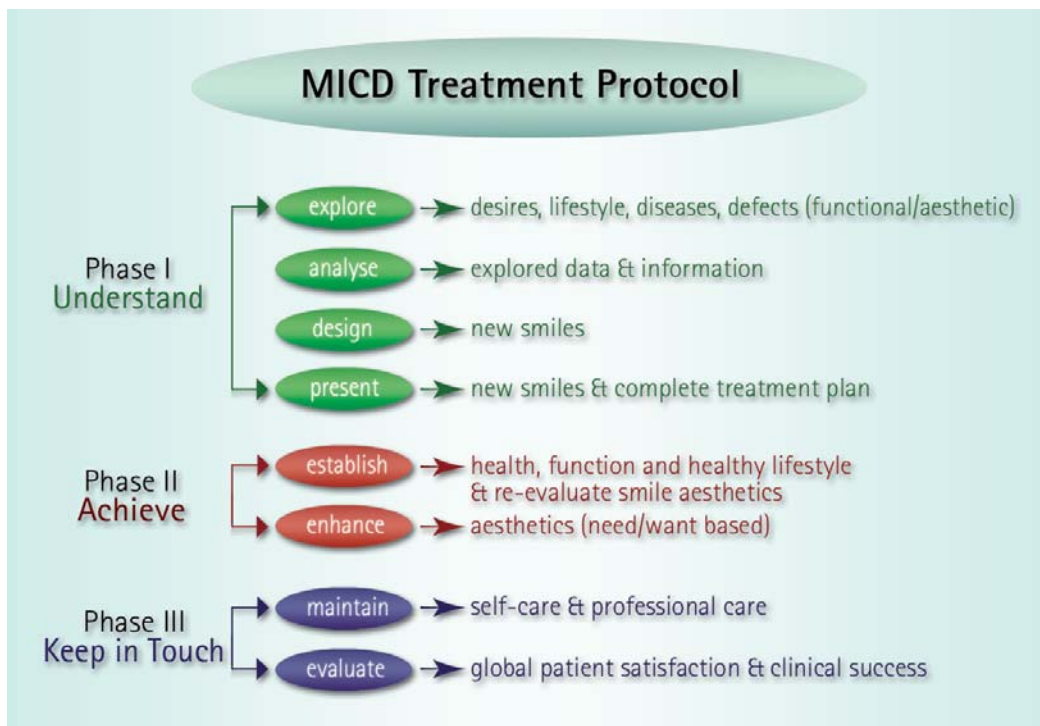
In my experience, the TPs that are currently in use in aesthetic dentistry are mostly based on more invasive techniques and procedures.

| MICD treatment options | |
|---|--|
| NI TREATMENT OPTIONS | MI TREATMENT OPTIONS |
| SMILE TRAINING | MICRO- AND MACRO-ABRASION |
| TOOTH WHITENING | SELECTIVE CONTOURING (GUMS/TEETH) |
| RE-MINERALISATION OF WHITE SPOTS | DIRECT RESTORATIONS WITH MINIMAL TOOTH PREPARATION |
| SHORT ORTHODONTICS (SECTIONAL) | MINIMAL PREPARATION ADHESIVE BRIGDES |
| NON-PREPARATION VENEERS | VENEERS, INLAYS AND ONLAYS |
| ENAMEL AUGMENTATION | MI IMPLANTS |
| ADHESIVE PONTIC (LONG-TERM TEMPORARY RESTORATION) | |
| ORAL APPLIANCE | |

With the use of such protocols, cosmetic dentists are knowingly, or unknowingly, heading towards the over-utilisation of invasive technologies in their practices, which is becoming a professional and ethical concern. The basic aim of the MICD TP is to guide practitioners in achieving optimum results with as little intervention as possible. The intervention level of the treatment in MICD depends on the type of smile defects and the aesthetic needs (objective measurement and subjective perception) of the patient.

Table 1

Fig. 2



The basic framework and pathway of the MICD TP are illustrated in Figures 2 and 3. It is to be noted that the TP in medical and dental sciences must be dynamic in nature and should be flexible to incorporate evidence-based facts. I have therefore outlined the MICD core principles that are required to achieve the optimum result in terms of health, function and aesthetics with minimum intervention and optimal patient satisfaction. However, it is the practitioner's duty to incorporate all the necessary guidelines, protocols and regulations of the authority concerned (state or affiliated professional organisations) into the MICD TP.

Phase I: Understand

In the first step of Phase I, the perception, lifestyle, personality, and desires of the patient are explored. The primary goal of this first step is a better patient–dentist understanding. As the aesthetic perceptions of the dentist and the patient may differ, it is imperative to understand the subjective aesthetic perception of the patient. Various types of questions, personal interviews and visual aids can be used as supporting tools. In this step, the practitioner should ask the patient to complete the *MICD self smile-evaluation form*. The information obtained will help estimate the perceived smile aesthetic score (a-score) and will be used as the base-line data in the evaluation step.

Next, diseases, force elements and aesthetic defects of smile are explored. Information on the

medical and dental history, general health and specific health (oral-facial) of the patient is collected and complete dental and periodontal charting is performed. In order to understand the force elements, the existing occlusion, comfort, muscular activity, speech and phonetics are thoroughly examined with the evaluation of para-functional and other oral habits, comfort during mastication and deglutition, and temporo-mandibular joints (TMJ) movements. The necessary diagnostic tests, photographic documentation and the diagnostic study models are prepared during this step for the further exploration of existing diseases, force elements and aesthetic defects.

In the following step, the data collected is analysed in relation to the accepted normal values of a patient's sex, race and age (SRA) factors. The aesthetic components of the smile are analysed in detail grouped into macro- (facial and dental midline relation, facial profile, symmetry of the facial thirds and hemifaces), mini- (visibility of upper anterior teeth, smile arc, smile symmetry, buccal corridor, display zone, smile index and lip line) and micro-aesthetics (dental: central dominance, teeth proportion, axial inclination, incisal embrasure, contact-point progression, shade progression, surface texture; gingival: shape, contour, embrasure and zenith height). The practitioner can now grade the smile in terms of the patient's health, function and aesthetics as follows:

_Grade A: The established parameters of oral health, function and aesthetics are within normal limits and aesthetic enhancement is required only to fulfil the patient's cosmetic desires.

_Grade B: The established parameters of oral health and function are within normal limits; however, the aesthetic parameters are below the accepted level. Aesthetic enhancement can further improve the aesthetic parameters.

_Grade C: The established parameters of oral health or function or both are below the normal limits. An establishment treatment is mandatory prior to aesthetic enhancement.

From the above, the practitioner will obtain a smile aesthetic grading in terms of the patient's health, function and aesthetics, as well as a complete overview over the smile aesthetic problems and the macro-, mini- and micro-smile defects.

The patient's PHFA factors are the four fundamental components of aesthetic dentistry¹⁸ and must be respected to achieve healthy, harmonious and beautiful smiles. The design step depends on the information obtained from exploration and analysis. The information on psychology is subjective in nature; however, health, function and aesthetic analysis provides the objective information that will guide the design with the various established and basic principles of smile aesthetics and also the feasible and practical extent of the aesthetic desires of the patient. The aesthetic mock-up, manual tracing, digital makeover and smile catalogues are some of the popular tools used in this step. A new smile, alternative designs, types of treatments involved, complexity, possible risk factors and complications, treatment limitation, and tentative costs should be established during this step.

For easy application, the aesthetic treatments in MICD are categorised as follows:

_Type I: Micro-aesthetic components;

_Type II: Mini-aesthetic components; and

_Type III: Macro-aesthetic components: facial and dental midline relation, facial profile, symmetry of facial thirds and hemi-faces.

As the treatment modality depends on the professional capability and experience of the practitioner, simple and practical methods are used to categorise the MICD treatment complexity:

_Grade I: Treatment that may require consultation with a specialist (preventive, simple oral surgery/endodontics/periodontics/implants, short orthodontics);

_Grade II: Treatment that requires the procedural involvement of other dental specialists (complex endodontics/periodontics/orthodontics) but not oral and maxillofacial surgery or plastic surgery; and

_Grade III: Treatment that requires the procedural involvement of oral and maxillofacial surgery or plastic surgery.

With the aid of this simple grading system, any practitioner can determine the complexity of the treatment involved for the accomplishment of a new smile design for an individual patient and can plan for the necessary multi-disciplinary support.

The last step of this phase is the most important in MICD TP because in this step the patient is presented with an image of his or her future smile. Visual aids, such as a smile catalogue, aesthetic mock-ups, manual sketches, modified digital pictures, computer-designed makeovers or animations can be used as presentation tools. The results of the design step are systematically presented to the patient with professional honesty and ethics. All pertinent queries of the patient related to the proposed smile need to be addressed during presentation. The treatment complexity, its limitations, the risks involved, possible complications, treatment cost estimation and maintenance responsibility must properly be explained to the patient. The patient is thus involved in finalising the treatment plan and will sign the written informed consent form before proceeding to Phase II.

Phase II: Achieve

As per the TP, which is finalised during the presentation step, all necessary preventive interceptive and restorative (curative) dental

Fig. 3





Fig. 4a



Fig. 4b

Fig. 4a_Gummy smile with lack of upper central dominance.
Fig. 4b_Harmonised smile with proper central dominance. Treated with MI approach.

treatments are conducted in order to establish the proper health and function of the oral tissues. Owing to the complexity of the treatment, a multidisciplinary approach may be necessary for a good result. Once the case is stable in terms of health (controlled disease) and function (balanced force elements) with good oral habits, the patient is requested to re-evaluate his or her smile in terms of aesthetics with the help of the *MICD self smile re-evaluation form*. This is important, because in some cases the patient is fully satisfied with the results of the establishment step alone and may modify his or her idea

of further aesthetic enhancement. In MICD TP it is considered unethical should the practitioner not collect self smile re-evaluation information from the patient.

The enhancement step of MICD is focused on the fulfilment of the patient's aesthetic desires, which can be grouped into two categories based on the patient's needs and wants. Even though it is sometimes difficult to draw a clear line between the two and their related treatment, in MICD they are categorised as follows:

- _needs: objective restorative needs of the patient in harmony with the SRA factors and due emphasis on health and function of oral tissues (naturo-mimetic smile enhancement)
- _wants: subjective desires of the patient, which may not be in harmony with the SRA factors (cosmetic smile enhancement)

During any want-based aesthetic treatment, where healthy oral tissue is treated with no direct benefit to health or function, the treatment modalities should be within the scope of non-invasive (NI) or MI procedures.¹⁹ The patient's desires alone should not be the rationale for the treatment.²⁰ *Do no harm!* should always be the credo pertinent to all dental treatment procedures.

Phase III: Keep in touch

Regular maintenance, compliance and timely repair play a crucial role in the long-term success of aesthetic enhancement procedures. Hence,

MICD emphasises the *keep-in-touch* concept and encourages patients to go for regular follow-up visits. Responsibility for maintenance is grouped into two categories:

- _Self-care: Patients are advised to continue their normal oral hygiene procedures. If necessary, special care and precautionary methods are given, as well as protective devices. Self-care should focus on regular tooth brushing, flossing, the use of prescribed protective devices and other pertinent professional advice for maintaining general health.
- _Professional care: The oral habits, health of the oral tissues, and the functional and aesthetic status of the work performed are well documented during each follow-up visit, and necessary maintenance repair jobs are carried out.

Evaluation is the final step of MICD TP. Any 'completed' treatment without a proper evaluation is considered incomplete in MICD protocol. The following components need to be evaluated:

- _Global patient satisfaction: After receiving aesthetic dental treatment, the patient is requested to complete the MICD exit form, in which the patient evaluates his or her new smile, gives a second perceived smile aesthetic score (b-score), and indicates his or her global satisfaction score. The b-score is compared with the previous a-score. This process helps determine the patient's actual satisfaction status. In MICD, this is the main parameter for evaluating a patient's aesthetic satisfaction.
- _Clinical success: Clinical success is a multifactorial issue. Selection of proper cases (the patient), restorative materials, TPs and their correct and skilful application are the key factors for clinical success. Therefore, MICD TP suggests self-evaluation of the following four factors (4Ps) using the *MICD clinical evaluation form*:
 - _Patient factors: regular maintenance status, compliance issues and attitude of the patient towards aesthetic treatment;
 - _Product factors: bio-compatibility, mechanical and aesthetic quality of the products used for the treatment;
 - _Protocol factors: TP used in terms of its simplicity, predictability and its evidence-based nature;
 - _Professional factors: existing knowledge and skills, and attitude towards developing these.

Detailed clinical documentation of the case during maintenance and evaluation can provide

various cues to the practitioner in the evaluation of his or her clinical success in terms of case planning, material and protocol selection, as well as his or her existing restorative skills. I believe that a thorough evaluation can support any practitioner in initiating practice-based research and keeping up-to-date with the recent trend of evidence-based dentistry (Figs. 4a–5b).

MICD treatment modalities

Various types of treatment modalities are available in MICD. Their effective use depends on the level of smile defects, type of smile design, proposed treatment type and the treatment complexity grade. There is only one principle in selecting treatment modalities in MICD: always select the least invasive procedure as the choice of the treatment.

The two categories of MICD treatment are NI and MI treatment (Table 1). However, conventional invasive treatment modalities may also be required, depending on the complexity of the case.

Conclusion

MI dentistry was developed over a decade ago by restorative experts and founded on sound evidence-based principles.^{21–30} In dentistry, it has focused mainly on prevention, re-mineralisation and minimal dental intervention in caries management and not given sufficient attention to other oral health problems. I believe that the MI philosophy should be the mantra adopted comprehensively in every field of the dentistry.

For this reason, I have explained the MICD concept and its TP, which integrates the evidence-based MI philosophy into aesthetic dentistry, in the hope that it will help practitioners achieve optimum results in terms of health, function and aesthetics with minimum treatment intervention and optimum patient satisfaction.

Acknowledgements

In formulating the MICD TP, I discussed the concept with several national and international colleagues in order to ensure that it is simple, practical and comprehensive. I would like to extend my gratitude to Dr Akira Senda (Japan), Dr Didier Dietschi (Switzerland), Dr Hisashi Hisamitsu (Japan), Dr Oliver Hennedige (Singapore), Dr Dinos Kountouras (Greece), Dr Mabi L. Singh (USA), Dr Ryuichi Kondo (Japan), Dr So-Ran Kwon (Korea), Dr Prafulla Thumati (India), Dr Vijayaratnam Vijayakumaran (Sri Lanka), as well as Dr Suhit R. Adhikari, Dr Rabindra Man Shrestha, Dr Binod Acharya and Dr Dinesh Bhusal of Nepal, for their valuable comments, advice and feedback.

Editorial note: A complete list of references and the MICD forms are available from the publisher.



Fig. 5a



Fig. 5b

Fig. 5a Smile after establishment treatment.

Fig. 5b Smile aesthetic enhancement with non-invasive veneers treatment.

about the author

cosmetic
dentistry



Dr Sushil Koirala is the founding president of the Vedic Institute of Smile Aesthetics and the chief instructor of Comprehensive Aesthetic Dentistry, a two-year training programme based upon Vedic philosophy of beauty and aesthetics. He maintains a private practice focusing primarily on MI cosmetic dentistry (MICD). Based on more than 17 years of clinical experience in aesthetic dentistry, Dr Koirala developed the Vedic Smile Concept, the Smile Design Wheel, the MICD TP, and various clinical techniques for direct aesthetic restorations. He is the founding president of the Nepalese Academy of Cosmetic and Aesthetic Dentistry and South Asian Academy of Aesthetic Dentistry.

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He has published numerous clinical articles in aesthetic dentistry and authored *A clinical guide to Direct Cosmetic Restorations with Giomer*, published by Dental Tribune International GmbH. In addition, Dr Koirala serves as Editor-in-Chief of **cosmetic dentistry** beauty & science. He frequently conducts hands-on programmes and delivers lectures globally on smile aesthetics. He can be contacted at skoirala@wlink.com.np.

CAD/CAM expands the scope of restorative dentistry

Author_ Manfred Kern, Germany



Fig. 1

Fig. 1 _Prof Werner Mörmann and Dr Marco Brandestini in 1985 with the CEREC 1 prototype.

(Photo: Prof Werner Mörmann/ Quintessenz)

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

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

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

Adhesive bonding furthered the development of CAD/CAM restorations

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

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

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

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

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

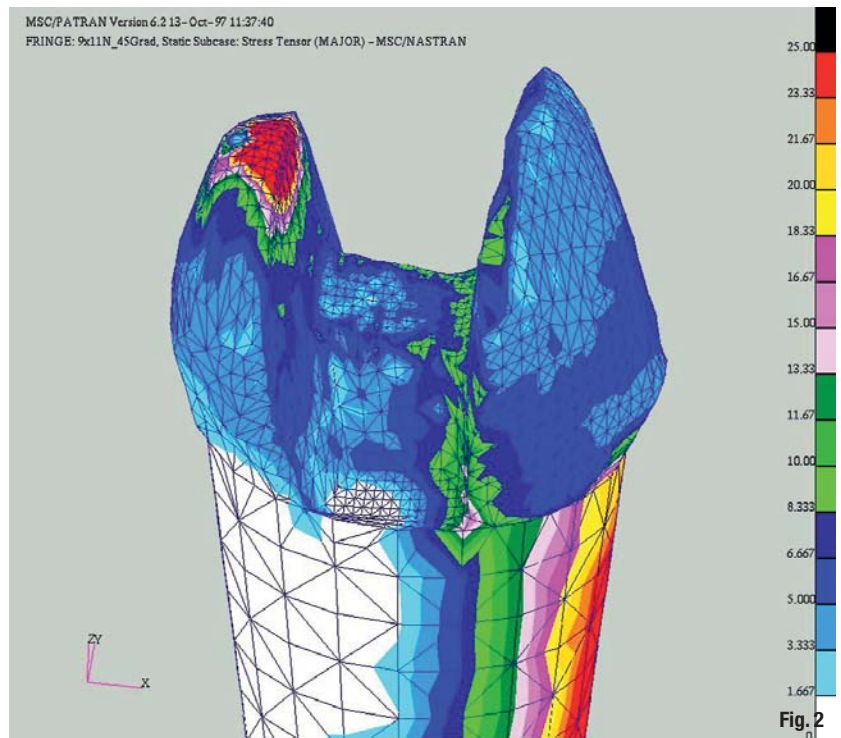
Another recent development is the online transmission of intra-oral and extra-oral digital impressions and restoration design data to external dental laboratories, which then perform the milling tasks. As a result, the dental laboratories are now more closely integrated into the work flow of dental practices.

Clinically proven

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

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

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



to that established by Smales⁴ for cast inlays after 15 years (loss rate: 1.5%). It also compares favourably with the 1.3% annual failure rate established for all-ceramic, non-CAD/CAM ceramic inlays.⁵

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

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

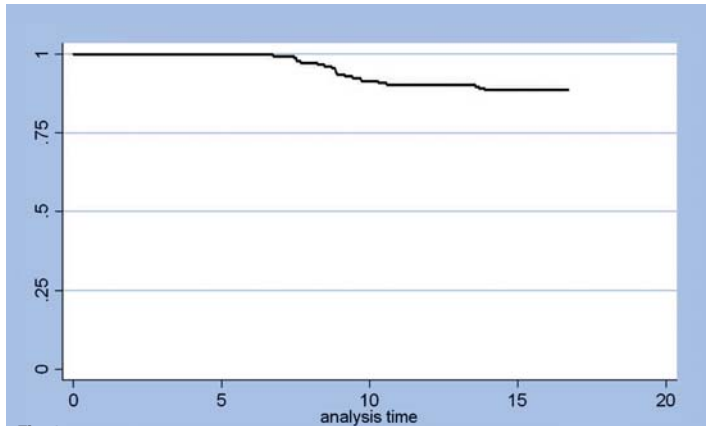


Fig. 3

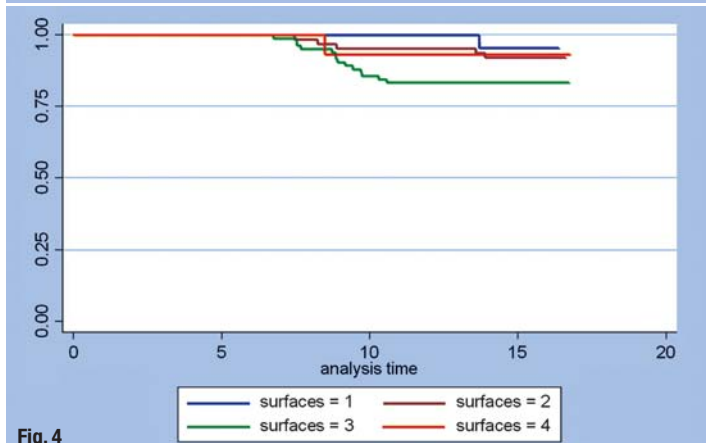


Fig. 4

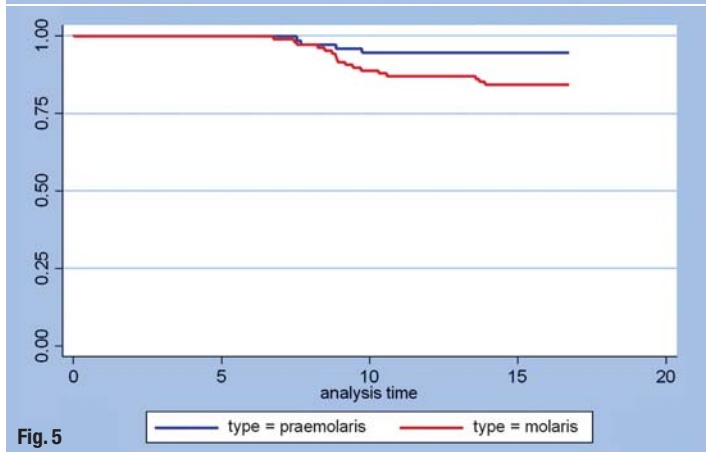


Fig. 5

composite are ignored), the Kaplan–Meier survival rate was 89 % over the observation period. Dental adhesives were not yet available at the beginning of the study. If the patients are separated into two groups (that is, patients treated with and without the use of a dental adhesive), a significant difference is revealed. Without dental adhesive, the survival rate fell to approximately 80 % after 16 years; with dental adhesive, the survival rate was 90 %. The size of the filling did not play a role. Premolars performed better than molars. Vital teeth performed better than non-vital teeth. During the observation period, 122 events occurred. In 86 % of the cases, this resulted in the loss of the restoration. Fractures (39 %) were the most frequent reason for renewal.⁷

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

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

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

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

_CAD/CAM ceramics conform to the gold standard

A further long-term study of the durability of CEREC restorations was published by Dr Bernd Reiss in 2006. In a private dental practice, 1,010 CEREC inlays and onlays were placed in 299 patients. After 15 to 18 years, 84.4 % of these restorations were still clinically perfect (Figs. 6 & 7). Up to the end point of the study (18.3 years), no further events were observed. If the retention of the restoration is seen as the sole criterion for evaluating survival (that is, if therapeutic procedures such as trepanation and subsequent margin corrections with the aid of

Fig. 3 Survival rate (according to Kaplan–Meier) of CEREC inlays and onlays: 88.7% after maximum of 17 years. (Source: Dr Tobias Otto)
Fig. 4 Survival rate of one- to four-surface restorations (no significant difference) after maximum of 17 years. (Source: Dr Tobias Otto)
Fig. 5 Survival rates of restorations on molaris and praemolaris: CEREC restorations on praemolaris display a slightly higher success rate. (Source: Dr Tobias Otto)

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

Biogenic occlusal surfaces

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

The extension of the CEREC indications spectrum to chairside crowns and multiple-unit labside bridges (both temporary and permanent) has placed increased demands on the intra-oral measuring process. The recently introduced CEREC AC system deploys a short-wavelength blue LED light source. In combination with the built-in anti-shake system this blue light source reduces the measurement tolerance to 19 µm in comparison with a stationary reference laser scanner.¹⁶ The preparation is optoelectronically scanned from various angles in the patient's mouth. The individual images are then combined to create complete quadrants (Fig. 9). Inadequate images are automatically detected. With a scan of the antagonists, the digital impression of the partial arch/quadrant is transmitted via a wireless link to the in-house dental laboratory. Alternatively, the data can be sent via the CEREC Connect web portal to an external dental laboratory or to an external milling centre equipped with a stationary



Fig. 6

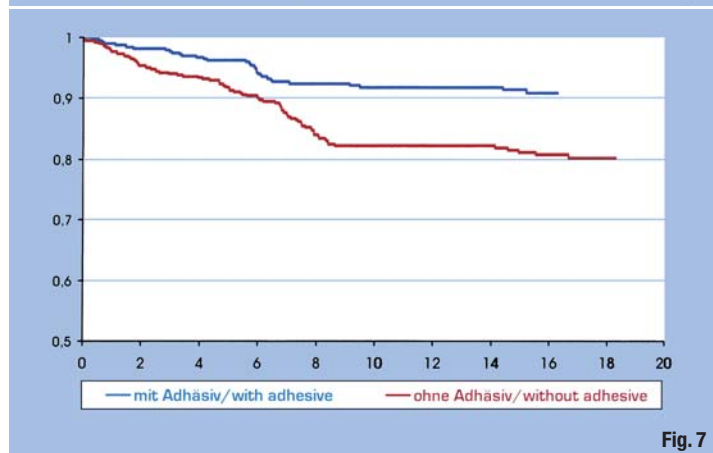


Fig. 7

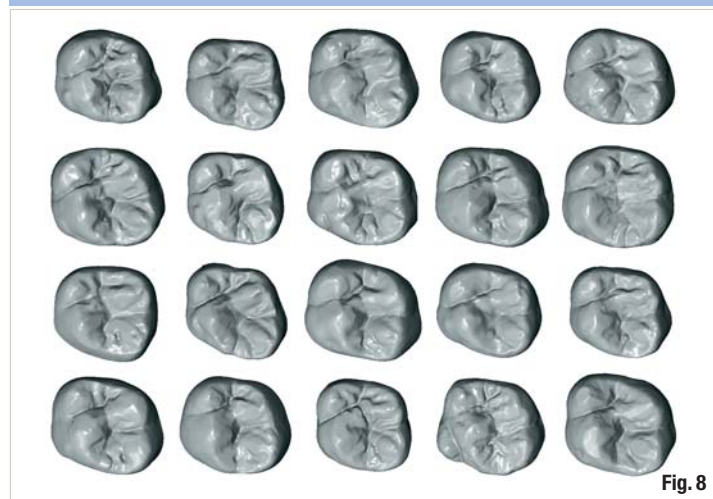


Fig. 8

CAD system. This is followed by the virtual design of the restoration. If required, a 3-D working model can be created using a special stereolithography process (SLA). This model provides the basis for the fine tuning of the CAD/CAM-milled crown or bridge framework.

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

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

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

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

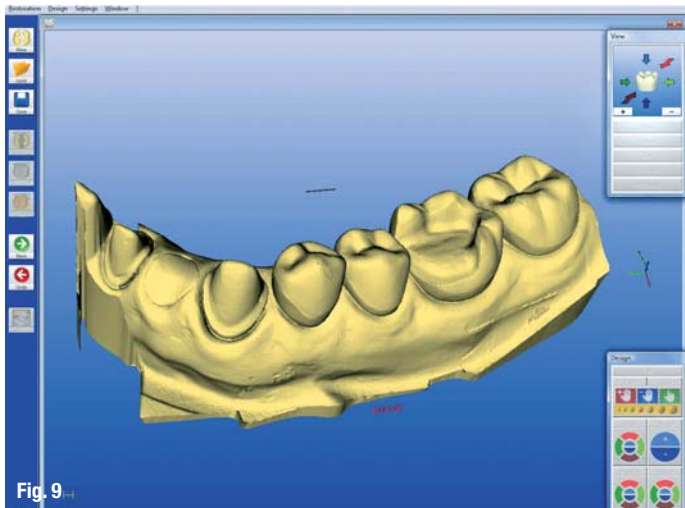


Fig. 9

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

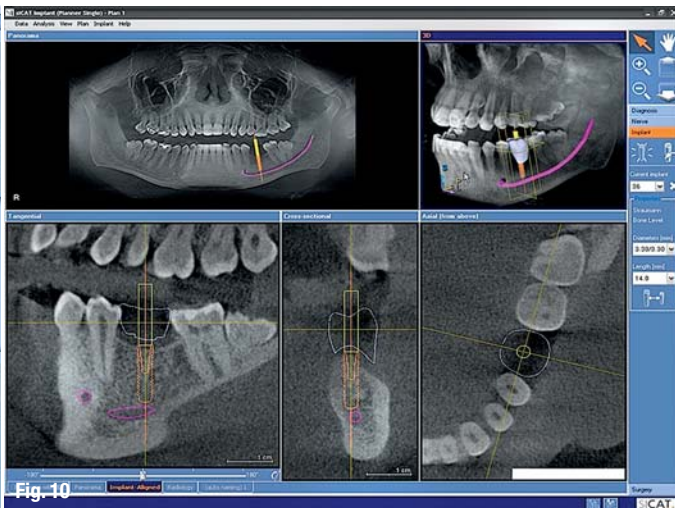


Fig. 10

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

_Implant planning with the help of imaging systems

The integration of the CEREC system and cone-beam volumetric tomography (CBVT) enhances the reliability of implant planning. The low-radiation CBVT system generates a detailed 3-D image of the bone structure. This ensures greater diagnostic accuracy, as well as the precise localisation of the anatomical structures. CBVT thus provides the basis

reported that anatomically sized, adhesively bonded implant molar crowns (VITA Mark II silicate ceramic) with occlusal wall thicknesses of 1.5 mm have performed well in laboratory tests. This applies to crowns placed on titanium abutments and crowns placed on ZrO₂ abutments.¹⁸

_Summary

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

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



Fig. 11

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

for the surgical planning of the implant.¹⁷ The CEREC intra-oral camera is used to scan the implant site and the adjacent teeth. Following this, the software generates a virtual 3-D model, on the basis of which the future implant crown is designed and prosthetic planning conducted. The 3-D model with the implant crown is then superimposed on the 3-D CBVT image. This allows the clinician to position the implant with reference to the planned prosthesis and the available bone structure (Fig. 10).

CEREC is already deployed for the fabrication of implant superstructures. Dr Daniel Wolf et al.

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

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| _contact | cosmetic dentistry |
| <p>Manfred Kern, Wiesbaden, Germany German Society of Computerized Dentistry – International Society of Computerized Dentistry secretariat@dgcz.org www.dgcz.org</p> | |



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Safety and reliability with CAD/CAM technology

Authors _ Hans Geiselhöringer & Dr Stefan Holst, Germany



clinical protocol. Simplicity for the dental technician primarily concerns the time required to design and manufacture a restoration. However, in order to ensure an efficient workflow, a user-friendly software interface and intuitive handling are also of utmost importance.

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

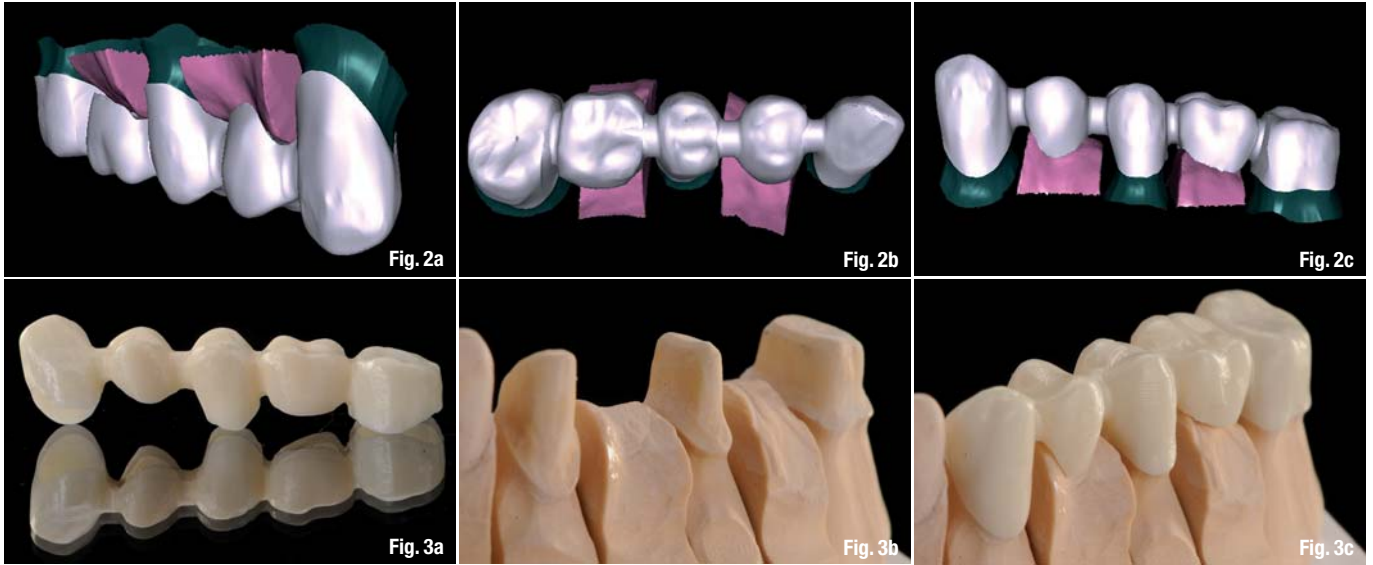
The most eminent facts for the practitioner are that no major changes in clinical protocol are required when working with CAD/CAM technology and industrially manufactured components. Only when it comes to oxide ceramics are slight modifications of preparation design required for long-term success. These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

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

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

_Simplicity in clinical and laboratory routines

A key aspect of the successful application of new technologies and clinical protocols is the time required to adapt to and utilise a system in a daily routine. This aspect is not only of relevance for the dental laboratory in manufacturing a restoration, but also to the practitioner considering changes in



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

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

Safety for the patient

Providing the patient with a reliable and long-term successful restoration is key in today's highly competitive dental market. Product and material quality significantly influence the long-term clinical outcome. From a clinical perspective, important aspects to consider include long-term stability in the oral cavity, bio-compatibility, post-processing options (for example, type of veneering material), reasonably low costs and clinical versatility. While

the aesthetic potential was initially due to using high-strength all-ceramic restorations, the true benefit of Y-TZP/ZrO₂ (yttria-stabilised polycrystalline tetragonal zirconia), for example, is its excellent bio-compatibility paired with flexural strength values that allow for application in any area of the oral cavity for both natural teeth and dental implants. When in close contact with the surrounding tissues, the reduced plaque and bacterial accumulation, as well as the development of currently undefined pseudo-attachments leads to long-term tissue stability around these components (Figs. 6 & 7). This fact makes zirconia products the primary choice not only for non-compromised clinical situations, but also for pre-existing periodontal conditions whenever restorations, such as implant abutments, are in close contact with surrounding tissues.

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

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

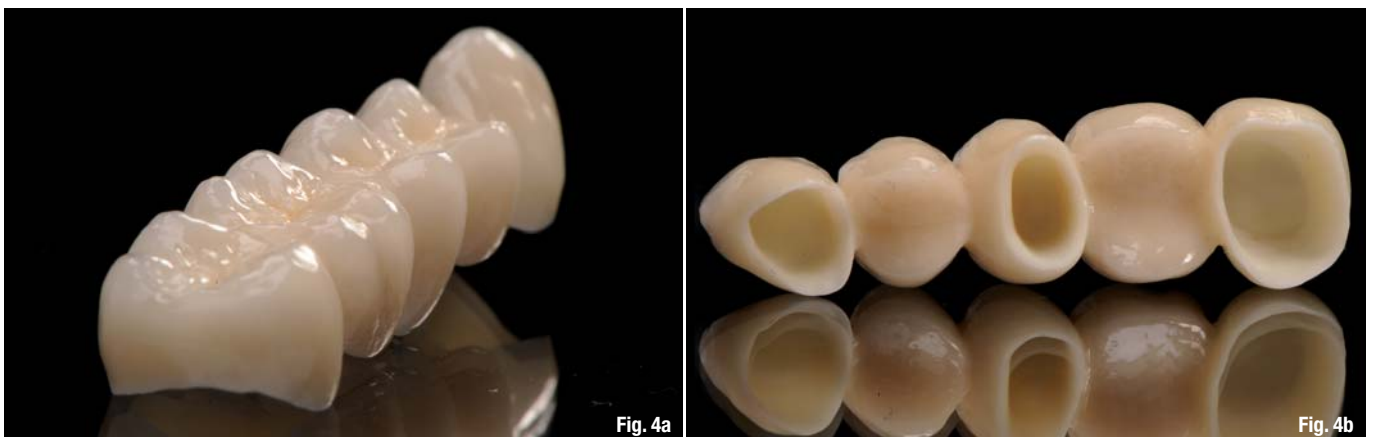




Fig. 5 _Intra-oral lateral and occlusal view of definitive solutions; the clinical benefit of zirconia products is the application of everyday clinical protocols, including cementation with conventional cements.

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

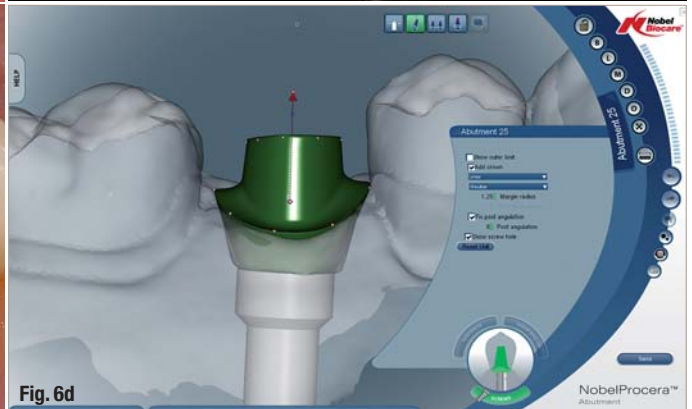
the design and dimensions according to the anticipated final contour of the definitive restoration is achieved in a few minutes instead of taking several hours with conventional fabrication protocols.

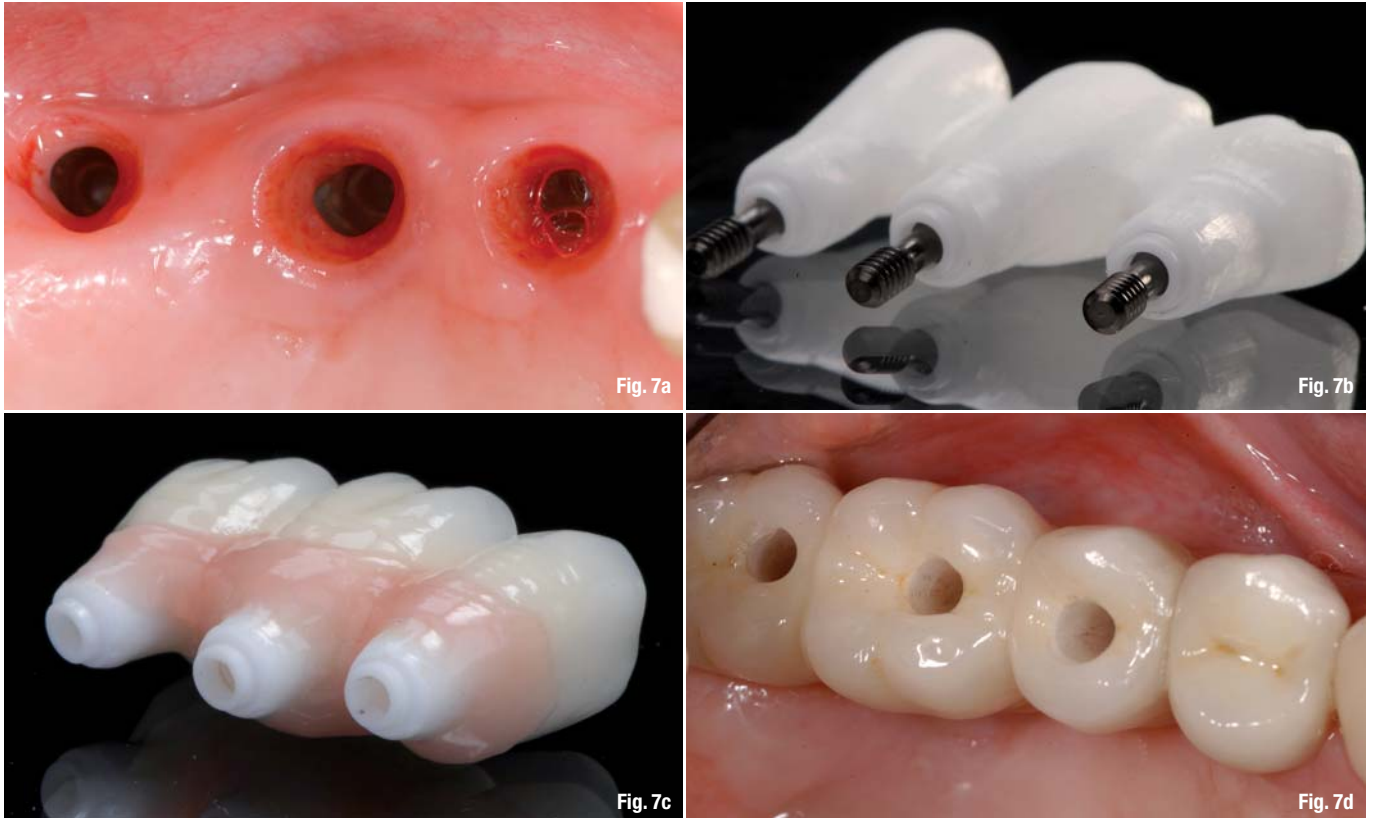
Figs. 6 a-d _Standard clinical protocols apply when restoring natural teeth or dental implants with cement-retained crowns. For long-term success, it is important to position the abutment-crown margin at the level of or slightly below the gingival margin to ensure complete removal of excessive cement.

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

_Cost-efficient solutions for laboratory and patient

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





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

Benefits of a versatile CAD/CAM system

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

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

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

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dentistry

Hans Geiselhöringer

Dental Technician
Dental X Hans Geiselhöringer GmbH & Co. KG
Lachnerstraße 2
80639 Munich, Germany

Dr Stefan Holst

University Clinic Erlangen
Dental Clinic 2 – Department of Prosthodontics
Glückstraße 11
91054 Erlangen, Germany

Smile upgrade— Highly aesthetic composite restorations in the anterior region

Author_ Dr Ronald D. Jackson, USA

Figs. 1 & 2_ Female patient with a prominent white spot on the right central incisor: The influence of the white spot on full face appearance is clearly visible.



Figs. 3 & 4_ This 'appearance lesion' was treated with a conservative IPS Empress Direct restoration, showing that a small treatment can have a significant effect on the overall image. Note that the patient underwent tooth bleaching prior to the placement of the restoration.

_The emphasis on appearance is pervasive in today's media-driven culture. It is particularly keen in adolescents as a result of constant exposure to images of beautiful young celebrities (real or media-created) in magazines, television,

pop music and everywhere on the Web. Because the smile is such a significant factor in facial appearance, the impact of this culture shift on dentistry has been enormous. In particular, young teenagers are seeking out aesthetically oriented dentists and requesting correction of mild to moderate imperfections in teeth that previous generations tolerated because dentistry lacked a simple, predictable aesthetic solution (Figs. 1–4).

_History and diagnosis

A sixteen-year-old female patient presented with the chief complaint of being dissatisfied with the previous dental treatment of her maxillary central incisors. Her dental history revealed that she had large white spot lesions in the incisal one third of each of these teeth, which she said appeared following orthodontic treatment. She had seen a dentist several months earlier, who placed composite resin restorations in both centrals, but she was dissatisfied with the result (Fig. 5). The clinical examination showed these





Fig. 5 Clearly visible white spot lesions.

Fig. 6 An oval diamond was used to create a saucer-shaped preparation of approximately 0.8 mm central depth.

quite visible restorations to be lacking in natural appearance and to have marginal discolouration. Although the shade was close to being correct, the lack of a lifelike appearance was deemed to be the result of using a single opacity of composite resin. The discolouration was likely due to inadequate enamel adhesion at the margins.

Clinical technique

It is important to record the shade quickly at the beginning of treatment to avoid the effects of dehydration. Using the middle third of the lateral incisors as a reference, the shade was determined to be A1. Also observed were mild, dispersed white areas scattered irregularly in all the upper incisors.

The existing composite resin on the right central incisor was removed using an oval diamond

(Fig. 6). No anaesthetic was used. The preparation using this diamond is saucer-shaped with a centre depth of approximately 0.8 mm and tapering to a shallow depth at the margins. The preparation is feathered and scalloped another 1.0 mm beyond the outline of the white lesion (Fig. 7).

The preparation, including enamel beyond the margins, was etched with 37 per cent phosphoric acid for 20 seconds, then washed and dried. Since no dentine was exposed, Heliobond, an enamel-bonding resin without hydrophilic monomers or solvent, was placed and light-cured.

A new, naturally shaded composite resin system (IPS Empress Direct) was selected because of its accurate shades and consistent opacities. As the combination of the dentine and enamel



Fig. 7 The preparation was feathered and scalloped an additional 1 to 1.5 mm beyond the white spot.

Fig. 8 Opaque Dentin shade A1 blocks the visibility of the white spot.

Fig. 9 A1 Enamel was extended to just short of the prepared margin. It occupied approximately two thirds of the remaining depth of the preparation.

Fig. 10 Tetric Color white was placed with a brush.

Fig. 11 The restoration was completed to slight over-contour with a translucent composite resin, Trans 30 (clear).

Fig. 12 Post-op view of the minimally invasive, aesthetic restorations fabricated with the IPS Empress Direct composite resin system.



of the tooth yielded a shade of A1, A1 Dentin- and A1 Enamel-shade composite resins were used to restore the cavity. No recipes or combinations of a darker dentine and lighter enamel were needed.

The A1 Dentin was applied on the white spot area only and occupied about one half the depth of the preparation. Because of the opacity of the dentine composite resin, the white spot was no longer visible (Fig. 8). After curing, the A1 Enamel was applied. This increment of material occupied approximately two thirds of the remaining depth of the preparation and was extended to just short of the prepared margins. Before light curing, multiple grooves and surface irregularities were sculpted with a thin, bladed instrument (Fig. 9). A small amount of Tetric Color white was then placed with a brush and light-cured (Fig. 10).

Depth and natural-looking aesthetics were achieved by the application of translucent composite resin (Trans 30), which completes the restoration to slight over-contour. This layer extended beyond the prepared margins (Fig. 11). Finishing and polishing were accomplished using aluminium oxide discs and the Astropol System. The patient was pleased with the result (Fig. 12).

Conclusion

Today's patients want their dentistry to be more aesthetic but less invasive. Directly placed composite resin accomplishes both. Further, there is no question that the emphasis on appearance and, in particular, the smile, has raised the aesthetic standard in dentistry. Good enough is no longer good enough. Manufacturers have met this challenge by creating materials that better mimic tooth structure. The challenge for dentists is to learn the skills to use them in order to satisfy the desires of today's discerning patients.

Fortunately, this challenge is made much easier when using the naturally shaded composite resin system IPS Empress Direct. The broad range of shades (which are true to the shade guide), the three opacities (Dentin, Enamel and Translucent), each accurate in a narrow range, combined with excellent handling and ease of polish significantly shorten the learning curve. In addition, the new opalescent shade allows an easier and more accurate creation of the effect seen in bleached teeth.

Finally, the joy of creation is enhanced further for dentists when the results are evident to patients. In addition to gratitude, patients express admiration of clinicians' artistic skills.

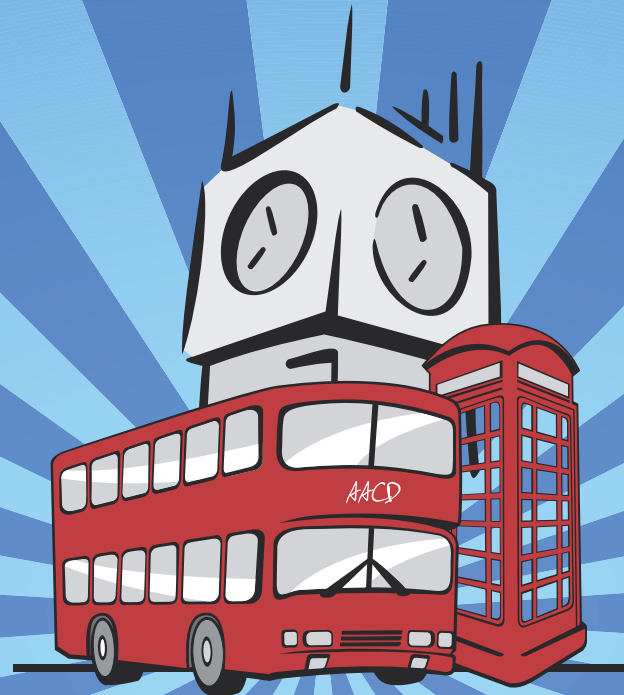
about the author

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Dr Ron Jackson has published many articles on aesthetic and adhesive dentistry and has lectured extensively across the United States and abroad. He has presented at all the major US scientific conferences. Dr Jackson is a fellow in the American Academy of Cosmetic Dentistry, a fellow in the Academy of General Dentistry and is director of the Advanced Adhesive Aesthetic Dentistry and Anterior Direct Resin programmes at the Las Vegas Institute for Advanced Dental Studies. He maintains a private practice in Middleburg, VA, USA, emphasising on comprehensive restorative and cosmetic dentistry.

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c.salwiczek@dental-tribune.com

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Torsten R. Oemus
t.oemus@dental-tribune.com

Editor-in-Chief

Dr Sushil Koirala
skoirala@wlink.com.np

Co-Editor-in-Chief

Dr So-Ran Kwon
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Managing Editor

Claudia Salwiczek
c.salwiczek@dental-tribune.com

Product Manager

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b.moldenhauer@dental-tribune.com

Executive Producer

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g.meyer@dental-tribune.com

Designer

Franziska Dachsel
f.dachsel@dental-tribune.com

Copy Editors

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International Administration

President/CEO

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Executive Vice President

Finance
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h.estrada@dtamerica.com

International Offices

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Dental Tribune International GmbH
Contact: Nadine Parczyk
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Dr Vijayaratnam Vijayakumaran, Sri Lanka

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AT THE GNYDM NOVEMBER 29 - DECEMBER 2, 2009

The DTSC Symposia at the Greater New York Dental Meeting offer an inspiring schedule of continuing education lectures in various dental disciplines. Each scientific lecture will provide an invaluable opportunity to learn diverse aspects of dentistry and how to integrate a variety of treatment options into your practice.

We have developed a course schedule that is both diverse and engaging, and which also offers you the opportunity to earn C.E. credits. The symposia sessions are FREE for all Greater N. Y. Dental Meeting visitors, but pre-registration is recommended to ensure preferred seating.

| SUNDAY NOVEMBER 29 | MONDAY NOVEMBER 30 | TUESDAY DECEMBER 1 | WEDNESDAY DECEMBER 2 |
|---|---|---|--|
| <p>10:00 - 11:00 am ONE-STEP ADHESION, ONE-STEP CEMENTATION Dr. George Freedman DDS</p> <p>11:30 - 12:30 pm HIGH RESOLUTION CONE BEAM WITH PREXION 3D Dr. Dan McEowen DDS</p> <p>1:30 - 2:30 pm SIMPLIFY ESTHETIC DENTISTRY Dr. Steven Weinberg DDS</p> <p>3:00 - 4:00 pm THE BEAUTY OF +BONDING Dr. Howard Glazer DDS</p> <p>4:15 - 5:15 pm NEW DISCUSSION: RISK OF CORONARY HEART DISEASE IN ASSOCIATION WITH PERIODONTITIS AND PERIMPLANTITIS Dr. Hans Dieter John, Dr. Richard Meissen and D.R. Gieselmann</p> | <p>10:00 - 11:00 am E4D SKY: DENTISTRY'S DESTINATION Dr. Gary Severance DDS and Lee Culp CDT</p> <p>11:30 - 12:30 pm KNOW YOUR PRODUCTS & TOOLS FOR TODAY'S HEALING DENTISTRY Dr. Fay Goldstep DDS</p> <p>1:30 - 2:30 pm ORAVERSE™ - IN PRACTICE Dr. Steven Glassman DDS</p> <p>3:00 - 4:00 pm THE ADVANTAGE OF SMALL FOV HIGH RESOLUTION CBCT IMAGING Dr. Dan McEowen DDS</p> <p>4:15 - 5:15 pm NEW DISCUSSION: RISK OF CORONARY HEART DISEASE IN ASSOCIATION WITH PERIODONTITIS AND PERIMPLANTITIS Dr. Hans Dieter John, Dr. Richard Meissen and D.R. Gieselmann</p> | <p>10:00 - 11:00 am TECHNOLOGICAL RESOURCES AND BIOLOGICAL CONCEPTS IN MINIMALLY INVASIVE ENDODONTICS Dr. Renato Leonardo DDS</p> <p>11:30 - 12:30 pm THE AFFORDABLE SOFT TISSUE DIODE LASERS Dr. George Freedman DDS</p> <p>1:30 - 2:30 pm ESTHETICS USING COSMETIC PERIODONTAL SURGERY Dr. David Hoexter DMD</p> <p>3:00 - 4:00 pm YOU'VE TAKEN IMPLANT TRAINING ...WHAT DO YOU DO NEXT? Lynn Mortilla, RDH</p> | <p>10:00 - 11:00 am ICON - INNOVATIVE CARIES TREATMENT WITHOUT DRILLING Dr. George Freedman DDS</p> <p>11:30 - 12:30 pm IMMEDIATE TOOTH REPLACEMENT IN THE ESTHETIC ZONE Dr. Barry Levin DDS</p> <p>1:30 - 2:30 pm MORE THAN JUST TEETH AND GUMS Dr. Ron Schefdore DDS</p> <p>3:00 - 4:00 pm MY FIRST ESTHETIC IMPLANT CASE - WHY, HOW, & WHEN? Dr. Marius Steigmann DDS</p> |

FREE FOR REGISTERED GNYDM ATTENDEES, BUT PRE-REGISTRATION IS RECOMMENDED.
 Register now for the GNYDM under www.gnydm.com and find full program details under www.DTStudyClub.com.



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For more information, please contact **Julia E. Wehkamp**, C.E. Director, Dental Tribune Study Club
 Phone: (416) 907-9836, Fax: (212) 244-7185, E-mail: j.wehkamp@DTStudyClub.com

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