issn 1616-7890

Vol. 5 • Issue 2/2011

cosmetic dentistry _ beauty & science

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MICD
Computer-guided occlusal force management

research
Investigation of enamel following bleaching

industry report
Compobond: Evolution of a new restorative dental material

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Dear Reader,

Dr Sushil Koirala
Editor-in-Chief

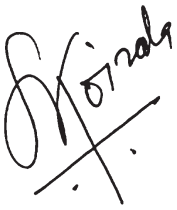
_Welcome to this year's second issue of cosmetic **dentistry**! I hope you enjoyed our first issue. All editions of cosmetic **dentistry** are available online at www.dental-tribune.com at no charge.

With the rapid development of global information technology, knowledge has become much more accessible to everyone keen to acquire it. Online continuing education (CE) programmes are quite popular now in most countries, as it is an easy-to-access and affordable mode for CE. Global online CE programmes are gaining popularity amongst young generations. However, CE accreditation systems have yet to become mandatory in most Asian countries. There are various online CE models, including text lectures, slide shows, recorded movies and live web seminars—webinars. Online study clubs, such as the Dental Tribune Study Club (www.dtstudyclub.com), and forums are very popular for sharing knowledge and skills in dentistry.

In February 2011, I travelled to Chicago to participate in the International Federation of Esthetic Dentistry (IFED) general assembly and executive council meeting. I am pleased to announce here that the general assembly unanimously passed the resolution of the executive committee to start a free e-learning system through the IFED website (www.ifed.org). Furthermore, I was nominated as project coordinator. Once the project has been completed, I believe it will help many young professionals to acquire quality aesthetic dentistry education free of charge. As the coordinator, I am now working at developing professional links amongst various aesthetics magazines and journals around the world, and am seeking quality articles/clinical cases from authors and clinicians for our e-learning section. I invite all of you to share your knowledge and skills for better patient care around the world.

For this issue of cosmetic **dentistry**, we have selected various clinical articles for you and hope they will help to advance your clinical excellence. Enjoy!

Yours faithfully,



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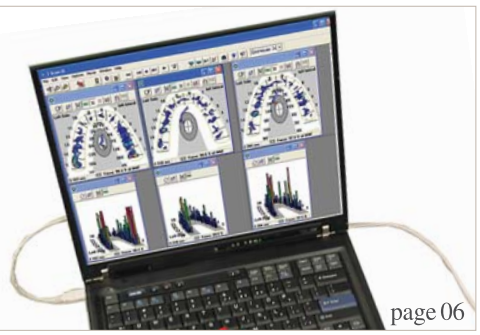
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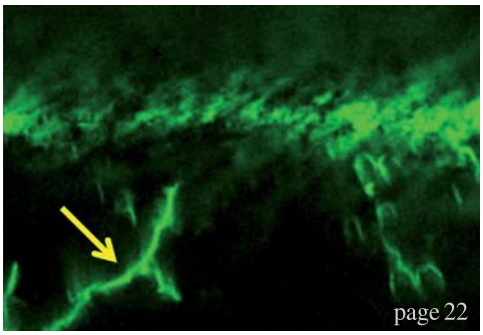
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Cover image courtesy of Leonid and Anna Dedukh.


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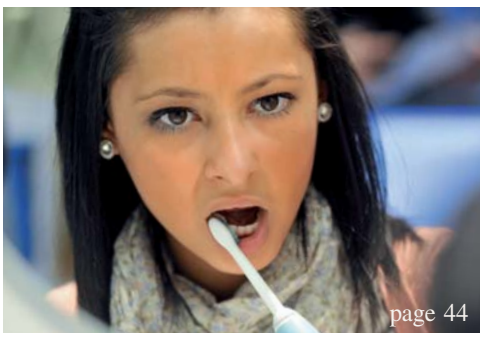
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SUNDAY, NOVEMBER 27

10:00 - 11:00 DR. HOWARD GLAZER
GIOMERS: NEW GIANTS OF MI DENTISTRY

11:15 - 12:15 DR. SHAMSHUDIN KHERANI
COMPREHENSIVE DENTISTRY USING DIGITAL IMPRESSION TECHNOLOGY

12:45 - 1:45 DR. RON KAMINER
MINIMALLY INVASIVE DENTISTRY: TIPS AND TRICKS TO MAXIMIZE SUCCESS

2:00 - 3:00 DR. LOUIS MALCMACHER
THE HOTTEST TOPICS IN DENTISTRY

3:15 - 4:15 TBA
TECHNOLOGY TO IMPROVE YOUR CARIES MANAGEMENT

4:30 - 5:30 DR. GEORGE FREEDMAN
EVOLVING CONSERVATIVE RESTORATIONS

MONDAY, NOVEMBER 28

10:00 - 11:00 DR. FAY GOLDSTEP
WHAT PATIENTS WANT... WHAT DENTISTS WANT: EASY, HEALTHY DENTISTRY!

11:15 - 12:15 DR. SHAMSHUDIN KHERANI
LASER DENTISTRY OVERVIEW WITH AN UPDATE ON CLOSED FLAP OSSEOUS

12:45 - 1:45 DR. LARRY EMMOTT
REMEMBER WHEN "E" WAS JUST A LETTER? USE E-SERVICES TO IMPROVE PATIENT CARE AND INCREASE PROFITABILITY

2:00 - 3:00 DR. GEORGE FREEDMAN AND DR. FAY GOLDSTEP
DIODE LASERS AND RESTORATIVE DENTISTRY

3:15 - 4:15 DR. DAMIEN MULVANY
WHY VIEW YOUR 3D PATIENTS WITH 2D IMAGES? A COMMON SENSE APPROACH TO 3D IMAGING IN THE GENERAL PRACTICE

4:30 - 5:30 DR. MARTY JABLOW
UNDERSTANDING THE ADVANCES IN SELF-ADHESIVE TECHNLOGY AND HOW TO INCORPORATE THEM INTO YOUR RESTORATIVE PRACTICE

TUESDAY, NOVEMBER 29

12:45 - 1:45 DR. GEORGE FREEDMAN AND DR. FAY GOLDSTEP
THE DIODE LASER: THE ESSENTIAL SOFT TISSUE HANDPIECE

WEDNESDAY, NOVEMBER 30

11:20 - 12:20 DR. GEORGE FREEDMAN AND DR. PAT ROETZER
CEMENTING ALUMINA AND ZIRCONIA RESTORATIONS

12:30 - 5:00 **OSSEO SUMMIT**
DR. DAVID HOEXTER,
ALONG WITH VARIOUS IMPLANT EXPERTS
THE 2ND ANNUAL OSSEO UNIVERSITY SUMMIT: REVOLUTIONARY IMPLANT DESIGN UNVEILED

THIS PROGRAM IS SUBJECT TO CHANGE

Healthy and harmonised function via computer-guided occlusal force management

Author_ Dr Robert Kerstein, USA

Fig. 1a_A smile defect of discoloured teeth and presence of a diastema.
Fig. 1b_Four anterior veneers placed to improve smile defects.

Fig. 2_Smile Design Wheel that incorporates patient psychology, health, function and aesthetics.

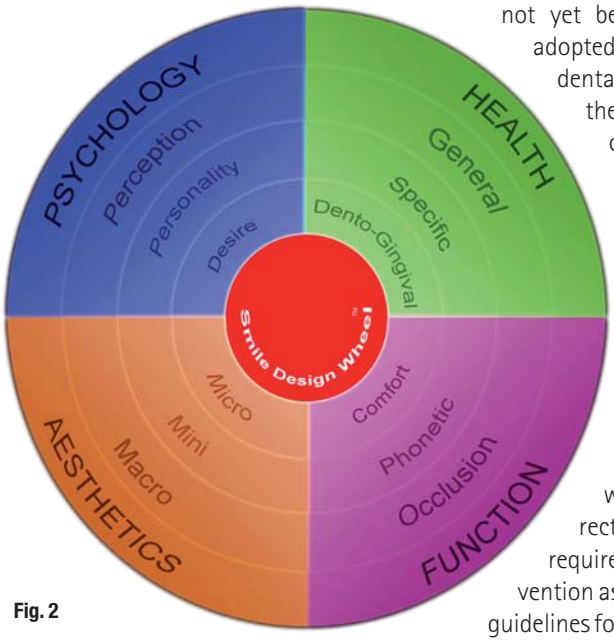


Fig. 2

_The minimally invasive (MI) concept was initially introduced in physical medicine and adopted into dental medicine in the early 1970s with the application of diamine silver fluoride to teeth.[1] This was followed by the development of preventive resin restorations (sealants) in the 1980s[2] and the atraumatic restorative treatment (ART) approach[3] with Carisolv (MediTeam) in the 1990s.[4] Since its inception, the focus of MI dentistry has been caries detection and treatment.[5] It has not yet been comprehensively adopted in other fields of dental medicine; however, the comprehensive concept of minimally invasive cosmetic dentistry (MICD) and its treatment protocol were introduced in 2009 with the basic aim of a clinician effecting optimum clinical therapeutic improvements in smile enhancement, while performing corrective procedures that require as little clinical intervention as possible.[6] Additional guidelines for MICD treatment are:

_the adoption of the "Do No Harm" philosophy to maximise possible preservation of healthy oral tissues;
_the proper selection of appropriate dental materials;
_the use of supportive procedure methodologies that offer clinicians an "evidence-based" treatment approach that will reliably improve treatment outcomes.

With respect to smile design, the intervention level of a selected MICD treatment will depend on the types of smile defects present, combined with the subjective perception of the patient's own pre-treatment smile condition (Figs. 1a & b). Some of the more common smile defects are:

_presence of diastemas;
_discoloured teeth;
_worn and flattened incisal edge contours;
_missing teeth;
_rotated and misaligned teeth;
_teeth internally stained by fluoride or through childhood disease;
_gingival absence, leading to visible "black triangles";
_uneven crestal gingival heights;
_maxillary and/or gingival excesses resulting from altered passive eruption;


Fig. 3

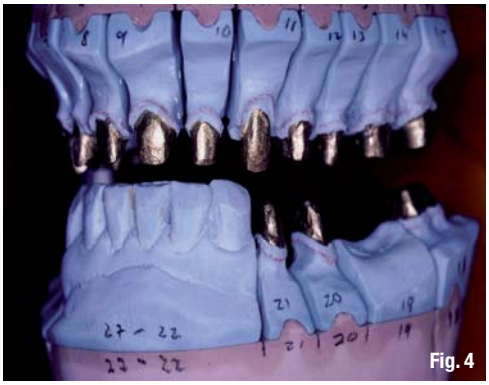


Fig. 4

Fig. 3_Veneer preparations conserve tooth structure compared with full coverage crowns.
Fig. 4_Articulated casts require remounting to ensure minimal spatial distortions at case delivery.

_malocclusion according to Angle's classification; and
_reverse smile curve.

Contemporary aesthetic dentistry can correct most of these defects utilising a simple, comprehensive, MI approach that places equal emphasis on patient psychology, health, function and aesthetics. Each of these aspects of treatment consideration can be best analysed using the decision-making system of the Smile Design Wheel, which includes each individual aspect as a continuum (Fig. 2).[6]

_Smile design with all-ceramic, partial coverage restorations

All-ceramic, partial coverage adhesive restoration (porcelain veneers, inlays and onlays) is considered one of the MI treatment options in MICD treatment as opposed to placing complete coverage restorations (full crowns) that require significantly more tooth preparation. In certain situations, no-preparation veneers may be placed but only if the final aesthetics will not be compromised by the added thickness of the labio-lingual restorative material that a no-preparation veneer creates.

Adhesive restorations conserve tooth structure because less tooth preparation is required for mechanical retention of the restoration when porcelain-enamel adhesion is employed (Fig. 3). Less mechanical retention preparation is required to stabilise a bonded porcelain restoration in comparison with a non-bonded restoration. The chemical adhesion between etched porcelain and etched enamel provides increased retention. Less tooth preparation can minimise untoward pulpal responses that frequently result when a vital tooth is prepared for full coverage.

Another significant patient benefit of employing adhesive restorations is that treatment time is usually shortened to only two visits:

_first visit: partial coverage preparation, provisionalisation that incorporates the desired smile design improvements, and one inter-occlusal registration;
_second visit: porcelain try-in, enamel adhesion, occlusal adjustments and case finishing.

During the second visit, the clinician cannot perform any insertion occlusal adjustments prior to bonding these very brittle restorations in place, as they cannot safely withstand any occlusal alterations without introducing the possibility of restoration fracture.

_Shortened treatment times can introduce occlusal errors

However beneficial these short treatment times may be for the patient, they may have two potentially problematic post-insertion results:


Fig. 5


Fig. 6a


Fig. 6b

Fig. 5_Articulating paper markings do not measure occlusal force by paper mark appearance, regardless of their depth of colour, mark size or shape. Paper markings cannot determine tooth contact timing sequences either.
Fig. 6a_T-Scan III recording handle with USB connection.
Fig. 6b_T-Scan III desktop.

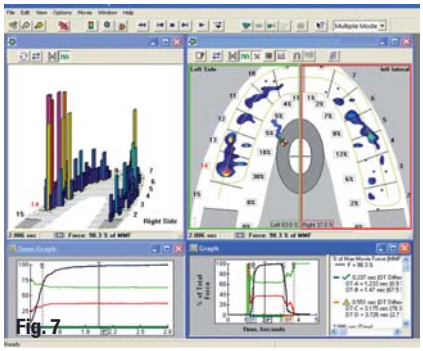


Fig. 7

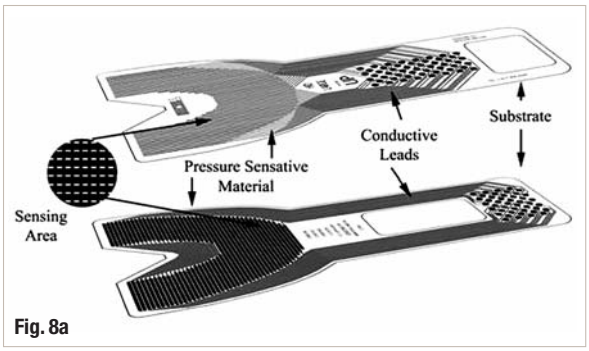


Fig. 8a


Fig. 8b

Fig. 7_T-Scan III graphical display illustrates excessive occlusal force in colour for simplified analyses by the clinician.
Fig. 8a_T-Scan III sensor schematic.
Fig. 8b_T-Scan III high definition recording sensor.

_patient discomfort owing to difficult occlusion initially post-insertion;
_potentially shortened restoration lifespan.

These sequelae result from the lack of repeated inter-occlusal remounts, which conventional prosthodontic cases commonly undergo. Remounting at metal try-in, porcelain bisque try-in and possibly once more prior to prosthesis installation greatly improves the accuracy of the true maxillo-mandibular, inter-arch spatial relationships (Fig. 4). This reduces the number of occlusal adjustments required at insertion, thereby preserving restorative material thickness and restoration strength.

Adhesive restorations are almost incapable of being reliably remounted. Because of the minimal preparation configuration of partial coverage, non-bonded, all-ceramic restorations, they are unstable on their supporting teeth. Mousses, waxes, silicone putty, injected impression materials and impression tray seating can all easily dislodge the non-bonded restorations from their supporting teeth when taking inter-occlusal records. The movement of non-bonded restorations can also occur during a "pick-up" or transfer impression. The instability of non-bonded restorations complicates all aspects of any remounting procedure greatly.

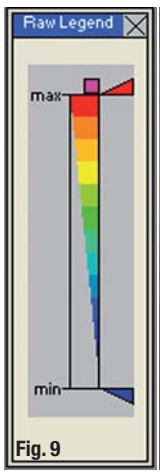


Fig. 9


Fig. 10

Fig. 9_Legend of colour-coded occlusal force data.
Fig. 10_Doughnut-shaped paper mark supposedly indicates high force.

Without the series of laboratory remounts that a cemented prosthesis often undergoes, the all-ceramic restoration is susceptible to significant spatial misalignment and excessive occlusal force that can go undetected clinically until after the insertion has been started. This lack of proper detection of the location of problematic force is worsened by the fact that articulating paper markings do not measure the occlusal forces or the occlusal contact timing sequence in any quantifiable way, regardless of the false and often-advocated paper marking beliefs (Fig. 5).[7–16]

Poor maxillo-mandibular spatial relationships and occlusal force detection can be reliably overcome when an MI clinician employs computer-guided occlusal analysis technology at restoration insertion (T-Scan III, Tekscan; Figs. 6a & b). When properly used after the completion of bonding procedures, this digital occlusal technology helps to locate regions of excessive occlusal force accurately within the occlusal surfaces and incisal edges of the newly placed restorations. The clinical reduction of these excessive forces leads to easier post-insertion acceptance of the new occlusion and increases the restoration's lifespan.

_Computer-guided occlusal analysis system

The T-Scan III Computerized Occlusal Analysis System offers precision technology that analyses occlusal contact force and time sequences in 0.003-second increments and graphically displays them in movie form.[17,18] The system simplifies occlusal adjustments at aesthetic prosthesis insertion, as it quickly isolates excessive force concentrations and time-premature contacts, so their eradication is predictable and effective (Fig. 7). The preservation and longevity of ceramic restorations are enhanced, as any potentially destructive occlusal forces are isolated at delivery, and then removed prior to the patient's long-term use of the new smile design prosthesis.

The occlusal force and time-sequence data are relayed to a PC through a high-definition recording sensor that measures contact-varying relative force sequentially as differing tooth contacts interact at the occlusal surfaces (Figs. 8a & b). During a turbo-mode recording, the sensor is scanned 3,000 times per second, resulting in a dynamic movie of changing occlusal forces that can be incrementally viewed in a slow-motion playback.


Fig. 11a


Fig. 11b

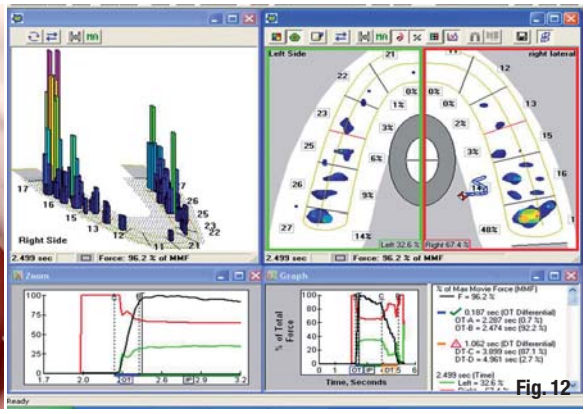


Fig. 12

This dynamic playback separates all the force variances into their contact order, while simultaneously grading their relative occlusal force, so that a clinician can observe them for diagnosis and possible treatment. In two or three dimensions, the contact timing sequence can be played forwards or backwards continuously or in 0.003-second increments, to reveal an occlusal "movie" that describes the occlusal condition.[19] In the 3-D playback view, the force columns change both their height and colour designation. In the 2-D contour view, the colour-coded force concentration zones alter size, shape and colour as the occlusal forces change (Fig. 7). Warmer colours indicate forceful contacts, while darker colours indicate lower force contacts (Fig. 9).

_Limitations of articulating paper markings

Clinicians routinely employ articulating paper to visualise the presence of occlusal contacts, their force and their time simultaneity. They determine whether contacts are forceful by subjective judgement of the paper markings for their supposed force content.

In dental medicine, it is strongly advocated and strongly believed by many clinicians that the characteristics of the paper markings indicate occlusal forces.[10,12–16] The appearance characteristics of the paper markings are based upon:

a) the size of the mark: large marks supposedly indicate higher forces; small, light markings indicate lesser forces;
b) the relative colour depth and intensity of the ink mark: the darker the mark and/or its colour intensity, the higher the force content; the lighter the mark, the less force content present;
c) the presence of doughnut and halo shape(s): these shapes indicate that the contact is forceful because these contacts do not have ink in the middle (Fig. 10).

Despite the persistence of the "clinical beliefs" listed above, there is no published scientific evidence that supports that these appearance characteristics actually indicate the relative force of occlusal contact.[7–11] Studies on articulating paper markings demonstrate consistently that occlusal forces cannot be reliably determined based upon their size or colour. Additionally, paper markings have never been shown in any study to be able to describe contact-timing sequences.[7–11]

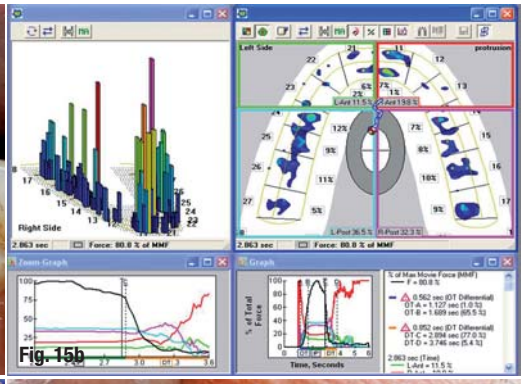
Figure 11a clearly illustrates the limitations of the articulating paper in describing force and that

Fig. 11a_Upper first molar with three large paper marks and upper second molar with mesial scratchy paper markings.
Fig. 11b_Opposing lower molars with large black paper marks on first molar and small, light marks on the second molar.
Fig. 12_T-Scan III data of upper right first and second molar occlusal forces.

Fig. 13_Pre-op fractured veneers.
Fig. 14_Replacement of broken veneers completed with six new veneers.


Fig. 13


Fig. 14



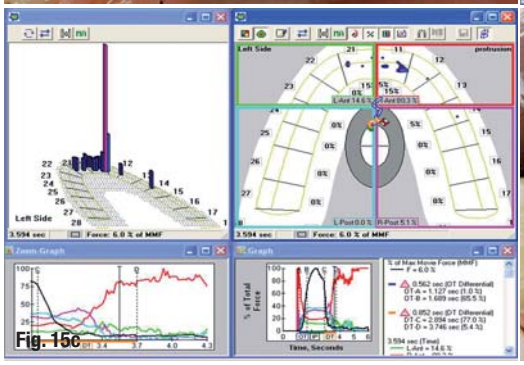


Fig. 15a_Paper markings of protrusive movement pre-treatment.
Fig. 15b_T-Scan data of early protrusion.
Fig. 15c_High force on distal incisal region #11.
Fig. 16_Mid-treatment paper markings of protrusive movement.

the clinical belief that the appearance of paper markings can indicate forceful contacts is flawed. Three large marks are present on tooth #16 and small scratchy marks on the mesial of tooth #17. Note the lightly exposed dentine on tooth #17, where the scratchy red marks are located. Visual inspection of the dark marks on tooth #16 is believed to indicate that high force contacts are present there. The clinician has been indoctrinated to believe that this is the case. Figure 11b shows the counter-arch paper marks with large black marks on tooth #46 and lighter marks on tooth #47.

The T-Scan data shows that the small contacts present on the mesial aspect of tooth #17 are actually a region of extreme occlusal force and the neighbouring three large dark marks on tooth #3 are actually three regions of very low occlusal force (Fig. 12). Notice that tooth #17 makes up 48 % of the patient's right arch, half of the total occlusal forces. This explains why there is visible exposed dentine. Years of unseen occlusal overload on this tooth (and the opposing tooth #47) have worn the enamel, whereas tooth #16 with its very big, dark marks has intact enamel.

Compared with the results of the T-Scan III, it becomes clear that the characteristics of paper markings do not in any way describe the occlusal forces. Computer-guided occlusal analysis illustrates the true nature of the occlusal contact force patterns. This offers clinical insight about the degree of occlusal force demonstrated by articulating paper markings.

Lastly, had the advocated "beliefs" about the characteristics of paper markings been used as a guide for the clinician who, in this case, was attempting to make decisions regarding occlusal adjustment to control force, the clinician would have clearly chosen the wrong teeth to adjust, despite seeking to diminish the occlusal overload. This example illustrates that clinicians' eyes and the articulating paper markings do not illustrate occlusal forces reliably. Computer-guided occlusal analysis clarifies which articulating paper markings should be treated so that the operator makes appropriate treatment decisions as to which tooth contacts truly require force lessening.

Therefore, T-Scan III technology represents the *essence of MI dentistry* with respect to dental occlusion. A clinician treats only what needs to be treated and should not perform random occlusal adjustments judged with the naked eye according to paper markings. This method of judging force is so prone to error that it will always have more invasive results than when properly performed computer-guided occlusal adjustment is employed.

_Computer-guided occlusal analysis for a case of six anterior veneers

Improved force and timing of all tooth contacts, both static and functional, can be precisely adjusted when corrections to the paper labelling are guided by computer analysis. The following case illustrates the utilisation of computer-guided occlusal analysis to refine the protrusive movement on six anterior veneers.

A 21-year-old female patient presented for replacement of six anterior veneers owing to visible material fractures (Fig. 13). The old veneers were removed, the teeth were slightly re-prepared, and six new Empress II veneers (Ivoclar Vivadent) were placed (Fig. 14).

After the veneers had been cured and the excess bonding material trimmed, gross occlusal adjustments were performed to return the patient to the pre-treatment vertical dimension of occlusion. Although the lingual veneer margins were

incisal to the original vertical stops on the anterior teeth, some excess bonding cement required removal to maintain the vertical dimension.

Next, protrusion and laterotrusive excursions were analysed with the T-Scan III system to determine whether extreme forces were present at the incisal edges or on the lingual functional inclines of the veneers. The maxillary anterior lingual surfaces provide tooth-borne ramps for the lower anterior teeth to glide over during mandibular excursions. Controlling any extreme forces on the lingual veneer ramps will aid in ceramic material longevity.


Fig. 17a

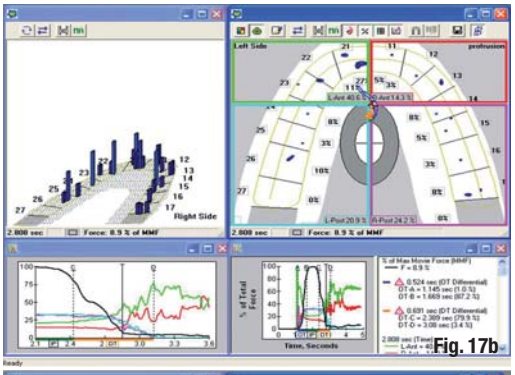


Fig. 17b

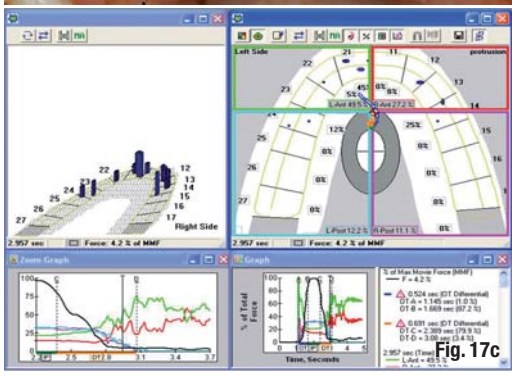


Fig. 17c

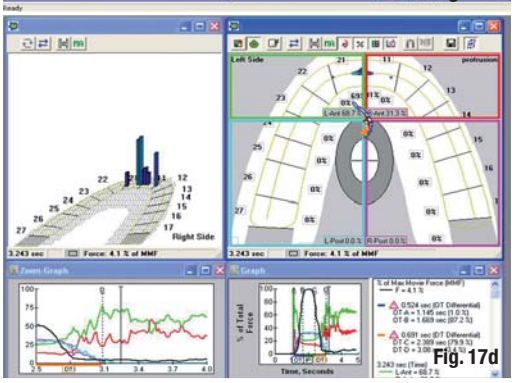


Fig. 17d

Fig. 17a_End of treatment paper markings of protrusive movement.
Fig. 17b_Corrected post-op early protrusion.
Fig. 17c_Corrected post-op mid-protrusion.
Fig. 17d_Corrected post-op end protrusion.

Dynamic excursive functions are recorded by instructing the patient to occlude through the T-Scan III sensor into his/her maximum inter-cuspal position (MIP), holding the teeth together for one to two seconds, then commencing an excursive movement across the guiding teeth.[20–22] Right–left and protrusive excursions can be recorded for force analysis. Only the protrusive excursion will be discussed here. Figure 15a illustrates the first articulating paper labelling of the protrusive movement made as the mandibular incisors leave the MIP and travel towards the incisal edge. Note that there is a dark long protrusive track line on the distal-incisal aspect of tooth #12, a shorter line on the distal of tooth #11 and a horizontal line on the incisal edge of tooth #11. Despite the appearance of these ink representations, the paper labelling offers no indication as to whether any high force region even exists.

Figures 15b and c describe the movement as recorded by the T-Scan III. As the excursion progresses after the patient leaves the MIP position (Fig. 15b) and transitions onto the anterior teeth, tooth #11 becomes very forceful near the incisal edge (tall pink force column) as the protrusive movement advances to include only the incisors (Fig. 15c). If left untreated, possible fracture of the distal incisal edge of this veneer could result from the extreme force applied each time the mandible protrudes.

To correct this excessive protrusive force, adjustments guided by the recorded force data were employed. The disto-incisal paper track line was occlusally adjusted with a medium coarse diamond bur with water spray. Following this first adjustment sequence, a new recording was made to ascertain new force and time changes resultant from the previous adjustment. These new force and time aberrations were isolated, labelled and adjusted. This was repeated until no extreme occlusal forces were present throughout the duration of the protrusive excursion and moderate to low forces were shared between the guiding inclines and incisal edges.

Figures 16 and 17a show the mid-treatment and final articulating paper markings of protrusive movement. Note that in Figures 15a, 16 and 17a, the paper markings offer no quantifiable force or time information to guide corrective adjustments. Figures 17b to d illustrate that in the corrected final protrusive movement there are shared force transitions between teeth #11 and 21 all through the movement. The computer-guided result has protrusive contacts that never reach the potentially damaging force levels seen preoperatively (Fig. 15b).

This case illustrates the use of computer-guided occlusal analysis with adhesive restorations to minimise excessive occlusal forces that result from the all-ceramic restoration placement, where the bonding process must precede all occlusal adjustments. This reversal of the conventional placement process (absent of inter-occlusal remounts) can introduce significant occlusal errors that are poorly discerned with articulating paper. Com-

puter-guided occlusal analysis affords the operator precision, occlusal force isolation and predictable control of restorative occlusal error, which aids in prolonging the longevity of the all-ceramic restorations.

_Conclusion

For MICD, computer-guided occlusal analysis systems offer data on quantifiable pressure, force and contact time sequence that can be employed to guide the occlusal adjustment of the restoration to precise measurable endpoints.[2,3] These endpoints establish uniform force distribution, bilateral simultaneity and measurable immediate disclusion, and minimise the damaging effect of concentrated, excessive, isolated occlusal force. Avoiding potentially destructive intra-oral use, the overall prosthetic occlusal scheme preserves the ceramic materials utilised in the procedure, ensuring long-term survival.

Lastly, occlusal adjustments that are guided by T-Scan III technology represent the essence of MICD because a clinician treats only what needs to be treated and does not perform random subjective occlusal adjustment based on mere judgement of paper markings with the naked eye. Measured occlusal force and timing data direct the MI clinician to adjust only the locations of excessive force, while leaving the areas of measured low occlusal force untouched. Cosmetic restorations and tooth structure are therefore preserved and overtreatment is minimised. The clinical implementation of this technology mirrors the core message of the "Do No Harm" philosophy._

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cosmetic dentistry

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A banker's bond: When less is more

Author_ Dr Sarah Kong, USA

Fig. 1_Full face pre-op.
Fig. 2_Pre-op close-up, retracted.


Fig. 1


Fig. 2

_This banking executive was an existing patient who wished to improve his smile. His first treatment arose from a desire to reduce the prominence and pointedness of his upper canines (Figs. 1 & 2). We recommended he try orthodontics and whitening first, and then possibly some cosmetic treatment thereafter, depending on the desired result.

The patient was adamant about not having orthodontics, so we did a mock-up on his canines to see if he liked the way it would look if we bonded his teeth sans orthodontic treatment. He loved the look and was immediately motivated to have his teeth whitened and bonded.

His teeth were deep bleached and the mesial surfaces of the canines were bonded to diminish the pointedness of his canines. He loved the more natural and harmonious look created by the bonding (Fig. 3). That was about three years ago.

Fig. 3_Pre-op close-up, after canines were bonded.


Fig. 3

More recently, he came in for his routine prophylaxis appointment and wished to improve his smile a little more. This time, he wanted to see whether we could better align his teeth, again without the aid of orthodontics. He enquired whether porcelain veneers for all his teeth would be a feasible option.

Closer clinical examination revealed several cosmetic issues, including but not limited to:

1. palatally inclined lateral incisors;
2. prominent and mesially rotated canines;
3. tooth #9 was slightly more retroclined than tooth #8;
4. an uneven gumline due mainly to a large cervical divot on tooth #8 with associated gingival overgrowth;
5. anterior crowding; and
6. retruded premolars that caused the smile to end at the canines in a narrow arch form (Fig. 3).

We discussed all these issues with the patient and then, as before, created a mock-up of teeth #7 to 10 to show the patient what he would look like with four resin veneers (Figs. 4 & 5).


Fig. 4


Fig. 5

Fig. 4_Full-face with mock-up of teeth #7 and 10.
Fig. 5_Mock-up, close-up of veneers on teeth #7 to 10.

The patient did not understand the need for the gumlift on tooth #8, so we added bonding to the gumline to give the illusion of a more uniform gumline that the patient could see and understand. At this stage, we pointed out that his premolars appeared to fall away from his smile and become lost in the buccal corridor. The premolars on one side were mocked up as resin veneers so he could see the difference the built up teeth would make in comparison to the other side.

Multiple images of the various mock-up options were taken and e-mailed to the patient, along with multiple treatment plan options. After careful consideration, the patient opted for the resin veneers on teeth #7 to 10, as well as the gumlift.

It was because of the mock-up and photographs that the patient realised the value of the gumlift in creating a more attractive smile. He wanted to consider the resin veneers for the premolars and possibly have them done in the future.

_The procedure

The patient presented for the bonding appointment with his teeth already whitened. We began by placing topical anaesthetic before anaesthetising teeth #7 to 10 with The Wand (Milestone Scientific). Subsequent injections of lidocaine were placed around the gumline of teeth #7 to 10 before electrosurgery of the gums.

Using Bident (Synergetics), a bipolar electrosurgery unit, the gingiva around tooth #8 was contoured to ideal proportions (Figs. 6 & 7). Once the gingiva had been removed, it was discovered that the underlying bone had grown into the cervical divot of tooth #8, right on top of the enamel. It was then decided that crown lengthening was indicated, so a small, round diamond bur was used to contour the bone to match the ideal gumline. We proceeded to contour the gingiva on the mesials of teeth #7 and 10 and to create symmetry of tooth #9 with tooth #8 (Fig. 8). The Bident unit allowed for gentle, clean coagulation in a wet field. There was no grounding needed, and because the unit is meant to be used with water, there was no tissue charring or shrinkage. A more effective, more precise and safer result was achieved, with essentially no post-operative bleeding—a perfect scenario for bonding teeth immediately with no fear of a contaminated field.

The teeth were now ready to be bonded. They were carefully cleaned with pumice to remove any surface debris and stains. Metal strips were placed interproximally to isolate each tooth. Thereafter, they were micro-etched

Fig. 6_Bident on tooth #6.
Fig. 7_Gumline after Bident and CCL.


Fig. 6


Fig. 7


Fig. 8


Fig. 9

Fig. 8_Immediate post-op photograph of resin veneers and gumlift on teeth #7 to 10.
Fig. 9_Close-up two weeks post-op, retracted.

with aluminium oxide to allow for better mechanical retention. Before the application of a bonding agent (OptiBond Solo Plus Unidose, Kerr), 37 % phosphoric etch was placed and rinsed.

Tooth #8 was bonded first using various layers of composite, starting with a micro-hybrid (Premise, Kerr/Sybron) and ending with a micro-filled composite (Renamel, COSMEDENT). This tooth was contoured and polished with a series of polishing discs (SHOFU) before proceeding so that the next tooth (#9) could be matched to this tooth without being bonded to it.

Teeth # 7, 9 and 10 were bonded in a similar fashion with various shades to create a more natural, graded appearance. As before, each tooth was polished before bonding the next one. Final contouring and polishing were achieved, and a high shine was gained with a Twist-2-It and polishing paste. In about two hours, the patient had a new smile! Even the post-operative gumline looked amazing immediately, with no bleeding (Fig. 9).

Gentle Gel, an *Aloe vera* and herbal gel, was placed along the gumline and given to the patient to apply at home to help soothe the gums and facilitate quicker healing. The patient was amazed with and loved his new smile immediately.

When he returned for his two-week follow-up visit, the gums were ideally contoured, the resin veneers looked wonderful, and the patient said they felt wonderful too (Fig. 10). No polishing was required, so another high shine polish was done to make them sparkle. Post-operative photographs were taken and the patient was very pleased with the results (Fig. 11).

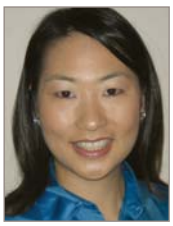

Fig. 10


Fig. 11

Fig. 10_Close-up two weeks post-op.
Fig. 11_Happy patient.

He also mentioned that he had no immediate post-operative pain, and his gums looked and felt better in just a couple days after the bonding appointment. Overall, the patient was ecstatic about the dramatic improvement, especially the contouring of the gumline, which contributed immensely to the final cosmetic result. He also loved that his beautiful smile was achieved in a single bonding appointment with a minimally invasive approach—less is more. Now he is already thinking about and looking forward to his next dental venture—resin veneers for his premolars._

_about the author



Dr Sarah Kong graduated from the Baylor College of Dentistry, where she was later Professor of Restorative Dentistry. She specialises in preventive and restorative dentistry, transitionals, anaesthesia and periodontal care. Dr Kong is an active member of numerous professional organisations, including the American Dental Association, Academy of General Dentistry, American Academy of Cosmetic Dentistry, Texas Dental Association and Dallas County Dental Society. She can be contacted at drkong@dallasdentalspa.com.

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DENTAL TRIBUNE

The World's Dental Newspaper

Photos: Yuri Arcurs

Wanted: Whiter, brighter teeth

_Teeth whitening seems to be on everyone's wish list—and this trend is likely to continue through 2011, according to a quick poll of member dentists of the American Academy of Cosmetic Dentistry (AACD).

AACD members performed an average of 77 whitening treatments last year, and 57 % said that they expect this number to increase. "We are doing more whitening than ever before in our practice," says Shannon Pace Brinker, certified dental assistant and clinical editor of *Contemporary Product Solutions*. Pace Brinker performed more than 400 whitening treatments in the past year, and attributes increased treatment acceptance to the ability to offer a high-quality whitening system with various options to treat her patients based on bleaching strength, time, finances and patient compliance at her practice at Greenbrier Dental Center in Chesapeake, Virginia.

Pace Brinker says that her practice has reduced its fees for whitening, which has not only brought in more patients seeking whitening—but also opened their eyes to other cosmetic dental treatments. "Our existing patients are saying 'yes' to other procedures after the whitening, such as bonding, replacing amalgam fillings and porcelain restorations to match the whitening they have achieved," she said.

While the number of patients seeking whitening treatments will likely increase this year, Pace Brinker expects that the fees for whitening will decrease owing to specials offered by dental practices through deal-a-day sites like *Groupon and LivingSocial*. The average price for a whitening treatment is about US$150 for take-home whitening and US$350 for in-office treatment, Pace Brinker says. Since her practice adjusted its fees for treatment, she sees up to 12 to 14 patients per day on Mondays and Tuesdays just for whitening.

"Our case acceptance has exceeded our expectations with these adjusted fees," Pace Brinker said.

AACD members said their practices generated about US$19,100 on average from whitening last year. The majority of AACD members polled said that they provide in-office and take-home whitening treatments. In addition, 22 % said that their patients have told them that they use over-the-counter or commercially available whitening treatments.

Regarding gender, it seems that women are more concerned with having a white smile. Roughly 65 % of dental patients who sought whitening treatment last year were female, according to the poll.

_Fountain of youth at the dentist?

Brushing, flossing and regular care are still key ways for patients to have a younger looking mouth, but more dentists will be adding Botox to their offerings in 2011, another AACD survey has found. "Cosmetic dentists are now using Botox and dermal filler treatments to improve patient smiles and reduce wrinkles in addition to treating problems like temporomandibular joint disorders," said Dr Christopher Ramsey, accredited member of the AACD.

Cosmetic dentists say another major area of growth in 2011 will be dental implants, or replacement of missing or decayed teeth, owing to the increasing size of the ageing population. "Tooth decay is a growing concern for older patients who are using more medications, which lead to dry mouth," said Dr Ramsey. "More seniors are turning away from dentures and bridge work for a more comfortable and longer-lasting implant option." Other popular procedures noted include veneers (52 %), replacement fillings (45 %) and dental bonding (37 %).

_New technology makes dentist visits quicker and easier

According to the survey, 63 % of the cosmetic dentists expect their business to experience at least moderate growth in 2011. Dentists in the survey attribute this predicted growth mainly to technology. Today, more cosmetic dentists are using the Apple iPad and other technologies to make visits quicker and easier. New technologies have reduced patient office time by at least 50 %, increasing patient safety, and making the whole dental process easier and more comfortable. In 2011, dentists predict that there will be increased use of:

_iPads and iPhones: Cosmetic dentists cite a wide range of uses from charting, displaying X-rays and managing dental records to improving diagnoses and educating their patients. Multiple new apps are also emerging, including an iPhone calculator that helps cosmetic dentists analyse and plan new smiles for patients. Dentists and patients are also using smartphone apps to connect with each other—set up and confirm appointments, learn about the office staff, request medication refills and more.

_Digital X-rays: Using these, cosmetic dentists can obtain a clearer picture of problems, such as an abscess or decay, in a much shorter time than with the older version of X-rays.

Computer-aided dentistry: CAD/CAM is revolutionising tooth restorations, replacing goop-filled trays with 3-D scans that mean no mess and no second appointments. Milling machines then use this 3-D data to create perfect ceramic crowns.

_about the academy

cosmetic dentistry

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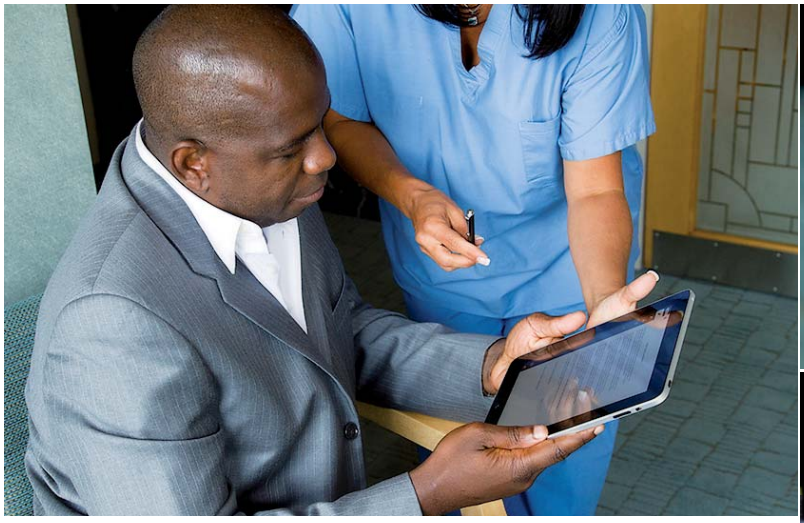
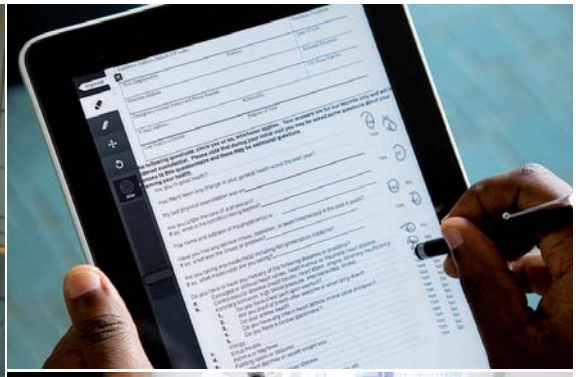
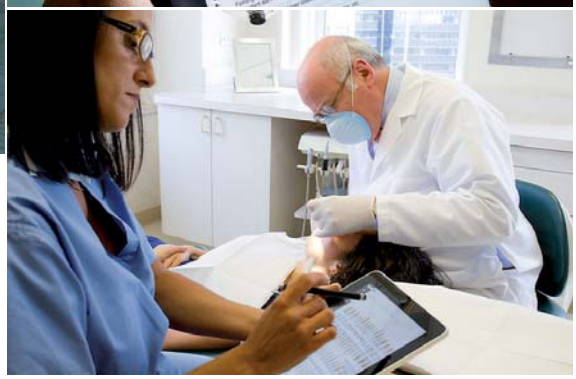
iPad in business: Advancing digital dentistry







_When new patients enter Dr Jonathan Ferencz's thriving prosthodontics practice in midtown Manhattan, they are greeted with a smile—and an iPad.

For Dr Ferencz, the latest technology has always driven quality patient care. As an early iPad adopter, Dr Ferencz knew the device could launch a new era in digital dentistry. iPad has become central to all aspects of the practice. In addition to simplifying patient forms and record-keeping, iPad enables Dr Ferencz to show his clients photos of treatment options. And his technicians refer to digital images on iPad to create perfect-looking dental prosthetics.

_Painless patient records

iPad simplifies the record-keeping process for both patients and staff. Rather than designing, filling out, scanning, and then shredding paper forms, Dr Ferencz and his staff have created a fast, efficient system using iPad.

Patients complete their intake forms directly on iPad using the Adobe Ideas app, and can even sign the form using a stylus on the iPad screen. From there, a member of his staff emails the forms into the practice's database. There is no paper and nothing to file. "It is efficient," Dr Ferencz says. "With iPad, we save so much time—and space." And patients can stay productive and up-to-date with their personal lives during their visits. "If there is any kind of wait before the appointment, we give them an iPad," Dr Ferencz says. "They can check their email, surf the Internet, read the *New York Times*—all the rich content that is available on iPad."

Putting iPad into patients' hands also helps emphasize Dr Ferencz's commitment to the latest and best dental practices. "It conveys a subliminal message that this office is up-to-date technologically," he says. "So they know that we are up-to-date in our dentistry as well."

_Visual conversations

When patients enter the treatment room, iPad takes on another role: communication tool. Prosthodontics deals with aesthetic and reconstructive dentistry, such as crowns and veneers. Dr Ferencz's challenge is to get patients to see what he sees, and to show them what he can do. With iPad, he can effortlessly display photo-

graphs and X-rays to patients during consultations. And using the Adobe Ideas app, he can annotate the images onscreen while pointing out areas of interest.

"iPad is ideally suited to this kind of visual conversation," he says. "The patient and I can flip through the X-rays and clinical photos together, and I can illustrate my points as we go." Because the patient has a visual idea of the procedure and a sense of what the outcome will look like, the result is a direct improvement in care. "With iPad, I can greatly enhance patient acceptance of my proposed treatment," Dr Ferencz says.

Helping him in the conversation are two iPad features that Ferencz can not match elsewhere: high resolution and zooming. "The resolution of iPad is so incredible that I can see details I could not on a conventional X-ray," he says. Zooming also allows Dr Ferencz to focus a patient's attention on one aspect of the image. "To do that with your fingers is absolutely invaluable, compared to a laptop or a conventional display."

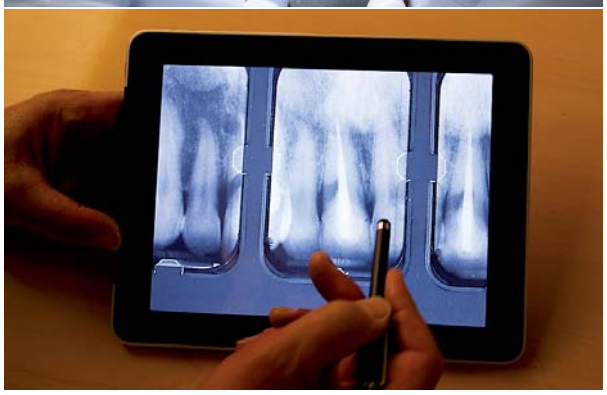
_iPad in the laboratory

Dr Ferencz's iPad use does not end in the treatment room. Immediately after a discussion with a patient using iPad, Dr Ferencz might bring the device to his in-house laboratory to demonstrate an issue to one of his technicians. "On a dental restoration, the most effective way to make a correction is to show the photograph to my technician and say, 'Here is how I would like you to reshape it,'" he says. "That way, we are having a conversation about a clinical photograph, not a drawing or a diagram."

From there, the technician can get to work. "The technician just takes out an iPad, pulls up the images, and goes to work," Dr Ferencz says.

_A business of trust

iPad is also a powerful, persuasive way to share images during doctor-patient conversations about treatment options. "On our first day with iPad, I used it three times to show patients X-rays and photographs of clinical conditions," Dr Ferencz explains. "And in each case the patient booked the procedure immediately." When he asked the patients whether the presentation on iPad had an impact on their decisions, one of them said, "I trust Dr Ferencz, and I would have done what he said, but the way the images appeared was just amazing. I had to schedule the procedure immediately."



In a single day, iPad paid for itself. "As a business owner, I think iPad is a no-brainer," Dr Ferencz says. "With its high resolution and ease of use, iPad has the ability to make a major impact on oral health care."

And this is just the beginning. "I think we have just begun to scratch the surface with iPad applications," he says. "It really is totally revolutionary."_

_contact

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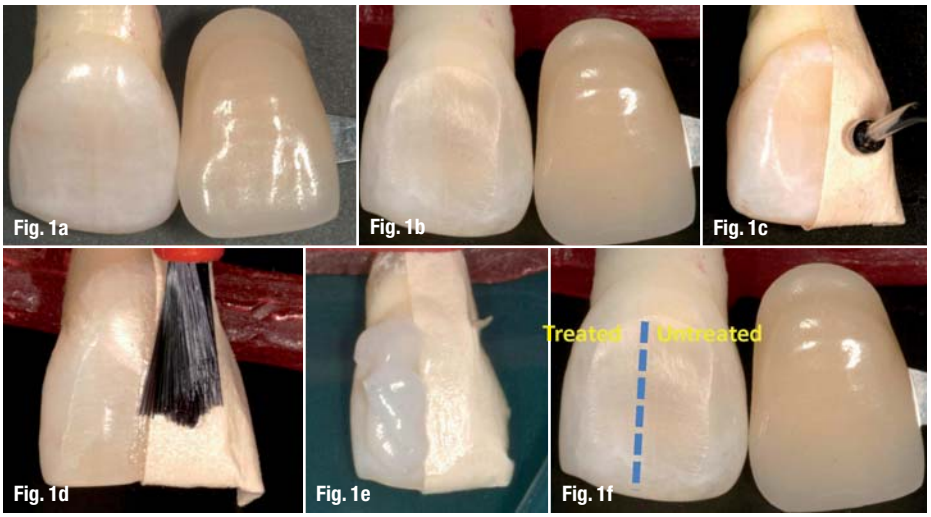
Confocal microscopy investigation of enamel subsurface structure following bleaching

Authors_ Prof Daniel C. N. Chan, Prof William D. Browning, Prof Albert Kwok-Hung Chung & Prof So-Ran Kwon, USA & Korea



Figs. 1a–f_Pre-op view of one of the incisors selected for the study (a). Flattened area (≈ 4 x 5 mm) created by serial polishing with sandpaper up to 1,200 grit (b). A piece of water-resistant tape is applied to one-half of the tooth and burnished (c). The edge of the tape is sealed by painting it with a transparent nail varnish (d). Bleaching gel is applied to the exposed area (e). Diagrammatic representation of the control and treated areas (f).

_Tooth-whitening procedures have been associated with morphological changes in the enamel surface. As early as 1993, Shannon *et al.* reported significant surface topographic alterations in enamel slabs that had been treated with bleaching solutions for four weeks.[1] These findings were confirmed in another study with 30 % H_2O_2 mixed with PBS.[2] Teeth that were bleached *in vivo* with 35 % carbamide peroxide lost the aprismatic enamel layer and the damage was not repaired after 90 days.[3] A confocal laser scanning microscopic study evaluating the micro-roughness of enamel surfaces after bleaching procedures with 10 and 16 % carbamide peroxide found roughness to be significantly higher than in control surfaces.[4]

However, another study reported no or minimal changes in the enamel surface after bleaching. Leonard *et al.* evaluated casts made from impressions of teeth bleached with 10 % carbamide peroxide for eight to ten hours per day for 14 days, and found no or minimal changes in the enamel surface.[5] Their findings may be explained by the limits of the methodology, in which there was inadequate reproduction of the minor enamel alterations in the impression. Other *in vitro* SEM studies published recently have also revealed no enamel irregularities after bleaching.[6,7]

In general, recent literature supports the theory that a high concentration of carbamide peroxide is detrimental to enamel surface integrity, while low concentrations were found to produce no changes.[8–11] A clinical implication of these findings may be that the teeth are more susceptible to extrinsic discolouration after bleaching due to increased surface roughness.

The changes may be deeper than superficial. Using infrared spectroscopic analysis, Oltu and Gürgan reported that *in vitro* treatment of extracted teeth with 35 % carbamide peroxide for 30 minutes per day for four days changed the inorganic composition of the enamel, whereas 10 and 16 % concentrations did not.[12] Cavalli *et al.* also demonstrated that bleached dentine could lose inorganic components, resulting in ultrastructural alterations.[13]

Studies have demonstrated a dynamic process of demineralisation of human enamel intra-orally.[14] In these studies, the existence of subsurface enamel pores, which increase and decrease in size in relation to this de- and remineralisation process, has been demonstrated. Amorphous calcium phosphate (ACP) has been shown to shift the de-/remineralisation balance towards remineralisation, resulting in a decrease in size and/or number of pores.[15] It has been theorised that bleaching creates subsurface

Table I_Bleaching agents used in the study.

Bleaching agent	Main ingredient and concentration	Manufacturer
Nite White Excel 3 with ACP	16 % hydrogen peroxide (+ ACP)	Discus Dental
Opalescence PF	10 % carbamide peroxide (+ fluoride and potassium nitrate)	Ultradent

Table I

pores and that this is a cause of the transient sensitivity experienced by some people when they whiten their teeth.

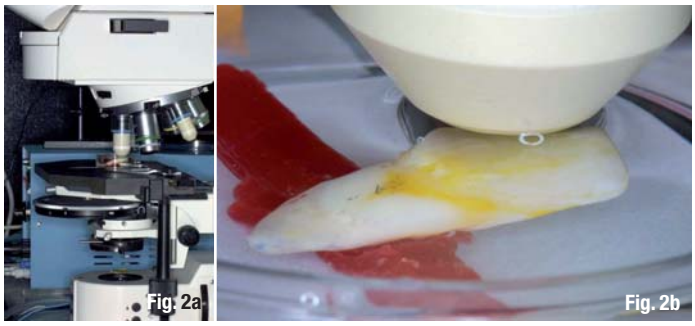
Recently, some companies have added ACP to their formulations. Claims have been made that the addition of ACP reduces tooth sensitivity by decreasing the size of these pores.[16] In addition, by filling minor defects within the enamel, the addition of ACP creates an enamel surface that is smoother and more lustrous. However, in an *in vitro* study on bovine incisors, no supporting influence of fluoride-containing bleaching gels on remineralisation was observed.[17]

The purpose of this study was to evaluate enamel subsurface structure following application of two bleaching agents to extracted incisor teeth using confocal microscopy.

_Materials and method

A flattened area (≈ 4 x 5 mm) was created on the labial surface of extracted central and lateral incisor teeth (n = 10) by serial polishing with SiC sandpaper of up to 1,200 grit (Figs. 1a & b). It is true that confocal microscopy holds greater advantages for samples that cannot be polished to a flat surface. In our case, the flattened surface helped in orienting the area of interest as a plane-parallel object held perpendicular to the optic axis for sharper image.

The teeth were ultrasonically cleaned with distilled water to remove debris. A piece of water-resistant tape was applied to one-half of the tooth and burnished (Fig. 1c). The edge of the tape was sealed by painting it with a transparent nail varnish (Fig. 1d). The exposed area was randomly assigned to one of two groups. The first group (ACP group) was treated with Nite White Excel 3 with ACP (Discus Dental). The second group (OP group) was treated with Opalescence PF 10 % (Ultradent). The untreated control for both groups was the area underneath the tape, allowing each tooth to serve as internal control. The composition of the whitening products is described in Table I.

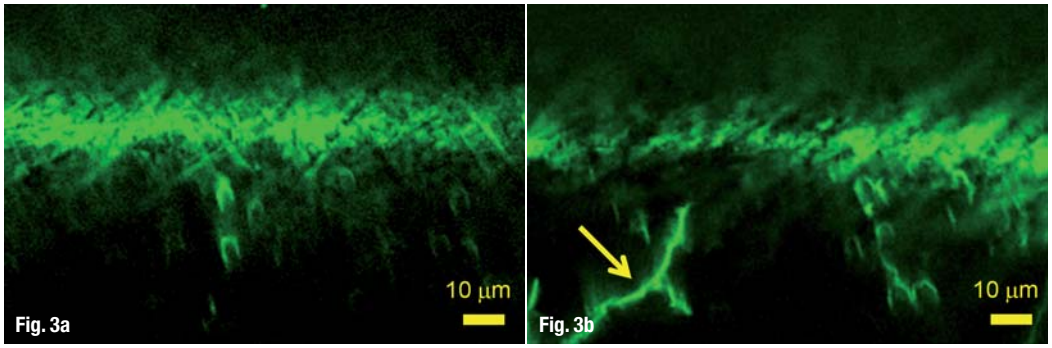


Figs. 2a & b_Experimental set up for confocal microscopy (a). Flattened surface of the incisor orientated perpendicular to the laser (b). Tooth sample immersed in distilled water.

Bleaching agents for both groups were applied for seven hours per day for 14 days. The materials were applied with a micro-brush, taking care to limit the application to the appropriate area only (Fig. 1e). Once the application of bleaching agent had been completed, the teeth were placed inside a plastic box, which acted as a moisture barrier, while keeping the bleaching agent undisturbed throughout the procedure.

After each daily application, expended bleaching material was first removed with a clean micro-brush. The area was then cleansed with water and blotted dry. Finally, the teeth were rinsed with air-water spray for 20 seconds. A cycling treatment methodology was employed. While not being actively treated, the teeth were stored in artificial saliva (Saliva Substitute, Roxane Laboratories). Up to the point of the microscopic examination, the tape covering the control group area remained in place (Fig. 1f).

Before confocal microscopic evaluation, the teeth were submerged in Texas Red dye with Dextran for 24 hours. A two-photon microscope (LSM 510 Meta, Carl Zeiss) was used to detect the fluorescence under an Argon 488 laser (Fig. 2a). Each area was examined up to a depth of 100 µm. The flattened enamel surface was orientated perpendicular to the laser beam with sticky wax and the whole tooth sample was placed under water contained in a Petri dish (Fig. 2b). Samples were viewed with a 5X/0.16 objective, focusing approximately 5 to 100 µm below the surface. Images were relayed to a computer monitor for viewing. Additional images were made



Figs. 3a & b_OP control area 6 µm subsurface (a). OP-treated 10 µm subsurface (b). Arrow indicates subsurface crack.

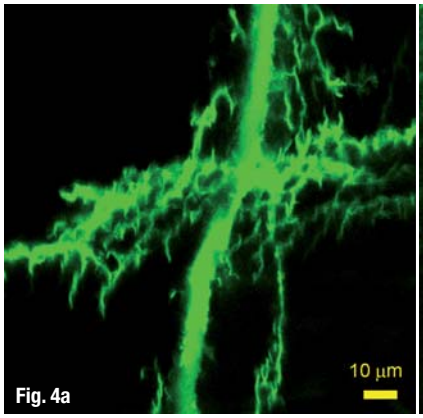


Fig. 4a

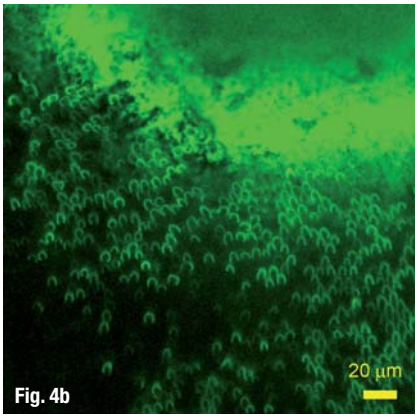


Fig. 4b

Figs. 4a & b_OP control area 28 µm subsurface (a). The dye penetrated via the crack. OP-treated 24 µm subsurface (b).

(10X/0.3 objective). High-resolution confocal microscopic images were then obtained.

_Results

Figures 3 to 6 show representative confocal micrographs of treated sections and untreated sections. Figure 3a shows 6 µm subsurface of 10 % carbamide peroxide control area and Figure 3b shows the treated 10 µm subsurface. In Figure 3b, a subsurface crack is visible. As evident from Figures 3a, 4a, 5a and 6a, there was an uptake of dyes in the control groups.

From all our observations, there were no significant subsurface porosities observed up to a depth of 100 µm, the limit of our methodology. The dye was associated mainly with enamel cracks as the depth of observation increased. The periphery of the superficial enamel prism shows increased uptake of the marker, indicating a possible route for the oxidation product to diffuse through enamel surface. General observations indicate that the dye followed inherent cracks to deep areas in the enamel subsurface (Figs. 3b, 4a, 6a & b).

_Discussion

Figs. 5a & b_ACP control area 12 µm subsurface (a). ACP-treated 48 µm subsurface (b).

While most studies have evaluated the effect of whitening on the morphological effect of enamel and dentine, the present study focused on the significance of subsurface enamel pores and defects. In our study, we did not find any significant subsurface porosities, observed up to a depth of 100 µm. The cycling treatment methodology with artificial saliva storage for 17 hours may have repaired some of the initial damage done by the bleaching. We also did not find any difference between the ACP and the OP groups. Opalescence PF 10 % contains fluoride and potassium nitrate, but it is unknown whether these two ingredients perform the same desensitising function as claimed by ACP.

Iwamoto *et al.* showed similar negative results when silver nitrate was used as the staining agent. In that study, no penetration was seen in the enamel of any of the groups.[18] However, we did see penetration of the dye in the periphery of the enamel prism in both the control and the treatment groups for both whitening materials. The increased uptake may be due to the removal of the organic components from the superficial enamel layers by the bleaching agent. The uptake of dyes in the control groups was not expected. This may be explained by the fact that exposed enamel is under constant attack in the oral environment. The weakened pores may be the inroad for chromopores and peroxide alike.

The penetration of the dyes was especially noticeable when we followed surface cracks to a depth of 100 µm (Fig. 4a). The uptake of dyes through the cracks may be clinically significant, since it may explain why certain patients are especially sensitive to bleaching. If diffusion through the enamel intercrystalline spaces is the sole cause of sensitivity, one would expect to find higher incidence of severe sensitivity.[19] However, if subclinical defects/cracks are the cause, the clinical picture of severe sensitivity reported to be around 4 % can be better explained. Enamel cracks or lamellae have been suggested to be initiation sites for caries.[20]

As seen in Figure 4b, the periphery of the enamel prism shows increased uptake of the marker, indicating a possible route for the oxidation product to diffuse through the enamel surface. Based on our findings, we hypothesise that peroxide initially penetrated into and through the enamel intercrystalline spaces to reach the enamel dentine junction and dentine regions. Indeed, *in vitro* experiments by a number of authors have demonstrated the penetration of low levels of peroxide, from a range of peroxide products and solutions, into the pulp chambers of extracted teeth after exposure times of 15 to 30 minutes.[21–23] One would expect that diffusion of peroxide through

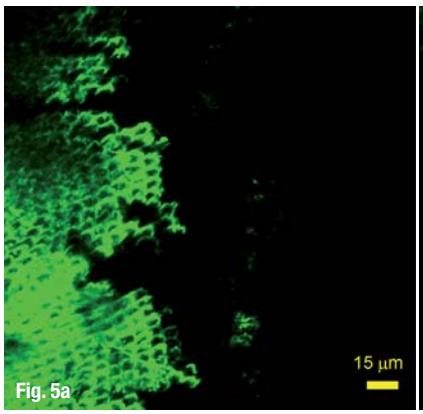


Fig. 5a

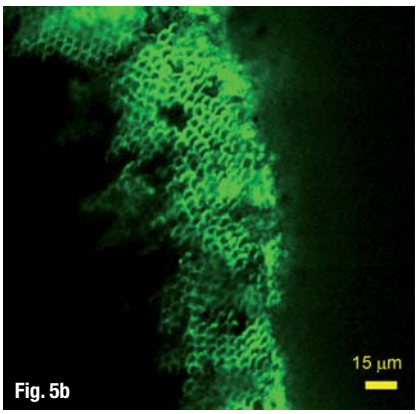


Fig. 5b

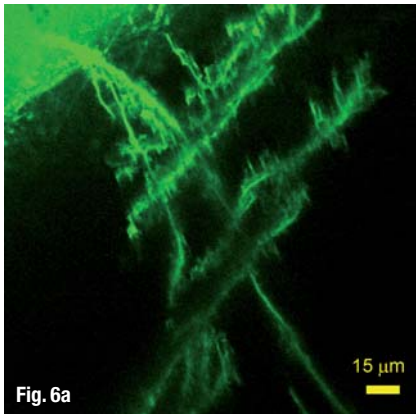
the intercrystalline spaces would be easier for peroxide, since the Dextran dye we used in our study has a high molecular weight of 3,000 to 70,000, while that of a hydroxyl radical is 17.

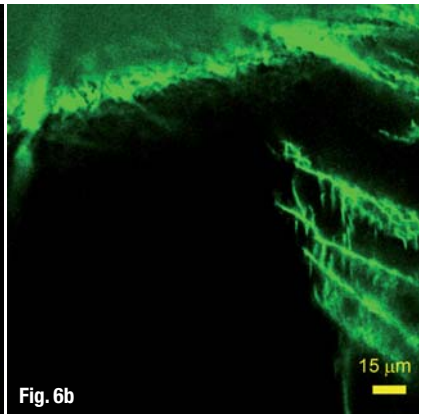
Our study did not find any evidence to support the claim that the addition of ACP reduces tooth sensitivity by decreasing the size of the pores. Another study looking at the simultaneous application of admixture solutions containing citric acid and sodium fluoride did find formation of CaF_2 globules deposited on the enamel surface. However, the CaF_2 globules deposited on the enamel surface appeared to be unable to prevent the alteration of the apatite structure during further exposure to acidic agents. No evidence of fluoride-induced recovery of the modified apatite structure was found. As for whether ACP can repair the pores simultaneously, previous studies of the repair of etched enamel reported that partial recovery from such damage takes several months *in vivo*.[24] It is unlikely that our study duration of 14 days could have offered noticeable repair.

Hypothetically, ACP could reduce the effect of sensitivity if the pore sizes were reduced. However, such reduction would also prevent efficient diffusion of hydroxyl radicals to effect bleaching. Instead, ACP could act via different mechanisms, for example by influencing the type of anion or radicals formed. Hydrogen peroxide can form a number of different active oxygen species, depending on reaction conditions, including temperature, pH, light and presence of transition metals. Whether one type of anion or radical is less prone to causing sensitivity deserves further study.

It has also been suggested that ACP may have the ability to directly depolarise nerve endings.[25] Additionally, in the generation of ACP by combining calcium nitrate and potassium phosphate, 0.25 % of potassium nitrate is generated.[26] A recent study on traditional low sensitivity whiteners raised the question of whether the low level of potassium nitrate generated as a by-product was, in fact, clinically relevant.[27]

Clinical studies have shown that ACP was effective in reducing sensitivity.[16,25] However, a recent *in vivo* study of 9 % H_2O_2 whitening strips with fifty subjects indicated that daily use of a Casein phosphopeptide-amorphous calcium phosphate paste in conjunction with tooth whitening has a minimal effect on tooth sensitivity compared with a placebo paste. Our study result raised the question of whether ACP might exert its desensitising effect through a mechanism other than decreasing the size of subsurface pores.





Figs. 6a & b_ACP control area 46 µm subsurface (a). ACP-treated 46 µm subsurface (b).

It is recognised that our study was limited by its small sample size and we only evaluated the enamel substrate. Severe sensitivity can be initiated through exposed dentine substrate. Another criticism may stem from the argument that cracks, which were shown in this study, may have been induced by extraction forces. Further studies need to be performed to explain the mechanism of ACP desensitisation better.

_Conclusion

Uptake of dye through enamel intercrystalline spaces exists in both control and bleached enamel surfaces. Whitening products with and without ACP did not appear to decrease the size of these spaces. Subclinical enamel defects/cracks may be the cause of severe bleaching sensitivity.

_Acknowledgement

We would like to thank Dr Katsuya Miyake and Mr Darren Baker, Cell Imaging Core Laboratory at Georgia Health Sciences University, for their help with the confocal microscopy. This project was funded by a grant from Ultradent._

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

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Compobond: Evolution of a new restorative dental material

Author_ Dr Irfan Ahmad, UK

Fig. 1

Fig. 1_TE DBAs involve etching (red) both enamel and dentine followed by the primer (yellow) and adhesive (green).

_Besides the physical and mechanical properties of dental amalgam, one of the main reasons for its success is its clinical simplicity and forgiving technique. The derisory "drill and fill" slogan associated with dental treatment pertinently describes the provision of an amalgam restoration. The usual protocol for amalgam restorations is a single-stage procedure. Following decay excavation and tooth preparation, amalgam is placed directly into the cavity and anatomically curved and burnished. In addition, amalgam restorations are relatively technique insensitive, have favourable wear resistance and high strength, are inexpensive and the post-operative expansion of the material helps "seal" cavity margins.

Amalgam's demise started in the eighties, with questions being raised about excessive tooth removal for creating undercuts for retention, metal corrosion products, poor aesthetics and possible mercury toxicity.[1] Since then, the profession has sought suitable alternatives for this iconic and ubiquitous restorative material—the candidate: resin-based composites. The last few decades have witnessed phenomenal research and improvement of composite technology, allaying concerns regarding wear resistance, retention of tooth structure, marginal adaptability and post-operative sensitivity. However, the unflagging Achilles' heel of composites is polymerisation shrinkage, which compromises the longevity of the restoration.[2] Nevertheless, newer materials have sought to overcome many of the negative effects associated with polymerisation shrinkage. The basis for improvement has been two-fold: firstly, a better understanding and efficacy of dentine bonding; and, secondly, development of the chemical composition of resin-based composites to meet the challenges of polymerisation shrinkage, including superior physical and mechanical properties to meet the hostile demands of the oral cavity. In order to appreciate the rationale for the development of compobonds, it is important to chart the scientific breakthroughs of both dentine bonding and resin-based composites.

_Historical

The ideal restorative material should be aesthetic, adhesive, abrasion-resistant and bioactive to encourage regeneration, rather than repair, of the dental hard tissues. The last six decades have witnessed the introduction of many innovative materials as amalgam substitutes, and to fulfil the criteria of an ideal restorative dental material. These newer materials can be categorised as resins and glass-ionomers with numerous hybrids, consisting of combinations of both materials. Resins yield a superior bond to enamel, but a less predictable bond to dentine.[3] Conversely, glass-ionomers bond better to dentine by offering true chemical adhesion and releasing fluoride for bioactivity, but have inferior mechanical properties compared with resins. Numerous hybrid materials such as resin-modified glass-ionomers, compomers and giomers have sought to exploit the beneficial properties of both materials, with varying degrees of success. For example, in 2001 giomers were introduced, incorporating a pre-reacted glass filler to facilitate fluoride release from a resin-based composite.[4]

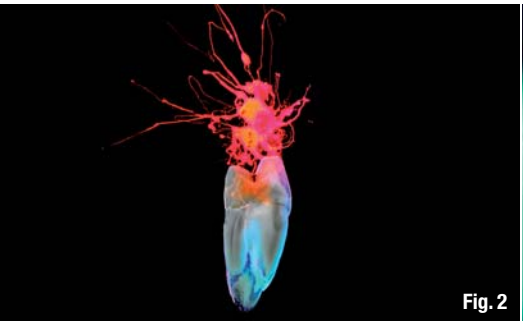
Fig. 2

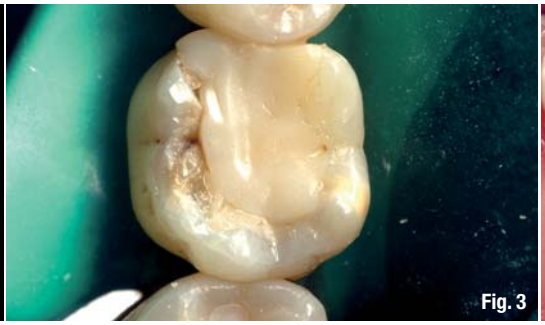
Fig. 3

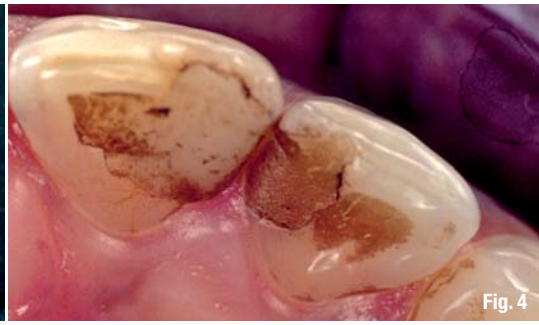
Fig. 4

Other classes of materials include siloranes and ormocers. Whilst the silorane-based composites have the lowest polymerisation shrinkage of any resin, they display mixed mechanical properties: flexural strength (FS) and modulus of elasticity (MOE) are higher, but their compressive strength and microhardness are lower compared with methacrylate-based composites.[5] Ormocer technology is another addition to the dental restorative armamentarium, having excellent wear resistance, but poor polishability. The evolution of compobonds, launched in 2009, is based on the premise of the promising clinical outcomes of dentine bonding agent (DBAs) and resin-based composites.

_Dentine bonding agents

The acid-etch technique, introduced by Buonocore in 1955, was seminal and opened the doors to the possibilities of achieving a bond to natural tooth substrates with artificial acrylic-based restoratives.[6] Whilst bonding to enamel has changed little since its inception more than half a century ago, bonding to dentine has proved far more elusive, undergoing enormous changes. A major advancement for achieving a sustainable bond to dentine was the introduction of the total-etch (TE) technique[7] in the late seventies (Fig. 1).

The first self-etching (SE) primer, combining an etchant and primer in a single step, was introduced in the early nineties.[8] The SE primers not only simplified bonding to dentine, but also eliminated the clinical errors associated with this exacting procedure. The result was a more predicable dentine bond and longevity of a composite resin filling. The next decade witnessed many formulations, including etchant+primer followed by adhesive, etchant followed by primer+adhesive, and more recently in the mid-nineties, combining all three constituents, etchant+primer+adhesive, in a single product and a one-step procedure (Fig. 2).

Contemporary DBAs can be divided into two varieties: TE or SE. To complicate matters further, the TE bonding systems are available as either three- or two-step systems, and SE as either two- or one-step systems, which are available as three-, two- or one-bottle components. Therefore, to resolve some of these dilemmas in choosing a DBA, simplifying clinical techniques and minimising errors, the current trend is moving away from multi-component and multi-step bonding systems.[9] Also, encouragingly, both TE and SE varieties have bond strengths to dentine that are comparable to that of enamel (approximately 22 MPa).[10]

The salient difference between the TE and SE agents is that an initial etching stage is required with the former, but unnecessary with the latter. For TE, both enamel and dentine are simultaneously etched, usually with phosphoric acid, and followed by application of the primer and adhesive, or both components together in a single liquid. With SE agents, precursory etching is superfluous, since this is concurrently performed with the primer and adhesive.

Although SE agents expedite the bonding procedure, the major difference between TE and SE bonding agents concerns the smear layer. With TE agents, the etching and drying of dentine is susceptible to

Fig. 2_SE DBAs combine the etchant, primer and adhesive into a in a single product and a one-step clinical procedure.
Fig. 3_One of the limitations of composite fillings is polymerisation shrinkage, leading to marginal breakdown.
Fig. 4_Polymerisation shrinkage of resin-based composites results in marginal staining.


Fig. 5


Fig. 6

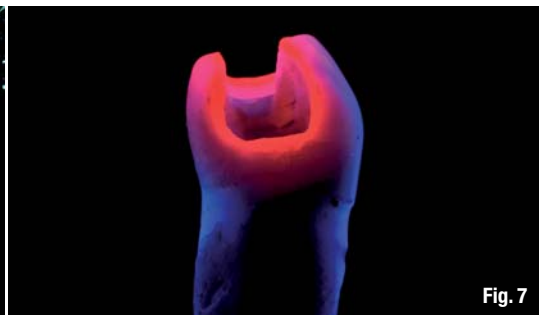
Fig. 7

Fig. 5_Vertise Flow is a self-adhering flowable composite, combining an SE bonding agent with a resin-based composite.
Fig. 6_The bonding agent in Vertise Flow is based on the technological advances of OptiBond, the first filled dentine-bonding agent introduced in 1992, which has now evolved into an SE system.
Fig. 7_When using Vertise Flow, it is advisable to either bevel or etch aprismatic enamel of the cavity margins.

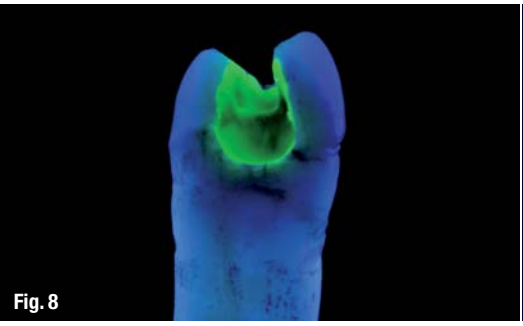
Fig. 8

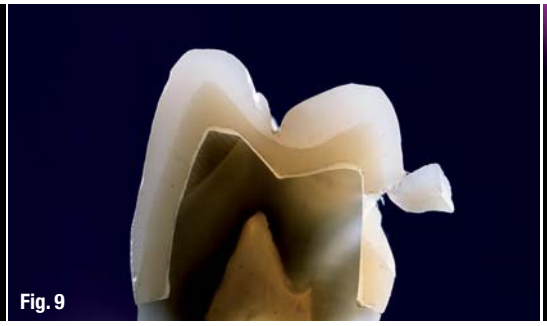
Fig. 9

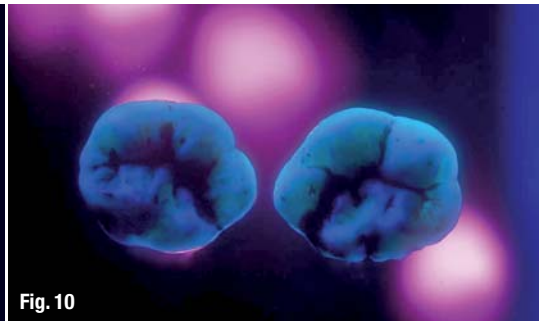
Fig. 10

Fig. 8_Vertise Flow is an excellent base lining, acting as a shock absorber due to its low MOE.
Fig. 9_Vertise Flow is ideal for intra-oral repairs of fractured porcelain.
Fig. 10_The Translucent shade of Vertise Flow is invaluable for detecting future decay underneath fissure-sealed teeth.

clinical errors. This is because the inorganic phase of dentine is dissolved, leaving the organic collagen matrix unsupported. If this organic matrix is not re-hydrated by the primer and adhesive, the dentine bond is severely compromised. Ensuring that the collagen fibres are hydrated necessitates leaving the dentine moist, which is difficult to assess clinically. Alternately, the DBA should contain a solvent to re-hydrate the collagen fibres, for example water or ethanol, so that the adhesive can impregnate the spaces once occupied by the inorganic phase and form a resin-collage complex, or a hybrid layer.

DBAs containing the solvent acetone are particularly likely to cause desiccated dentine, since acetone evaporates rapidly, leaving collapsed collagen fibres.[11] Therefore, if the adhesive bonding technique is incorrectly executed, the dentine bond will be inferior, causing poor adhesion, marginal leakage, discolouration and post-operative sensitivity. One of the reasons for post-operative sensitivity is inadequate sealing of the dentine tubules following etching during the dentine bonding procedure.[12] The latter is due to inadequate clinical protocols cited above, and particularly plagues TE, multi-step bonding agents. After the etching phase, the dentine tubules are exposed and at risk after removal of the inorganic matrix and the smear layer. If the next two stages, priming and introduction of the adhesive, are incompetently performed to seal the tubules by formation of an adequate hybrid layer, post-operative sensitivity is an inevitable result.

On the other hand, SE DBAs dissolve, rather than remove the smear layer, which is incorporated within the collagen fibres and the resin monomer to form a viable hybrid layer. Therefore, the reduced post-operative sensitivity reported by some studies with SE agents could be attributed to incorporation of the smear layer into the hybrid layer, and therefore never leaving the dentine tubules exposed.[13] Other studies have reported no difference in dentine hypersensitivity using either TE or SE systems, and poor clinical technique has been mentioned as the most significant factor, rather than the type of DBA, in causing post-operative symptoms.[14]

To summarise, the advantages of SE systems are:

1. less technique sensitive;
2. degree of dentine moisture not a concern; and
3. depth of etching and adhesive penetration are similar, since both processes occur simultaneously.

One of the drawbacks of the SE systems highlighted by some studies is the relatively high pH (≈ 2), compared with traditional phosphoric acid with a pH ≈ 1, resulting in inferior bond strengths compared with TE systems.[15,16] However, other studies have failed to find significant differences between the two systems,[17] and current research is inconclusive. The SE agents are divided into strong or mild groups, the former having a pH of 1 and the latter a pH of 2.

Although the milder versions are less aggressive and form thinner hybrid layers, a thinner hybridisation zone does not appear to compromise bond strength.[18] It is the integrity (absence of voids, tears) rather than the thickness of the hybrid layer that appears more significant to a viable dentine bond. Another possible drawback with the one-step SE agents is residual water that may remain in the


Fig. 11


Fig. 12


Fig. 13

Fig. 11_The lower first permanent molar is isolated with a rubber dam using a SoftClamp (KerrHawe SA). Notice the remnants of an old fissure sealant resin within the fissures.
Fig. 12_The tooth is air abraded with aluminium-oxide powder to remove plaque and decay, including remnants of old fissure sealants.
Fig. 13_A prophylaxis brush is used to clean the tooth with a slurry of pumice.

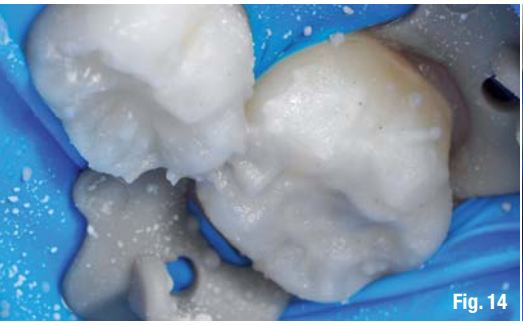
Fig. 14


Fig. 15


Fig. 16a

dentine tubules, thereby leading to incomplete polymerisation of the adhesive, and ultimately compromising retention.[19] However, SE agents are innovative products in their infancy, and further *in vivo* medium and long-term trials are necessary to investigate these concerns.

The eighth and future generations of DBAs should improve on the seventh generation of SE bonding agents by incorporating substances for regenerating natural hard tissues, rather than limiting their functions to adhesion. These new so-called biomaterials should have anti-bacterial, bioactive and biofunctional properties, amongst other properties.

_Resin-based composites

The number of resin-based composites on the market is both impressive and overwhelming. Developments in composite technology over the last few decades has resulted in many novel products, and selecting the correct material for a specific clinical scenario is both daunting and perplexing. The following generic classification categorises contemporary resin-based composites, together with their properties and uses:

_1. *Hybrids:* Universal or general purpose; low wear resistance, long-term increase in surface roughness, for example posterior restorations, Class I and II.
_2. *Micro-filled:* More aesthetic than hybrids, retains surface polish/lustre over time, for example Class III, IV and V; highly filled (loaded) variants for extreme occlusal loads, for example Class I and II.
_3. *Nano-filled:* Similar to micro-filled, most aesthetic; aesthetically demanding regions of the mouth, high polishability, excellent optical properties (opalescence, fluorescence), for example Class III, IV and direct composite laminate veneers.
_4. *Micro- and nano-hybrid varieties:* Universal or general purpose.
_5. *Flowables:* Low viscosity, low MOE, low filler content. Suited for areas of low occlusal loads due to poor wear resistance, low strength and increased polymerisation shrinkage. However, polymerisation stress is also lower owing to the reduced filler content. Ideal for small pits and fissures not exposed to occlusal loads, primary dentition restorations, blocking undercuts for indirect prostheses (for example, inlays and crowns) and stress-relieving liners for deep Class I, II, V and large cavities, preferably fluoride-releasing varieties, for example giomer.

Ideally, composites should possess similar physical, mechanical and optical properties to the natural hard tissues they are replacing. Therefore, for highly aesthetic restorations, where appearance and optical issues are of paramount concern, the ideal choice is a micro- or nano-filled composite. However, the later are unsuitable for high-stress-bearing posterior restorations owing to poor wear, and in these circumstances a prudent choice is a universal composite, for example a hybrid or micro- or nano-hybrid.

Whilst resin-based composites have revolutionised restorative dentistry, they are not without their problems. The main reason for the failure of composite fillings is marginal breakdown and secondary caries.[20] However, it is not a *fait accompli*

Fig. 14_The pumice removes residues of the aluminium-oxide power.
Fig. 15_The rinsed tooth following cleaning with pumice.
Figs. 16a & b_Etchant is dispensed into the fissures (a) and continued to the surrounding uncut, aprismatic enamel (b).


Fig. 16b


Fig. 17


Fig. 18a

Fig. 17_The classical frosty appearance of etched enamel is clearly evident (compare with Fig. 12).
Fig. 18a_Vertise Flow is dispensed into the fissures.


Fig. 18b


Fig. 19a


Fig. 19b

Fig. 18b_Vertise Flow is dispensed onto the entire occlusal surface.
Figs. 19a & b_A brush is used to press Vertise Flow onto the enamel surface for 15–20 seconds (a) and to obtain a layer of < 0.5 mm thickness (b).

that secondary carious lesions will ensue in the presence of an open or discoloured cavo-surface margin. The current thinking is that patient risk factors, such as oral hygiene, dietary considerations and attitude towards dental treatment, are pivotal in determining whether decay will occur.[21]

As previously stated, marginal breakdown is attributed to polymerisation shrinkage of a composite during its setting stage, ranging from 2 to 5 % by volume,[22] causing stresses that lead to bonding failure and gap formation (Figs. 3 & 4). Polymerisation stresses can be mitigated by the clinical technique, MOE of the material and cavity configuration or the "C" factor. In an effort to circumvent polymerisation shrinkage, manufacturers have altered the chemical composition of composites to have favourable properties. These include varying the size, shape and volume of the inorganic filler particles, as well as improving adhesion of the fillers to the organic resin matrix. Other factors that reduce stresses are the method of setting reaction, for example using pulse curing,[23] and incremental build-up of the composite filling during placement.[24] Another technique (discussed below) is using flowable composites with a lower MOE as the initial base-lining layer to absorb polymerisation stresses and counteract forces at the restoration-dentine interface.[25]

_Flowable composites

Flowables, introduced nearly two decades ago, have become ubiquitous for many applications. They exhibit greater fluidity and elasticity, offering better adaptation to internal cavity walls and are very user friendly. In addition, the radiopacity of these resins allows effortless detection of secondary caries, and reveals marginal integrity or open margins. A restorative material should possess radiopacity that is slightly greater than enamel to distinguish decay,[26] and greater than the ISO minimum standard or equal to or greater than an equivalent thickness of aluminium. This is especially significant if flowables are used as intra-coronal initial lining layers below subsequent increments of universal composite. The ISO standard for minimum FS of outer occlusal restorative materials is 80 MPa, which is displayed by most of the current flowables on the market. The FS depends on the specific proprietary material, ranging from 70 to approximately 100 MPa, deteriorating over time, and is approximately 80 % compared with non-flowable analogues.

Although micro-leakage is a multifactorial phenomenon, MOE of the material is a crucial factor that determines its magnitude. Similar to FS, MOE is variable, depending on the product, ranging from 3 to over 11 GPa, and also decreasing over time. The viscoelastic properties of a flowable determine its flowability and clinical handling. The flow characteristics of flowable composites can be divided into low, medium and high flow.[27] Each variety is suitable for different clinical tasks. For example, a highly flowable material is desirable as a liner or fissure sealant, to adhere to cavity walls or fissures crevices intricately, while a less flowable variety is preferable for small cavities or repairs, where excessive slumping is a nuisance. Currently, most of the flowable composites possess little bacterial inhibitory potential, especially against *S. mutans*, the main infective agent of dental caries. Whilst a few flowables on the market claim anti-bacterial activity, the effect is usually

Fig. 20_The set Vertise Flow after appropriate light curing.
Fig. 21_Articulation paper is used to verify occlusal contacts. Notice extraneous flash material at the distal aspect of the permanent molar.
Fig. 22_For mandibular teeth, all occlusal contacts are removed, except those on the buccal supporting cusps. Notice that the distal flash material has been removed.


Fig. 20


Fig. 21


Fig. 22


Fig. 23


Fig. 24


Fig. 25

ephemeral, effective for only a few days.[28] Future composite developments should endeavour to incorporate both anti-bacterial and bioactivity in their formulations for enhanced therapeutic value.

In conclusion, flowables are useful for areas of reduced occlusal stresses, but are contra-indicated for bulk build-ups in stress-bearing areas. Their popularity is due to ease of use and flexible adaptability, especially in areas of limited access. The clinical applications include fissure sealing, small cavities, base liners, repairing voids in defective restorations and blocking undercuts for subsequent indirect prostheses.

_Evolution of a new resin-based restorative: Compobond

As discussed above, the state-of-the-art of dentine bonding systems are the SE agents that obviate the need to perform an initial etching phase, while yielding bond strengths that are comparable to bonding to enamel. Also, the pinnacle of resin-based composite technology is the introduction of nano and nano-hybrid composites. The advancements in both bonding agents and resins have now evolved by uniting these two materials to produce a new dental restorative: compobond.

Compobonds exploit the benefits of SE DBAs and nano-filled resins, eliminating the precursory bonding stage necessary to adhere a resin to tooth substrate, and are termed self-adhering composites. In essence, an era is emerging in which composites, similar to amalgam fillings, can be placed in a single step, eliminating errors, expediting protocols, and improving predictability and longevity of restorations.

The first compobond, called Vertise Flow (Kerr), was introduced in 2009, a self-adhering flowable combining a resin-based composite and an SE bonding agent based on the seventh-generation DBA OptiBond All-in-One (Kerr). Vertise Flow is a light-cured composite with similar properties to conventional flowables but with the added advantage of eliminating the bonding stage that is prerequisite before using any resin-based restorative (Fig. 5).

Characteristics and properties of Vertise Flow

Vertise Flow incorporates the properties of the DBA OptiBond, the first filled bonding agent introduced in 1992 (Fig. 6), that realised the potential of using a filled adhesive as a shock absorber beneath resin-based composite restorations. The bonding mechanism of OptiBond to dentine is two-fold: firstly, chemical adhesion is realised by the phosphate function group of the GPDM monomer (glycerol phosphate dimetharcrylate) uniting with the calcium ions within the tooth; and, secondly, micromechanical adhesion by formation of the hybrid layer composed of resin impregnation with the collagen fibres and the dentine smear layer. Initial SEM and TEM images from the University of Leuven, Belgium, show tight adaptation of Vertise Flow to both dentine and enamel. In addition, micro-leakage tests show that Vertise Flow's marginal integrity is comparable to conventional (i.e. non-adhering) flowable composite when used in combination with an SE bonding agent.[29]

The shear bond strength (SBS) achievable with Vertise Flow and dentine is approximately 25 MPa,

Fig. 23_The post-op view showing sealed fissures and the high lustre obtained after polishing with Opti1Step Polisher (compare with Fig. 11).
Fig. 24_Pre-op view showing cavitation in the occlusal surfaces of a maxillary molar and pre-molar. The molar also requires replacement of an occlusal defective composite filling.
Fig. 25_Cavity preparation using micro-diamond burs for minimising excessive tooth removal.

Fig. 26_All aprismatic enamel margins are carefully bevelled.
Figs. 27a & b_The initial layer of Vertise Flow should be < 0.5mm thickness (a) and spread with a brush to ensure intimate contact with the cavity walls and bevelled margins (b).


Fig. 26


Fig. 27a


Fig. 27b


Fig. 28


Fig. 29


Fig. 30

Fig. 28_The initial layer of Vertise Flow is light cured before adding further material.
Fig. 29_The finished restorations are polished with tips for a high lustre, ensuring impeccable integration with the surrounding enamel.
Fig. 30_Pre-op occlusal contacts to verify that the cavity is not in a stress-bearing area.

comparable to bonding to cut, prismatic enamel. However, the SBS is lower with uncut or aprismatic enamel, which is similar to using SE agents alone. For this reason, it is advisable to either bevel or etch aprismatic enamel beforehand to ensure a sustainable and durable marginal seal (Fig. 7). Conversely, pre-etching dentine when using Vertise Flow reduces the SBS to dentine, and is therefore contraindicated. Another disadvantage of pre-etching dentine is opening dentine tubules that may not be sealed to the same depth by the subsequent use of Vertise Flow, and could contribute to post-operative sensitivity.

The chemical composition of Vertise Flow incorporates four types of fillers, with a total 70 % loading. The inclusion of nano-ytterbium fluoride yields excellent radiopacity and fluoride release (for bioactivity), the pre-polymerised fillers reduce microleakage, and nanoparticles improve polishability and thixotropic properties. The FS is 120 MPa for mitigating bulk fracture, and the MOE is low, approximately 7 GPa, for shock absorbing capability (Fig. 8).

Because Vertise Flow functions as both a dentine adhesive and a resin restorative material, a longer curing time is necessary to ensure that both constituents are fully polymerised. In addition, the light-curing reaction also halts the etching process of the SE agent, increasing its pH from approximately 2 to 7, so that continual acidity does not erode the dentine bond.

A further advantage of Vertise Flow is inclusion of the acidic phosphate monomer, which provides chemical adhesion to a variety of intaglio surfaces of indirect prostheses, including non-precious alloys, gold, alumina, zirconia and silica ceramics, for example feldspathic, lithium-disilicate or other pressed ceramic systems. This adhesive property is exceptionally useful for repairing intra-oral fractured porcelain, for example all-ceramic crowns, inlays or onlays, or patching up chipped porcelain defects without replacing the entire prosthesis (Fig. 9).

The handling properties of Vertise Flow are favourable for numerous applications. For example, its viscosity occupies a middle ground, neither too viscous nor too runny, and therefore satisfies a wider range of clinical applications, both as a liner/sealant and for entire small cavity restorations. Vertise Flow is available in a selection of shades for the subtlest of aesthetic requirements, ranging from XL for bleached teeth to Translucent for fissure sealing that allows visibility of any future decay (Fig. 10).

Similar to glass-ionomers and their variations, compobonds offer adhesion to natural tooth substrate. However, whilst both materials have similar indications, their properties and handling characteristics vary considerably. Glass-ionomers essentially adhere exclusively to dentine, have low mechanical strength, average aesthetics and low wear, but offer both fluoride release and recharge. In addition, the setting reaction is affected by the degree of moisture of dentine, and involves a two-stage clinical procedure. On the other hand, compobonds offer dentine and enamel bonding, high mechanical strength, low wear, better aesthetics, a single-stage clinical procedure and fluoride release, but not fluoride recharge.

Fig. 31_After rubber dam isolation, pumice is used to cleanse the tooth.
Fig. 32_A cavity is prepared with bevelled enamel margins.
Fig. 33_Post-op view showing the cavity restored with A3 Vertise Flow.


Fig. 31


Fig. 32


Fig. 33


Fig. 34


Fig. 35


Fig. 36

_Clinical applications of Vertise Flow

The clinical uses of Vertise Flow are not unlike those of conventional flowables, but with the added advantage of eliminating the bonding stage. Below are some suggested applications.

Fissure sealing

One of the fundamental treatments for preventative dentistry is fissure sealing of posterior permanent teeth soon after their eruption into the oral cavity. Traditionally, this has been achieved solely with enamel etching, relying on micromechanical retention, and depending on diet, the fissure sealants require periodic replacement or repair. Using Vertise Flow instead of conventional fissure sealants offers not only micromechanical retention, but also chemical adhesion to the enamel via the SE agent that links with the calcium ions from the hydroxyapatite matrix.

The following case reports on fissure sealing of a first permanent molar tooth in a 14-year-old child. Ideally, the tooth should be isolated with a rubber dam to ensure moisture control and a clear operating field (Fig. 11). Initially, the tooth was air abraded with aluminium-oxide powder to clean the pits and fissures, remove the plaque biofilm, superficial incipient decay and, if present, remnants of old fissure sealants (Fig. 12). The cleansing was continued with a slurry of pumice to eliminate residues of the aluminium powder (Figs. 13 & 14). After rinsing off the pumice (Fig. 15), 37 % phosphoric acid was dispensed to etch the pits and fissures (Fig. 16a) and surrounding uncut, aprismatic enamel (Fig. 16b). The classic frosty etched enamel appearance was clearly visible after rinsing off the etchant and drying the occlusal surface (Fig. 17).

Since Vertise Flow should be refrigerated to ensure extended shelf life and optimal performance, it is advisable to remove it beforehand to so that the material reaches room temperature. The Translucent shade of Vertise Flow was dispensed generously (Figs. 18a & b) and brushed onto the enamel to ensure intimate contact with its surface, and spread to a thin layer of less than 0.5 mm (Figs. 19a & b). The coated surface(s) were light cured for 20 seconds with a curing light with an output of 800 MW/cm^2 (Fig. 20). The rubber dam was then removed and articulation paper placed to check occlusal contacts (Fig. 21). All the articulation paper marks, except those on the supporting buccal cusps (palatal cusps for maxillary teeth), were adjusted and polished with Opti1Step Polisher (KerrHawe SA; Figs. 22 & 23).

Small, non-stress-bearing, non-contacting cavities

Small cavities in areas of minimum occlusal stress are ideal candidates for minimally invasive, microdentistry. Incipient carious lesions either can be monitored if the patient risk factors are low or may require intervention for patients with a propensity for dental decay. In this case, a 13-year-old female patient, who is an occasional attendee and relatively indifferent to dental treatment, was treated.

The preoperative status shows the maxillary second pre-molar and first molar with occlusal cavitations, and an old defective composite occlusal restoration in the molar (Fig. 24). Cavity preparation was carried out using small diamond burs specifically

Fig. 34_Pre-op view showing defective amalgam fillings in two mandibular molars. Pre-op occlusal contacts are identified before placing the rubber dam.
Fig. 35_The old amalgam restorations are removed.
Fig. 36_After removing soft decayed dentine, the enamel margins are finished with a 90° cavo-surface angle and etched with phosphoric acid for 15 seconds.

Fig. 37_The etched enamel peripheries are clearly visible on the second mandibular molar.
Fig. 38_The etched enamel peripheries are clearly visible on the third mandibular molar.
Fig. 39_Vertise Flow is dispensed into the cavity.


Fig. 37


Fig. 38


Fig. 39


Fig. 40a


Fig. 40b


Fig. 41

Figs. 40a & b_A brush is used to spread the Vertise Flow on the cavity walls (a) and floor, ensuing that it is evenly spread with a thickness less than 0.5 mm (b).
Fig. 41_The initial Vertise Flow lining is light cured.

designed to minimise removal of tooth substrate (Fig. 25). Current research shows that it is unnecessary to remove all decayed dentine. Instead, the cavity margins are clearly defined for creating a hermetic seal for guarding against the negative effects of the dental biofilm, which perpetually colonises the tooth surface.[30] As previously mentioned, in order to improve bond strength to aprismatic enamel, the margins can be either etched or bevelled (Fig. 26). The initial layer of Vertise Flow should be less than 0.5 mm in thickness and pressed into the recesses of the cavity floor and walls (Figs. 27a & b). The initial layer of Vertise Flow was first light cured (Fig. 28) before completing the cavity with additional layers. Finally, the restoration was polished with Opti 1Step Polisher and an OptiShine brush (KerrHawe SA) to yield a high lustre gloss (Fig. 29).

Class V and small buccal cavities

Class V cavities have variable presentations. The exposed dentine in Class V cavities can be the result of enamel loss due to erosion, abrasion abfraction or infectious caries. The dentine reaction is highly erratic, often leading to formation of hyper-mineralised sclerotic dentine that is resistant and less receptive to dentine adhesion.[31] Therefore, in the presence of sclerotic dentine, all DBAs are less efficacious and present a challenge for dentine bonding. For this reason, Vertise Flow is unsuitable for Class V lesions with blatant dentine hyper-mineralised sclerotic dentine.

If sclerotic dentine is absent, adhesion with DBAs is superior (28 MPa) compared with compomers (15 MPa) or a glass-ionomer (2.5 MPa).[32] For small buccal cavities within enamel, Vertise Flow is the ideal material of choice, as shown in the following case.

Preoperative articulation paper marks verified that the buccal lesion was free of occlusal, stress-bearing contacts (Fig. 30). After isolation with a rubber dam, the tooth was cleaned with a slurry of pumice (Fig. 31) and a cavity was prepared with bevelled enamel margins (Fig. 32). The final result shows restoration of the cavity with A3 Vertise Flow after polishing with Opti 1Step Polisher (Fig. 33).

Stress-relieving linings

The rationale for using different composites for various increments of a restoration is that the materials should possess similar properties to the natural dentine and enamel they are replacing. Dentine has a lower MOE and is therefore better able to absorb stresses than enamel. For this reason, in circumstances in which the cavity extends into dentine, the initial layer of composite should have shock-absorbing capabilities that are similar to dentine.

The polymerisation contraction stresses of a resin-based composite are directly related to its filler volume, which also affects its mechanical properties, such as wear resistance and MOE. High filler content results in less contraction, which in turn influences the marginal integrity of the restoration.[33] Flowables have approximately 25 % less filler than their non-flowable counterparts and therefore undergo increased volumetric shrinkage. However, since flowables have about 50 % less MOE than non-flowables, they can absorb more stresses and, in theory, maintain superior marginal integrity.[34]

The MOE of flowables ranges from as low as 1.4 GPa (low filler volume) to as high as 12.5 GPa (high filler


Fig. 42


Fig 43


Fig. 44

Fig. 42_A regular composite, Herculite XRV Ultra, is used in increments for replacing dentine and building up individual buccal and lingual cusps.
Fig. 43_An endodontic file, loaded with brown Kolor + Plus stain, is dragged through the unset composite resin to create fissure patterns in the second molar restoration.
Fig. 44_An endodontic file, loaded with brown Kolor + Plus stain, is dragged through the unset composite resin to create fissure patterns in the third molar restoration.


Fig. 45


Fig. 46


Fig. 47

content).[35] In addition to filler content, other constituents such as the type and quantity of resin, photoinitiators and accelerators also influence the final MOE of the material. As a generalisation, flowables with a lower MOE may act as shock absorbers when placed as pre-cured liners below subsequent increments of non-flowables. But current studies are inconclusive regarding this beneficial property,[36, 37] and further research is necessary to clarify the issue.

In the following case, large Class I cavities in two mandibular molars were restored using Vertise Flow as an initial layer to act as a shock absorber before completing the restoration with subsequent layers of a non-flowable composite. This case shows the second and third mandibular molars with defective amalgam restorations requiring replacement. In addition, these teeth also exhibit bruxism activity with tooth wear, resulting in occlusal enamel loss. Initial occlusal contacts were verified (Fig. 34) before placing a rubber dam and removing the amalgam restorations. Notice the extensive decay in the third molar (Fig. 35). Since molars are prone to high occlusal forces, placing bevels on enamel margins is unsuitable because the thin layer of composite resin periphery is likely to fracture during mastication. However, to achieve an efficacious bond to aprismatic enamel, it is prudent to etch the periphery while maintaining a 90° cavo-surface angle (Fig. 36).

After thoroughly rinsing and drying, the etched enamel periphery of both cavities was clearly visible (Figs. 37 & 38). Vertise Flow was dispensed into the cavity, brushed to ensure that the material was evenly spread along the cavity walls and floor, making sure that its thickness did not exceed 0.5 mm (Figs. 39–40b). This initial layer of Vertise Flow was light cured for 20 seconds and acted as the stress-relieving lining (Fig. 41). Subsequent layers of the filling were built-up using increments of a regular composite, Herculite XRV Ultra (Kerr), to replace dentine, and then successively building-up the buccal and lingual cusps[38] separately without contacting the opposing sides (Fig. 42).

Staining fissures is a contentious issue; some patients are indifferent to this practice, while others adamantly refuse to have their teeth stained. For those patients who are unconcerned, fissure staining and patterns impart a realistic appearance to a composite filling. The technique involves using different stains, for example Kolor + Plus (Kerr), that are dragged through the unset composite resin using an endodontic reamer or file (Figs. 43 & 44). Once the desired fissure pattern had been created, the composite was light cured (Figs. 45 & 46). After removing the rubber dam, articulation paper was used to check occlusal contacts (Fig. 47), and necessary adjustments were made to ensure occlusal harmony. The final stage was achieving a high surface lustre and texture using Opti1Step Polisher. The post-operative view shows composite fillings emulating natural cusps and fissure patterns, with imperceptible transition between the composite filing and surrounding enamel (Fig. 48).

Blocking undercuts

Another useful application of flowables is blocking undesirable undercuts prior to providing indirect restorations. Undercuts often complicate many clinical and laboratory procedures, for example impres-

Fig. 45_Once the fissure pattern has been established, the composite is light cured in the second molar.
Fig. 46_Once the fissure pattern has been established, the composite is light cured in the third molar.
Fig. 47_After removing the rubber dam, occlusal contacts are checked using articulation paper.

Fig. 48_The filling is polished to a high lustre with Opti1Step Polisher, ensuring an indiscernible transition between the composite filling and surrounding natural tooth.
Fig. 49_Underlying decay is evident after removing an old amalgam filling from the maxillary molar.
Fig. 50_Undercuts are evident following excavation of soft, carious dentine.


Fig. 48


Fig. 49


Fig. 50

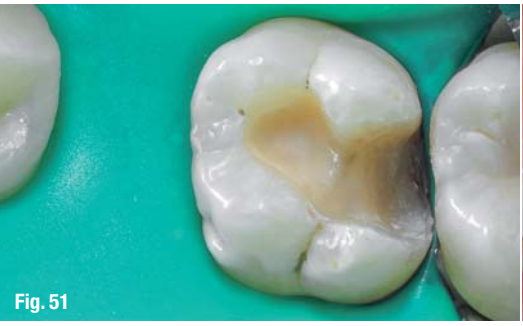
Fig. 51


Fig. 52


Fig. 53

Fig. 51_Vertise Flow is used to block the undercuts and acts as a stress-relieving lining.
Fig. 52_Pre-op view showing a distal fracture of the all-ceramic crown on the maxillary left central incisor.
Fig. 53_Shade analysis to ascertain colour of existing crown. Vertise Flow A2 and Translucent shades were selected to repair the fractured porcelain.

sion making or restoration fabrication. Unwanted sharp line angles or deficiencies, such as voids, can readily be blocked and sealed with the easily adaptable flowable composites for both intra- and extra-coronal tooth preparations.

In the following case, a large amalgam restoration with underlying profound decay was scheduled for an indirect ceramic inlay. After isolation with a rubber dam, the amalgam filling from the maxillary molar was removed, revealing gross carious dentine (Fig. 49). All soft, carious dentine was exacted, leaving blatant undercuts (Fig. 50). Due diligence was exercised not to remove all the hard, deeper decayed dentine to avoid possible pulpal exposure. In this instance, Vertise Flow has a dual function: firstly, to block undercuts; and, secondly, to act as a stress-absorbing liner for the subsequent indirect ceramic inlay (Fig. 51).

Repair

Lastly, Vertise Flow can be used for minor repairs, for either chairside or laboratory-made, acrylic based temporary restorations such as crowns with air blows or chips or fractures after a period of use in the mouth. Once again, the repair protocol is simplified and predictable, involving a single step, with the added benefit of the SE bonding agent within Vertise Flow.

Another form of repair involves the increasingly problematic fractures associated with ceramic prostheses, such as crowns or inlays. Since these types of all-ceramic indirect restorations are increasingly popular, the number of fractures is also becoming progressively more common, and replacement is costly. Traditionally, ceramic fracture repair involved several stages, that is etching with hydrofluoric acid, silanation and repairing with conventional resin-based composites, either a flowable or non-flowable variety.

As previously mentioned, Vertise Flow incorporates an acidic phosphate monomer, which links chemically to many ceramic substrates, such as silica, alumina and zirconia. Therefore, after roughening the fracture "lesion" with a diamond bur, only a single step is necessary with Vertise Flow, which combines both chemical bonding and a repairing composite to "heal" the fracture.

The following case illustrates repair of a fractured, alumina core crown, veneered with silica (feldspathic) porcelain. The patient presented with a distal fracture of the all-ceramic crown on the maxillary left central incisor (Fig. 52). A shade analysis was performed with the Vita Classic shade guide (VITA). Vertise Flow A2 was chosen for the body of the crown, and the Translucent shade for the incisal edge translucency (Fig. 53). Initial cleansing was carried out with a slurry of pumice to remove the plaque biofilm (Fig. 54).

To increase the surface area for bonding, the fractured porcelain requires pre-treatment roughening, which can be achieved either mechanically or chemically. The choice is mainly empirical, depending on the clinician's personal experience and penchant for either technique. Mechanical roughening involves using a rotary instrument followed by cleansing the site with phosphoric acid (Fig. 55), which does not etch porcelain, but removes any remaining debris (Fig. 56).

Fig. 54_Pumice is used to cleanse the crown and remove any plaque biofilm.
Fig. 55_The porcelain surface is mechanically roughened with a diamond bur and then cleansed with phosphoric acid.
Fig. 56_Prepared porcelain site.


Fig. 54


Fig. 55


Fig. 56


Fig. 57


Fig. 58


Fig. 59

The chemical method involves etching the porcelain with hydrofluoric acid for three minutes. It is important to note that only silica-based ceramics can be etched with hydrofluoric acid, and if the fracture extends deeper into an alumina or zirconia substructure, the latter will require mechanical roughening with a diamond bur.

Customarily, the next stage is application of hydrofluoric acid and silane for creating a silica–silane bond. However, this is superfluous when using Vertise Flow, as the later incorporates an acidic phosphate monomer that bonds to silica, as well as alumina and zirconia ceramics. The A2 shade of Vertise Flow was dispensed directly onto the etched fracture site (Fig. 57), and spread intimately, ensuring firm contact with the porcelain (Fig. 58). In order to mimic the incisal edge translucency, the Translucent shade of Vertise Flow was used at the incisal edge (Fig. 59), and slightly overbuilt to compensate for the polishing stage (Fig. 60). Finishing and polishing were carried out using sequentially finer grit discs (OptiDisc, Kerr; Fig. 61), creating a surface roughness (Ra) of approximately 0.2 µm, equal to or less than the threshold required for bacterial and plaque adhesion (Ra = 0.2 µm).[39] The post-operative result shows the polished repair harmoniously blending with the surrounding porcelain (Fig. 62).

Similar to porcelain repairs, existing chipped or marginally stained composites (both direct and indirect restorations) can be effortlessly repaired. The protocol is minimally invasive, economical, quick and spares the patient protracted appointments to replace the entire restoration, which can instead be monitored at periodic recalls.

_Conclusion

This article has introduced the evolution of a new dental restorative material, the compobonds. The discussion has focused on the rationale for the development of compobonds, citing technological advances in both DBAs and resin-based composite formulations. In addition, a proprietary product, Vertise Flow is described as the first generation of flowable compobonds with clinical applications similar to existing flowable composites, and some novel uses, such as direct, intra-oral, porcelain fracture repairs. The benefits of combining an SE DBA with a composite-resin eliminate the technique-sensitive protocols associated with dentine bonding, making the entire process simpler and more predictable. However, as with any new material, scientific scrutiny and clinical trials will untimely judge the efficacy of compobonds and, if successful, will pave the way for non-flowable varieties to simplify direct composite restorations._

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

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Fig. 57_The A2 shade of Vertise Flow is dispensed onto the site.
Fig. 58_A brush is used to spread the Vertise Flow to cover the fracture site.
Fig. 59_The Translucent shade of Vertise Flow is used to build the incisal edge.


Fig. 60


Fig. 61


Fig. 62

Fig. 60_Palatal view showing the overbuilt repair before polishing.
Fig. 61_Polishing is carried out with various grits of OptiDisc to create a high lustre.
Fig. 62_Post-op view showing the "invisible" repair with a smooth texture and high lustre, impeccably blending with the surrounding porcelain.

One step closer to nature: Imitating natural optical properties using lithium-disilicate restorations

Author_ Dr Bradley L. Jones, USA


Fig. 1


Fig. 2

Figs. 1 & 2_Pre-op 1:2 view showing discoloured temporary repairs to the central incisors.

_**The dental laboratory industry** has searched for a material that is structurally sound and highly aesthetic. This material is now available in lithium-disilicate glass ceramic (IPS e.max Press, Ivoclar Vivadent), which is a material like no other in dentistry. The IPS e.max Press lithium disilicate is the first structural (long-lasting) material that is aesthetic, even without layering, when its High Translucency ingots are used.

Its high strength comes from the lithium-disilicate crystals. The IPS e.max lithium disilicate is composed of quartz, lithium dioxide, phosphoric oxide, alumina, potassium oxide and other components. Overall, this composition yields a glass ceramic that shows low thermal expansion when it is processed.

Polyvalent ions dissolved in the glass provide the desired colour of the lithium-disilicate material. These colour-releasing ions are homogeneously distributed in the single-phase material, resulting in the elimination of colour pigment imperfections in the microstructure.

With its four levels of opacity and translucency—High Opacity, Medium Opacity, Low Translucency and High Translucency—IPS e.max Press enables laboratory ceramists to satisfy different aesthetic demands and deliver a beautiful and strong restoration. Overall, these materials demonstrate specific advantages, such as higher edge strength versus traditional glass-ceramic materials (can be finished more thinly without chipping); the low viscosity of the heated ingot, which enables pressing to very thin dimension (enabling minimal preparation or no-preparation veneers); and a chameleon effect owing to higher translucency. In some cases, minimal tooth preparation is needed (for example, thin veneers) and IPS e.max lithium disilicate enables restorations to be pressed as thin as 0.3 mm, while still ensuring strength of 400 MPa.

This article guides readers through the process of accurately maintaining the incisal edge position, length, shape and contour of provisional restorations when fabricating final IPS e.max Press anterior restorations. Additionally, if one were to


Fig. 3

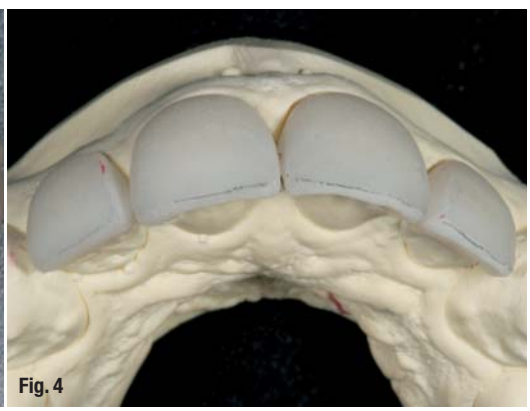
Fig. 4

Fig. 3_An approved model of the provisional restorations was perfected by adding wax and reducing stone.
Fig. 4_The facial incisal area was bevelled back 0.5 mm using a contour stone.

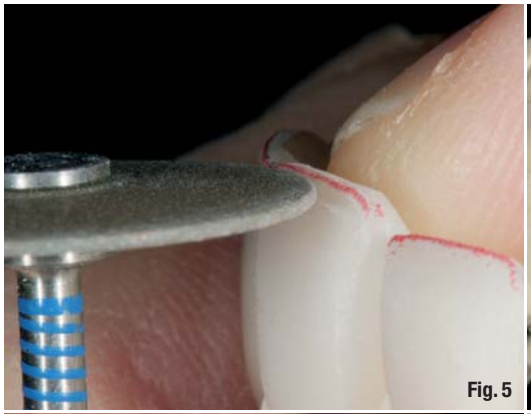
Fig. 5

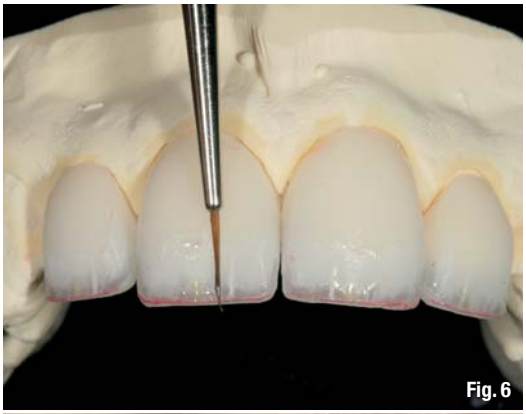
Fig. 6


Fig. 7


Fig. 8

Fig. 5_An undercut was made inside the silhouette of the incisal half to ensure the establishment of a halo effect.
Fig. 6_After smoothing out the incisal facial area, grey, vanilla and salmon stains were applied to create internal effects, then fired.
Fig. 7_IPS e.max OE4 was placed to shape the internal lobe structures. They were feathered out after being formed.
Fig. 8_To reproduce a natural halo effect, IPS e.max MM Light was added.

take the enamel (0.5 mm) off a natural tooth, the internal dentine effects would be visible. The technique described here also provides a step-by-step guide to precisely mimicking these internal effects. By enamelling over these effects quickly and accurately, the restoration can be returned to full contour, while including natural optical effects and segmenting both high- and low-value enamels.

_Case presentation

A 19-year-old male patient wished to improve the overall appearance of his smile (Figs. 1 & 2). As a child, he had chipped both central incisors and needed several temporary repairs that were performed by a dentist over the years.

The patient underwent a thorough examination. To ensure proper shade matching and design of the restorations, a complete laboratory aesthetic prescription, detailed shade mapping, alteration of the type of light source used to take the shade, the amount and colour of the incisal translucency, and surface texture were obtained and recorded.

An approved model of the provisional restorations was perfected by adding wax and reducing stone (Fig. 3). With a pair of dividers, the exact lengths were verified using a model of the provisional restorations.

After the facial incisal edge had been out-lined using a red pencil, a 0.3 mm lead pencil line was placed 0.5 mm lingually. A contour stone (Komet 9001,

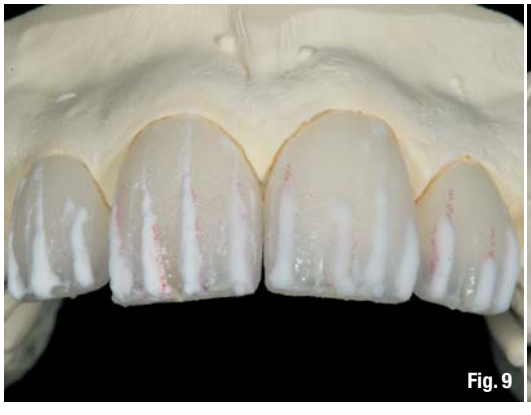
Fig. 9


Fig. 10

Fig. 9_IPS e.max OE3 was applied in thin segments to the line angles and strategic places.
Fig. 10_The IPS e.max TI1 was built in flush with the previously fired OE3 height of contour and high-value segments to full contour.


Fig. 11


Fig. 12

Fig. 11_A coarse rubber wheel was used to re-establish the deflective zones and redefine the line angles.
Fig. 12_Completed restoration on the model.

Komet) was used to bevel the facial incisal edge back 0.5 mm (Fig. 4). The value was drawn in and a centred diamond disc (Komet K6974) was used to carefully cut in the value area, making certain that a halo effect was established (Fig. 5).


Fig. 13


Fig. 14

Figs. 13 & 14_Post-op 1:2 view of the patient's new smile.

Using a contour stone (Komet 9001), the incisal facial area was smoothed out to create a canvas for the internal effects. To create the internal effects, grey, vanilla and salmon IPS e.max Essence stains were applied and fired (Fig. 6).

IPS e.max Opal Effect 4 (OE4) was placed to shape the internal lobe structures softly. Once the internal lobes had been formed, they were feathered out (Fig. 7). IPS e.max Mamelon (MM) Light was added to reproduce a natural halo effect (Fig. 8). After a thorough and careful evaluation, the external effects were fired.

A red pencil was used to identify the line angles, as well as places for a segment of high-value powder. IPS e.max Opal Effect 3 (OE3) was applied to the line angles in thin segments, as well as to strategic places, to achieve a natural optical effect and re-establish the heights of the contour (Fig. 9).

The segments of IPS e.max OE3 were built to 0.5 mm, which was the exact thickness of the initial facial cut-back, making it faster and easier to return to the original full contour. IPS e.max OE3 was fired to ensure that the high-value segments mimicked the enamel optics found in the natural teeth, after which the IPS e.max Transpa Incisal 1 (TI1) was built flush with the previously fired OE3 height of the contour and high-value segments to full contour (Fig. 10).

The restorations were bisque baked. Then, after using a diamond bur (Komet 842R) to smooth the facial surface, a coarse rubber wheel (Komet 9472C) was used to re-establish the deflective zones and redefine the line angles (Fig. 11). The facial lobes were recreated with a diamond bur (Komet 842R) after the desired amount of perikymata had been added with a diamond bur (Komet 850 016). The restorations were then glazed and polished.

_Conclusion

Today's patients have become increasingly more Internet savvy, demanding higher aesthetics and longer-lasting restorations. In my opinion, IPS e.max Press offers the ceramist—for the first time in the history of this industry—a restorative material that is both beautiful and incredibly strong. It surpasses our patients' expectations, as demonstrated in the case illustrated here (Figs. 12–14).

_Acknowledgement

I would like to acknowledge Dr James Gorczyca from Boise, Idaho, for his exceptional excellence in dentistry._

_contact cosmetic dentistry

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※ *In alphabetic order*

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- Erika Benavides (USA)
- Giulio Rasperini (Italy)
- Hom-Lay Wang (USA)
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Record-breaking IDS 2011

Author_Yvonne Bachmann, Germany

Photos: Koelnmesse GmbH

_With 115,000 visitors and nearly 2,000 exhibitors, this year's International Dental Show (IDS) was the biggest dental trade show ever. The show boasted a 9 % increase compared with 2009. People from 148 countries travelled to Cologne to see new products, learn about innovative treatment methods and network with other dental professionals. Exhibitors from 85 countries seized the opportunity to establish and further contacts, win new customers and open up new markets.

"The world's leading dental trade fair IDS closed, having achieved outstanding results," the organisers summed up after five busy days. Organisers and exhibitors were especially pleased with the large number of visitors from abroad. "The most customers we've had so far are from abroad," Marian Tempel, responsible for marketing at Korean company Neobiotech, told cosmetic **dentistry** on the third day of the exhibition. IDS visitors came mainly from Latin America and South America, Australia, the US and Canada, but also from Italy, France, the Netherlands, Spain, the UK, Switzerland, Russia, Ukraine, Turkey, Israel, China and India. The exhibition halls were constantly busy and booths extremely well visited. According to the exhibitors, 66 % of which came from

outside Germany, representatives of everything related to dentistry—dental practices and laboratories, trade, the higher education sector—visited their booths. The trade show meant a huge financial success for many exhibitors. Many companies took numerous orders, both domestically and internationally.

"We have succeeded in making IDS even more attractive, both domestically and internationally. The strong increase in international participants especially shows that IDS is the world's leading dental trade show," Dr Martin Rickert, Chairperson of the Association of German Dental Manufacturers, said. "Participants were able to forge high-quality business contacts between industry and trade professionals as well as between the industry, dentists and dental technicians. Thus, the trade fair once again signalled better times ahead and generated momentum that will help the dental sector stay on course for a successful business year."

Koelnmesse Executive Vice-President Oliver P. Kuhrt added: "IDS more than satisfied everyone's expectations. Once again, IDS offered a whole range of new products and excellent opportunities to exchange information, communicate with partners and place orders. That's why exhibitors, visitors and media representatives were all delighted with the trade fair."

A visitor survey carried out during IDS found that not only exhibitors, but also trade visitors considered the exhibition a success. According to the organisers, 95 % of the respondents indicated that they were satisfied/very satisfied with the event. They were pleased with the range of products and had achieved their goals at the trade fair. Furthermore, 93 % would recommend a visit to IDS to a close business associate. "It's my first time at the IDS and this is the biggest dental trade fair I have ever been to. I have scheduled three days to see everything," Dr Dusan Dimitrijevic told cosmetic dentistry. This dentist from Serbia brought his son and second-year dental student Lazar with him to Cologne.

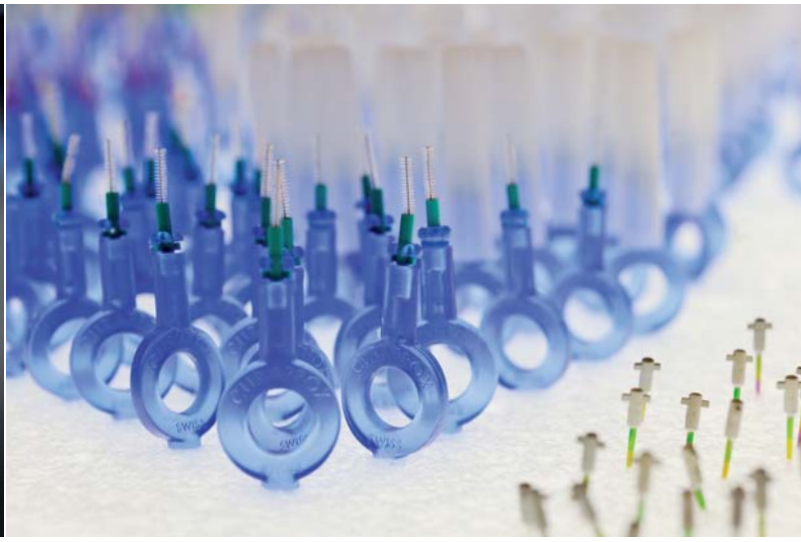
_Focus on digital innovation

This year, the focus of interest was on the innovative new products and technologies on display. According to Dr Rickert, the trade fair demonstrated that digital processes and technologies are becoming increasingly popular, since they facilitate even more efficient and higher quality treatments. In particular, products and systems that offer users and patients improvements in preventative care, diagnostics and dental treatment were in high demand. Those include ultrasound systems with expanded capabilities that enable painless and professional preventative care, digital intra-oral

scanners, improved root-canal treatment methods, new dental filling materials, aesthetic dental crowns and bridges that look most natural, as well as improved digital X-ray diagnostics that are especially useful in the field of implantology.

"As far as we are concerned, the trade fair was very successful," said Jost C. Fischer, Chairperson and CEO of Sirona Dental Systems, leader in CAD/CAM technology. "The number of visitors was amazing. In fact, all of our employees were in dialogue around the clock. You could clearly see that the economy has picked up again. As a result, the atmosphere at the fair was extremely positive. In my opinion, it was the best IDS ever."

Jürgen Schwichtenberg, President of the Association of German Dental Technicians' Guilds (VDZI), an IDS partner, was also very pleased with the trade fair. "From the point of view of the dental technician trade, the IDS 2011 once again proved the dental sector's innovative power. Considering the variety of products on display in Cologne and the rapid development of new, particularly digital technologies, it will be even more important in the future for dental technicians to actively supplement these new technologies and solutions with their expert knowledge and to put these into practice in their laboratories in order to ensure an all-round high-quality treatment. Our partners in the dental industry in general and dentists in particular will be able to continue to rely on these important services."



One partnership that was started at IDS is becoming an important political aspect of the profession: collaboration between the VDZI and the European Association for Dental Technology. The aim of the collaboration is to combine dental technology expertise and provide further training of the highest standard in both theory and practice so that practitioners can learn about the latest state-of-the-art dental technology.

_Speakers' Corner well visited

Many IDS visitors took advantage of the Speakers' Corner feature to gather information on the latest developments in science and research. Around 80 exhibitors presented their new products and technologies. The presentation topics included implant systems, digitisation, dental aesthetics, laser technology, dental anaesthesia and the benefits of modern stress management for dentists.

Dr Peter Engel, President of the German Dental Association (GFDI), one of the IDS organisers, is happy with the positive outcome of the trade fair: "Even more visitors and exhibitors than in previous years can mean only one thing: The profession is progressive and medium-sized German businesses are fostering innovation—and they're attracting enormous interest internationally."

At the exhibition, the GFDI held a coordinating conference for aid organisations, at which over 40 participants presented aid projects seeking to improve the dental health of the world's poor. The projects were developed by dentists and dental students who work in impoverished regions all over the world. Some of them also work in Germany. They provide dental services to a range of disadvantaged patients, including orphans, homeless people, disabled patients, drug addicts and inhabitants of remote areas, who would not receive treatment otherwise. To do this work, dentists and students often have to overcome enormous challenges. The coordinating conference offered participants a special opportunity to share their experiences in organising aid efforts.

In collaboration with the VDZI, the GFDI will also organise the 35th IDS, which will take place from 12 to 16 March 2013._

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Published by
Oemus Media AG
Holbeinstraße 29
04229 Leipzig, Germany
Tel.: +49-341/4 84 74-0
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kontakt@oemus-media.de
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Printed by
Messedruck Leipzig GmbH
An der Hebemärchte 6
04316 Leipzig, Germany

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is the official publication of:

THE ASIAN ACADEMY OF AESTHETIC DENTISTRY EST. 1990

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