Extreme masking: achieving predictable outcomes in challenging situations with lithium disilicate bonded restorations

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Abstract

In contemporary dentistry, we have a vast range of materials to choose from, and metal free restorations have become the premier materials for achieving the ultimate in both esthetics and durability.

Metal-free restorations are utilized with more conservative preparations to preserve the vital natural dentition, and have proven to be superior alternatives to traditional porcelain-fused-to-metal (PFM) restorations in many cases.

There are always "pros and cons" when selecting materials, and to make the best choice it is essential for dental professionals to plan precisely and understand their options in any clinical situation.

Selecting suitable materials and techniques involves consideration of the following factors:

- Esthetic zone.
- Required strength based on the patient's occlusion/dental habits.
- Preparation reduction.
- Position of the margin.
- Type of restoration/preparation.
- The treating clinician's philosophy.
- Stump shade.
- Final shade.

One of the most significant challenges in the metal-free dentistry is the reproduction of natural dentition without the influence of a "negative stump" – a very dark or metal core showing through the final restorations.

There are many factors to be considered when working on such a case, and controlling the opacity of the coping and crown is the key to success.

This article presents a unique "outside of the box" technique that provides consistent, predictable and durable restorations, which provide the best possible esthetic outcome.

(Int J Esthet Dent 2014;9:204–220)

Understanding opacity and translucency – e.max vs zirconia

"Translucency"[1] is the degree to which light is transmitted rather than absorbed or reflected. The highest translucency is transparency (all light transmitted) whilst the lowest is opacity (all light reflected or absorbed). In general, the higher the translucency, the lower the value (the relative lightness or darkness of the hue).

Figures 3a to 6b show the comparison of masking ability – e.max HO (High Opacity) 0 ingot (Ivoclar Vivadent, Liechtenstein) VS Lavaä Zirconia white coping (3M ESPE, Germany) in different thicknesses.[3]

In this experiment, a light dentin colored stump (IPS Natural Die Material ND1, Ivoclar Vivadent) (Figs 3a, 4a, 5a, and 6a) and a dark colored wax stump (Creation Set - YETI Dentalprodukte) (Figs 3b, 4b, 5b and 6b) were used.

At 0.4 mm thickness (Figs 4a and 4b), while the e.max coping held its value reasonably well, the Lava Zirconia showed a negative effect from the stump – its value was noticeably lower on the dark stump. At 0.6 mm (Figs 5a and 5b), while the masking ability of e.max was fully effective, the Lava Zirconia still showed some negative effect from the stump. At 0.8 mm (Figs 6a and 6b), Lava Zirconia is finally able to hold its value but the masking effect is still not perfect. In conclusion, the opacity of e.max HO ingots is superior to that of Lava Zirconia.

Under normal circumstances, the translucency of Lava Zirconia is beneficial for achieving life-like esthetics as the color of the coping mimics the color of natural dentin structure. However, it is less suitable for masking purposes where a greater thickness in the substructure cannot be maintained.

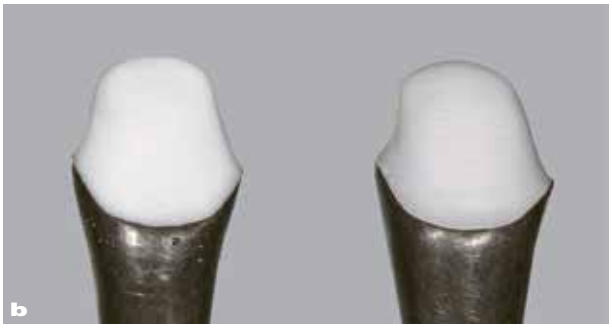
Ideally, any required masking should be completed within the substructure rather than during the build up, so selecting suitable materials in accordance with consideration of the factors mentioned earlier will determine the success of the case.

Fig 1 Example of dark/metal core stump.

Fig 2 Example of dark/metal core stump.

Fig 3a IPS Natural Die Material – ND 1.

Fig 3b Example of extremely dark core – black.



Figs 4a and 4b e.max HO 0 ingot 0.4 mm coping (left), Lava Zirconia 0.4 mm coping (right).

Figs 5a and 5b e.max HO 0 ingot 0.6 mm coping (left), Lava Zirconia 0.6 mm coping (right).

Figs 6a and 6b e.max HO 0 ingot 0.8 mm coping (left), Lava Zirconia 0.8 mm coping (right).

Case study

Pre-operative assessment

This case study presents the reconstruction of a single central incisor on 11 (upper right) for a male patient in his thirties. The patient presented with a temporary restoration *in situ*.

This was a traumatized case, with the tooth having a very dark non-vital stump with a gold core (Fig 7). The patient had previously been treated with multiple PFM restorations by different clinicians, but had never been satisfied with the final outcome.

The stump shade is the most essential information that the clinician needs to pass on to the ceramist when working on any metal free restorations as it has a significant impact on the final outcome of the restoration. Any shade guide can be used against the matching tooth to assess the color of the stump, and the ceramist can reproduce the stump using light cure composite material to mimic the color of the stump during the manufacturing process. Cases should not proceed until the clinician provides the stump shade. Once the shade in this case was obtained, the case was able to proceed.

The patient was reasonably happy with the shape of the temporary restoration, but thought it was too narrow at the neck (cervical third: Figs 8 and 9), and this concern was to be addressed within the final restoration.

Having a record of retracted lower anterior dentition (Fig 10) helped to determine the degree of overall translucency as well as the value transition; for example, the centrals were a fraction brighter than the laterals.

A close-up of the lips at the rest position (Fig 11) helped to determine the amount of opalescence (which appeared to be bluish-white) and it also made any hypocalcification and fluorosis more noticeable.

In the author's opinion, clinicians and technicians should have an established process for taking series of photos to ensure consistency when gathering information, regardless of the type of case.

A smile photo (Fig 12) and a full-face photo was used to determine the esthetic zone, which in turn influenced the treatment plan, prep design and material selection.

Patients relate better to these photos than to more clinical dental photos, so the photos that had been taken were used during communication between the clinician, technician and patient during the treatment planning stage.

The patient is the ultimate judge of the final outcome of restorations in the esthetic zone, a factor of which dental professionals must always be aware. In other words, if it does not look good to the patient, it does not matter how it looks to the dental team.

Shade taking

When we selected the shade tab for color matching, the hue and value was established first as these factors influence the ingot selection[1]. As chroma could be easily added during the build, it was important to keep the substructure at lighter shades to maintain its value. This is particularly important when sufficient thickness cannot be maintained – the thinner the restoration, the higher the

Fig 7 Stump shade – a very dark stump with metal core.

Fig 8 Retracted frontal view with temporary restoration *in situ*.

Fig 9 Retracted view – upper 6 anterior dentition with temporary restoration *in situ*.

Fig 10 Retracted view – lower 6 anterior dentition.

Fig 11 Close up of lips at rest.

Fig 12 Smile photo presents the esthetic zone.

translucency, and the higher the translucency, the lower the value.

Build-ups are created from the inside out, so as always, the shades needed to be selected in the same order – coping or ingot color, then dentin and internal characteristics, and lastly, enamel layers and external stains.

Even untrained eyes (such as the patient's) can detect differences in value quite easily, so it was critical to have the correct value, whereas slight variations

Fig 13 Shade photo with B1 tab (Vitapan Classical, Vita).

Fig 14 Shade photo with A1 tab (Vitapan Classical, Vita).

Fig 15 Shade photo with BL4 tab (Bleach shade guide, Ivoclar).

Fig 16 Shade photo with A2 tab (Vitapan Classical, Vita).

in hue and chroma might be forgiven in various circumstances.

As can be seen, many people would struggle to detect the differences in hue between B1 (Fig 13) and A1 (Fig 14), but it is clear that the overall brightness of the BL4 shade guide is higher in value than the matching tooth (Fig 15). The chroma of the A2 shade tab was reasonably close to the cervical third of the matching tooth, as can be seen in Fig 16.

Fabrication of e.max HO block out coping

The HO block-out coping was fabricated using the traditional "wax and press" technique (Figs 17 to 19).

The design of the block-out coping mimicked a ¾ crown preparation by creating interproximal openness (Fig 19). This gave a greater fitting surface area in comparison to a one-plane veneer design, and therefore helped increase the mechanical bonding strength for the final restoration.

A minor retention groove was placed in the interproximal area (thereby creating some vertical undercut) to help the final restoration resist the horizontal occlusal force generated during lateral excursion or anterior guidance.

Figure 21 shows the thickness of the coping. The HO-0 ingot required is between 0.4 and 0.6 mm to mask the darkness of the stump as previously

Fig 17 Solid model with preparation.

Fig 18 Completed wax-up.

Fig 19 Pressed e.max HO 0 coping mimicking a ¾ crown preparation.

Fig 20 e.max HO ingots.

explained (Figs 4a to 6b), so a 0.6 mm thickness was applied on the cervical half labially to conceal the dark brown stump.

The gold colored metal core had minimal 'negative effect' upon the restoration, so in that area, 0.4 mm (the minimum thickness recommended by the manufacturer) was required.

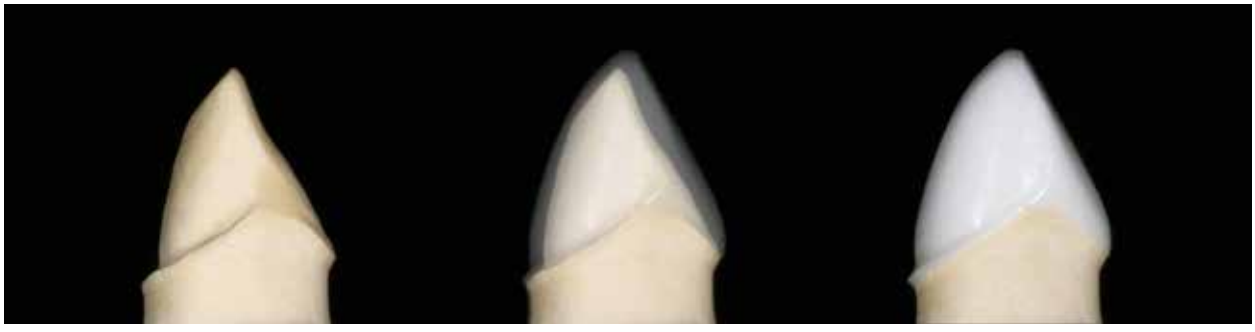


Fig 21 Profile view of preparation (left), pressed coping against preparation (middle) and pressed coping (right).

Fig 22 Stump shade.

Fig 23 HO 0 coping placed *in situ* using Variolink Veneer try-in paste HV+3.

Fig 24 Stained HO block out coping.

Fig 25 Application of Die Spacer.

The full anatomical shape was to be reproduced in the palatal region, hence the greater thickness of the coping in that region.

Assessing the effect of the e.max HO block-out coping

Figure 23 is an image of the block-out coping tried in using Variolink Veneer Try-in Paste HV+3 (Ivoclar Vivadent).

Although any try-in paste could be used due to the masking effect of the coping, the brightest and most opaque try-in paste was chosen to enhance the coping's masking effect. To ensure consistency, the same colored bonding/cementation material was planned for use during the cementation of the completed restoration.

Upon examination, there was no evidence of "negative effect" from the dark stump, confirming that full masking had been achieved. The value of the coping was obviously far higher than that of the matching adjacent tooth, so an increase of the chroma of the coping was planned.

Fabrication of e.max ¾ crown

To increase the chroma of the block out coping, IPS e.max Ceram stains and shades (Ivoclar Vivadent) were thinly

Fig 26 Completed wax-up.

Fig 27 e.max LT Ingots.

Fig 28 Completed layered veneer/¾ crown prior to glazing.

Fig 29 Completed, glazed and polished veneer/¾ crown prior to bonding.

applied (Fig 24). To increase the effectiveness of mechanical bonding, the surface should be rough rather than smooth. Glaze paste was not used at this point, and the base firing temperature was kept at around 725°C with no holding time (in other cases, the holding time and temperature can be varied depending on the furnace and placement of the restorations).

After the application of a die spacer (Fig 25), the coping was then processed with the traditional "wax and press" technique for the fabrication of the ¾ crown (Fig 26).

As the case's success was heavily influenced by ingot selection, a choice was made after taking the following factors into consideration:

- Stump shade
- Final shade
- Thickness of the restoration

This case had a need for the internal dentin structure to be reproduced, so an LT ingot was determined as the most appropriate (Fig 27).

With the LT ingot selected, the value of the ingot needed be increased by one shade from the final brightness. In this case, a basic value of A1/B1 was planned (Figs 13 and 14), so an LT BL4 ingot was chosen. Adding chroma during a build up is not difficult, but regain-

ing value is a greater challenge. Consideration was also given to the tendency of layered translucent porcelain to also drop the restoration's value.

Upon the completion of cut-back and porcelain build up (Fig 28), the restoration was then glazed and polished (Fig 29).

Surface treatment and bonding procedure

Discussion

There should be a discussion amongst the dental team as to whether the bonding of the two separate pieces is to be conducted by the clinician or technician.

Here are the positives and negatives of clinicians proceeding with the bonding procedure:

Positive:

- Lab technicians are, in general, unfamiliar with bonding and cementing procedures, so scientific and clinical doubts can be eliminated if this process is done by the clinician.
- If needed, minor color adjustment can be achieved by changing the color on the fitting surface of the HO block out coping at the try-in stage. For example, if the color of the crown comes out too low in value, sandblasting the stain off the HO block out coping could help to increase the overall value.

Negative:

- Unless specified beforehand, clinicians may not expect to receive two separate pieces for a crown. This could create unexpected additional work at the chair-side, which may cause unnecessary pressure or problems for the clinician.

Here are the pros and cons of technicians proceeding with the bonding procedure:

Positive:

- The junction between the two pieces can be polished properly to ensure correct fit and therefore comfort for the patient.
- Reduces potential problems and workload for the treating clinician.

Negative:

- If the cementation procedure is not followed precisely, de-bonding or other forms of failure could occur, potentially affecting the clinician's reputation and creating doubt and/or loss of faith in the technique.

This technique has been proven to work successfully, but since the general market is not completely familiar with it at this stage, a careful approach should be considered.

When this technique is selected as part of a treatment plan, the clinician and the technician must be in agreement regarding the division of roles to simplify the process of creating and placing the restoration.

It is important that the bonding procedure presented in this article, which is backed up by many clinical studies,[4-6] is followed precisely to ensure success.

Bonding a dental composite to porcelain primarily involves mechanical and chemical processes. The mechanical bond is generated by etching the porcelain with hydrofluoric acid 5% and the

Fig 30 Application of etching gel (IPS Ceramic etching gel).

Fig 31 Application of Silane Monobond Plus on the fitting surface of the HO block-out coping.

Fig 32 Application of Silane Monobond Plus on the fitting surface of the LT veneer/¾ crown.

Fig 33 Heat treatment using hairdryer.

chemical bond is achieved by using silane coupling agents.[7-10]

Step by step

Here are the steps of surface treatment and bonding procedure used in this case.

- *Step 1:* The fitting surface of the veneer was sandblasted with AL_2O_3 at 1 to 2 Bar (15–30 psi). In cases where the block out core is stained, it is not necessary to sandblast as the underfired stain creates increased surface roughness. Studies show that lithium disilicate glass ceramics (ie, e.max) specimens treated with airborne-particle abrasion and acid etching yielded the highest tensile bond strength values to a composite resin.[11-14]
- *Step 2:* The restorations were rinsed under water, and air-dried.
- *Step 3:* The technician washed their hands and donned clean gloves.
- *Step 4:* The veneer was etched for 20 s with <5% hydrofluoric acid (HF) (in this case, IPS Ceramic Etching gel, Ivoclar Vivadent). If stains had been applied on the HO block out coping, HF etching would have been carried out for 30 to 60 s (the thicker the staining, the longer the etching time) (Fig 30).
- *Step 5:* The restorations are steam cleaned. Unlike enamel, etching of

Fig 34 Application of bonding material – Variolink Veneer.

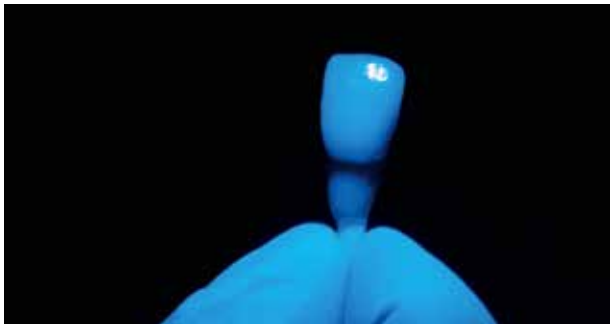


Fig 35 Light curing.

Fig 36 Completed restoration.

Fig 37 Completed restoration on model, palatal view.

porcelain results in the formation of water-soluble salts (hexa-fluorosilicate) that must be removed prior to bonding. Failure to remove this salt will result in a significant porcelain-bond reduction. Steam cleaning the fitting surface has been determined to be the most effective technique according to a recent study.[15]

- *Step 6:* A silane, in this case Monobond Plus, was applied on the fitting surface (Figs 31 and 32) and allowed to activate for 1 min. Silane must be applied in a thin layer. If not thinned properly, a thick layer of silane will result in the formation of a thick non-reactive polysiloxane layer that will likely act as a separating medium.[16]
- *Step 7:* The silane was dried using a hairdryer for 30 s (Fig 33). Studies have shown that a brief heat treatment aids in further evaporation of the solvents in silane products.[17,18]
- *Step 8:* A light-curing resin-based dental luting material was applied (in this case, Variolink Veneer) (Fig 34). Previous studies have examined color change of light-cured luting resin with dual-cure capability after accelerated aging.[19,20] The extent of this color change was reportedly detectable by human eyes ($\Delta E>3$),[12,22] hence pure light-cure luting resin is recommended for this purpose. Color stability is a crucial requirement, particularly when used for ultra-thin ve-

neers. The light cure luting resins are sensitive to blue light (such as operatory light and ambient light) it should not be dispensed from the syringe until immediately before use. Exposure to intensive light should be avoided during application.

- *Step 9:* The restoration was light-cured for 20 s (Fig 35).
- Step 10: The excess Variolink Veneer material was carefully removed and the restoration was polished.

Fig 38 Try-in with Variolink Veneer try-in paste HV+3.

Completed restoration

Figures 36 and 37 show the completed restoration prior to the try-in. The junction between the veneer and block-out coping is highly polished.

As can be seen, there is about 0.5 mm of white collar around the labial margin created within the block-out coping. This was a design decision intended to counteract the darkening of the soft tissue commonly seen around the margin over time. It is not uncommon to see unattractive old PFM restorations with black margins due to the exposure of the subgingival tissues to their metal copings, which in turn influences the color of the gum. The process outlined above utilizes the same concept, but aims for the opposite effect. The HO block-out coping acts as a "white metal" for the purposes of subgingival esthetics.

Try-in

During try-in, the contacts, fit, occlusion, and overall esthetics were evaluated by both the clinician and the patient. Note the dehydration on surrounding natural dentition (Fig 38).

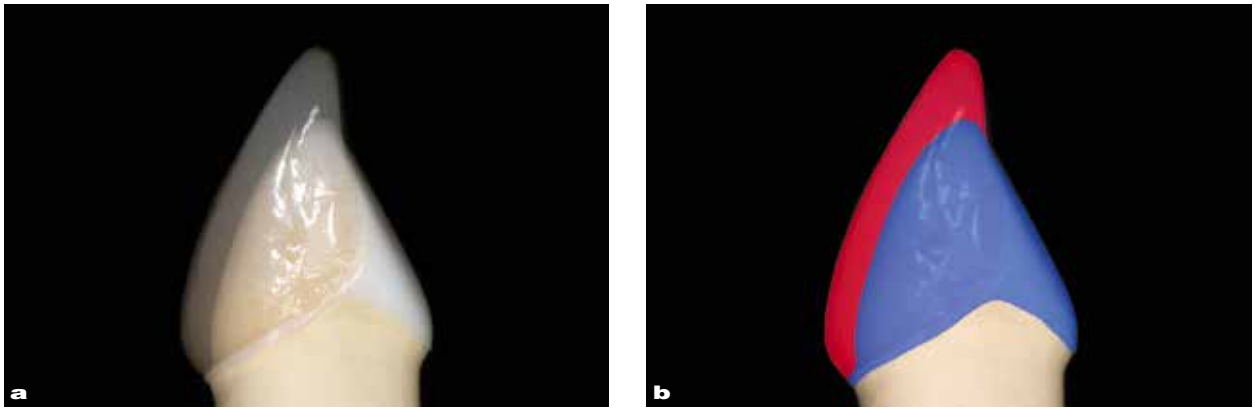
It was important for the patient to spend some time evaluating the restoration prior to final cementation. Different lighting conditions (natural daylight as well as artificial light within the clinic) gave the patient different perspectives on the esthetics of the restoration.

Had color adjustments been required for any reason, the resin cement could have easily been burned off prior to the modification.

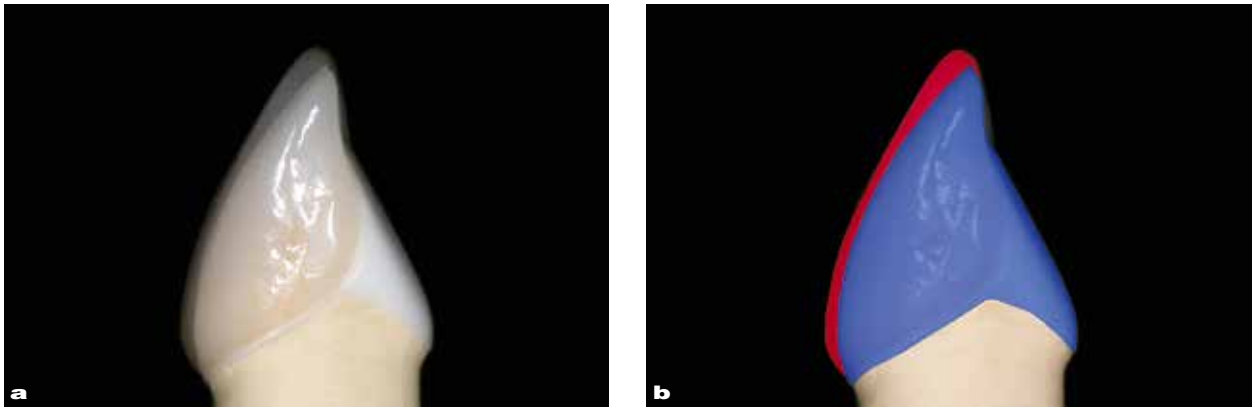
Resin cement burn-off is done in a porcelain furnace at approximately 400°C for 10 min, although this duration may be adjusted if needed. After re-sandblasting the fitting surfaces, any porcelain addition or color adjustment can be made without having to remake the whole restoration.

Traditionally layered ceramic crown vs two-piece bonded ceramic restoration

We shall now examine the reasons for going to the extra trouble of bonding a separate restoration on top of a pressed block-out core instead of simply build-



Figs 39a and 39b Traditionally layered ceramic restoration.



Figs 40a and 40b The 2-piece technique as described in the case study.

ing-up in porcelain as is traditionally done.

Even though HO ingot is suitable for masking and gives us a predictable outcome (that is, a 100% success rate in blocking out a dark stump color at only 0.5 to 0.6 mm thickness), the layering porcelain can then be made significantly thicker to achieve an esthetically pleasing outcome. This is an advantage conferred by the opacity of the substructure.

One of the benefits of selecting the pressed ceramic technique, especially e.max, is the strength within the monolithic structure. The more substructure that can be can preserved, the stronger the restoration becomes. It is well known that restorations made using the lithium disilicate "press and stain" technique are stronger than the ceramic layering technique for this reason.

Figures 39a to 40b show the differences between a traditionally layered ceramic restoration (Figs 39a and 39b) and the two-piece bonded restoration (Figs 40a and 40b). As can be seen, the restoration using the two-piece bonded technique has more monolithic pressed

Fig 41 Two-week post-operative retracted photo.

Fig 42 Two-week post-operative smile photo.

Fig 43 Two-week post-operative full face photo.

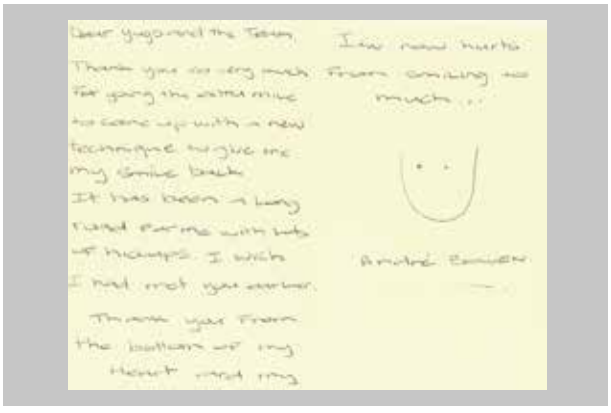


Fig 44 A heart-warming letter from the patient!

structure than the layered restoration without compromising the esthetics. This ultimately provides a better restoration for the patient.

Completed restoration in situ – 2-week post-operative outcome

Figures 41 to 43 present the 2-week post-operative outcome. The patient was extremely happy with the result, and in this case, as with many others, we received the following very pleasing feedback (Fig 44):

"Dear Yugo and the Team, Thank you so very much for going the extra mile to come up with a new technique to give me my smile back.

It has been a long road for me with lots of hiccups. I wish I had met you earlier.

Thank you from the bottom of my heart and my jaw now hurts from smiling too much…

Andre"

When a restoration, undetectable even by dental professionals, has been successfully placed and the patient is com-

pletely happy with the final outcome, the dental team may consider that they have achieved the ultimate in esthetics!

Acknowledgement

The author would like to take this opportunity to thank Dr Mark Levi (Sydney, Australia) for being the treating clinician and allowing the new technique within the treatment plan on this case. Special thanks go to Dr Andrew Chio (Melbourne, Australia) for the help gathering the clinical evidence and references. We also thank the Smile by Yugo team, each of whom has contributed to this case.

References

1. Hatai Y. Aesthetics of a single central incisor with soft tissue management. eLABORATE 2012;9:38–48.
2. Hatai Y. Ultimate zirconia coping design – understanding the aesthetics and function. eLABORATE 2012;38–48.
3. Suzuki J: Light and Shade – The opacity control. QDT 2012:37.
4. Barghi N, McAlister E. Porcelain veneers in 2011: improving the esthetics and longevity. Aust Dent 2011;39:54–58.
5. Alex G: Preparing porcelain surfaces for optimal bonding. Functional Esthetics and Restorative Dentistry 2008;2:38–49.
6. Powers JM, Farah JW, O'Keefe KL, Kolb B, Udrys G. Guide to All-ceramic Bonding. New York: Kuraray America, 2011.
7. Chen L, Wang J, Suh B. Over-etching of silica-based ceramics [89th General Session of IADR, 16–19 March 2011, San Diego]. San Diego: IADR.
8. Chen JH, Matsumura H, Atsuya M. Effect of etchant, etching period, and silane priming on bond strength to porcelain of composite resin. Oper Dent 1998;23:250–257.
9. Söderholm KJM, Shang S-W. Molecular orientation of silane at the surface of colloidal silica. J Dent Res 1993;72:1050–1054.
10. Nguyen R, Barghi N. Duration of efficacy of a two-mix silane following activation. J Dent Res 200180: Abstract 529, 2001.
11. Panah FG, Rezai SM, Ahmadian L. The influence of ceramic surface treatments on the micro-shear bond strength of composite resin to IPS Empress 2. J Prosthet Dent 2003;89:479–488.
12. Borges GA, Sophr AM, de Goes MF, Sobrinho LC, Chan DC: Effect of etching and airborne particle abrasion on the microstructure of different dental ceramics. Oper Dent 2007;32:457–465.
13. Kiyan VH, Saraceni CH, da Silveira BL, Aranha AC, Eduardo Cda P. The influence of internal surface treatments on tensile bond strength for two ceramic systems. J Prosthet Dent 2005;94:357–362.
14. Kim BK, Bae HE, Shim JS, Lee KW. The influence of ceramic surface treatments on the tensile bond strength of composite resin to all-ceramic coping materials. J Prosthodont 2008;17:409–414.
15. McDonald L, McAlister T, Barghi N. Effectiveness of postetching cleaning regimens on porcelain-composite bond [89th General Session of IADR, 16–19 March 2011, San Diego]. San Diego: IADR.
16. Suh BI: All-bond-fourth generation dentin bonding system. J Esthet Dent 1991;3:139–147.
17. Hooshmand T, Van Noort R, Keshvad A. Bond durability of the resin bond and silane treated ceramic surface. Dent Mater 2002;18:179–188.
18. Barghi N, Berry T, Chung K. Effects of timing and heat treatment of silanated porcelain on the bond strength. J Oral Rehab 2000;27:407–412.
19. Swift B, Walls AWG, McCabe JF. Porcelain veneers: the effects of contaminations and cleaning regimens on the bond strength of porcelain to composite. Brit Dent J 1995;179:203–208.
20. Aboush YE. Removing saliva contamination from porcelain veneers before bonding. Prosthet Dent 1998;80:649–653.
21. Alexander C, Barghi N. Color stability and microhardness of four luting resins [82nd General Session IADR/AADR, 10–13 March, 2004, Honolulu]. Honolulu: IADR/AADR.
22. Nathanson D, Bansar FK. Colour stability of resin cements – an in vitro study. Pract Proced Aesthet Dent 2002;14:449-455.