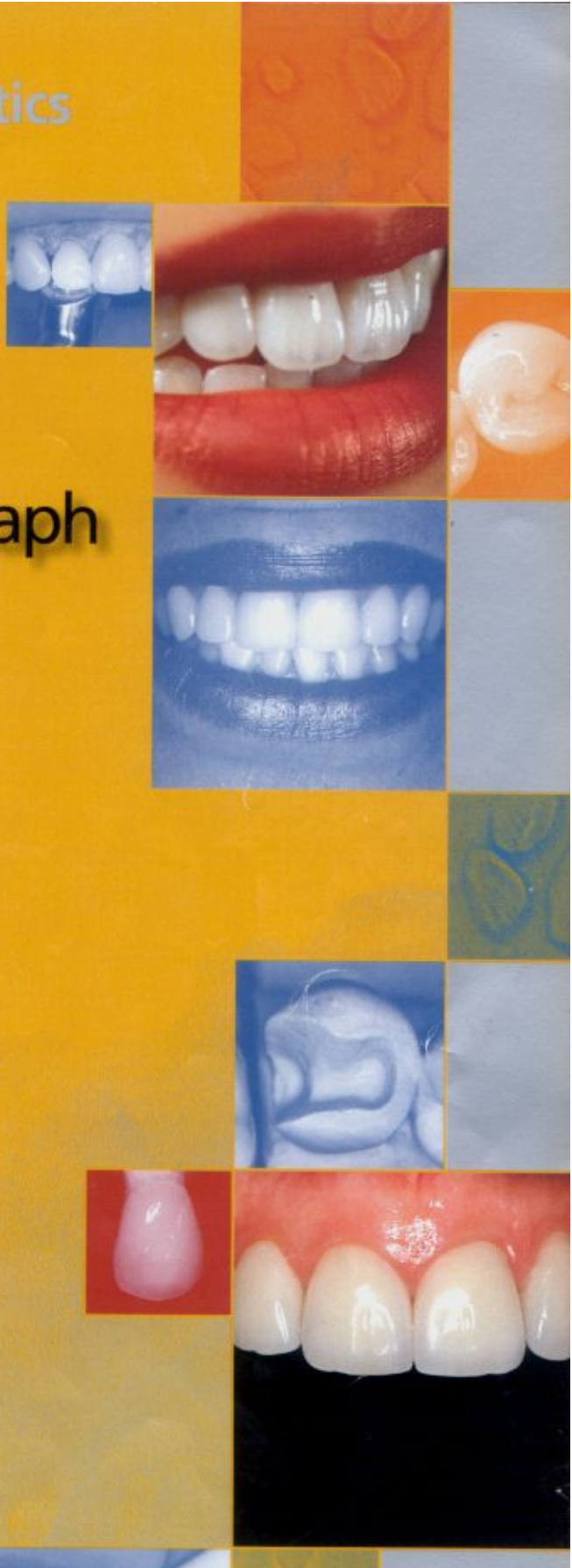
Ultimate Metal-Free Esthetics

A 15-year Retrospective Clinical Monograph



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AESTHETIC ALL-CERAMIC, RESTORATIONS: A PHILOSOPHIC AND CLINICAL REVIEW

Gernot Mörig, Dr. med.dent.

The current focus of aesthetic dentistry is on tooth-colored, metal-free restorations in the anterior and the posterior regions and the biocompatibility and toxicologic safety of these restorative materials. This article reviews eight years of clinical experience with all-porcelain restorations and documents the observations of several clinical cases. It discusses tooth preparation for all-ceramic inlays, onlays, and veneer and crown restorations, as well as isolation, etching, placement, bonding, and light- or dual-curing of the materials. The learning objective of this article is to share the experience and observations with other clinicians. The author concludes that restorations, identical to natural dentition, can be predictably achieved with current all-porcelain systems and that critical scientific analysis of dentin bonding agents must continue. The utilization of all-porcelain material in multiple-unit bridges should still be viewed with caution, and further long-term experience is required.

All-ceramic porcelain restorations have become a well-accepted treatment modality[1-13] for various defects in the anterior as well as posterior regions. Several excellent all-porcelain systems are available for the clinician (eg, Duceram, Degussa, South Plainfield, NJ; IPS Empress, Ivoclar Vivadent, Amherst, NY). Maxillary and mandibular anterior regions are the primary indications for all-porcelain veneer restorations; however, they are successfully utilized in the premolar regions as well. Special variants in the indications are the palatal veneers on maxillary canines, used to build up canine guidance. The classic indications for ceramic inlays and onlays are the maxillary and mandibular premolars. These indications have been extended to molars under specific conditions, such as optimal function, small defects, absence of bruxism, and excellent oral hygiene.

The utilization of porcelain in partial- or full-coverage crown restorations also began with the maxillary anterior dentition, and the application has since been extended to posterior dentition. Investigations are being conducted to determine the applicability of ceramic materials in multiple-unit bridgework; the results, however, are still to be viewed with caution.[14-17] The limiting factor is not inadequate stability, as often maintained, but rather the lack of resilience.[17,18]

The following objectives can be achieved with all-ceramic restorations:

- Optimum aesthetics of a restoration that closely resembles natural dentition.
- Reinforcement of the remaining tooth structure by using an adhesive bonding system.
- Suitability of the ceramic restoration for incorporation into a comprehensive, functional, and aesthetic rehabilitation concept.

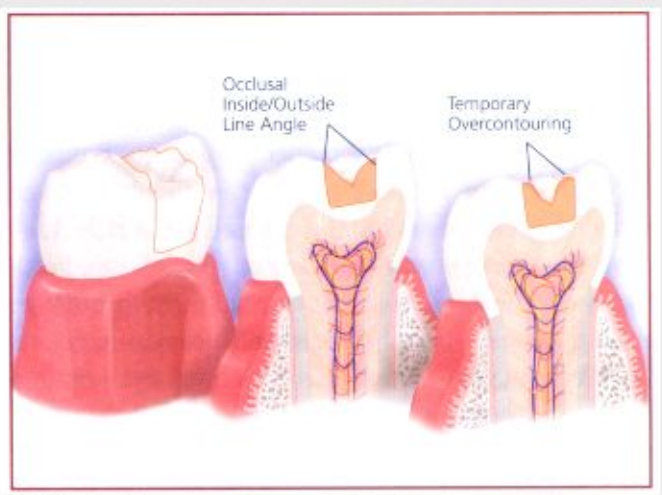

FIGURE 1. A drawing of a ceramic inlay that is especially susceptible to fracture at try-in at the occlusal inside/outside line angle. Temporary overcontouring can stabilize this region.

During the past 8 years, the author has placed in excess of 1,000 all-ceramic restorations, which have exhibited excellent long-term performance.

TOOTH PREPARATION

When preparing the tooth for an inlay, it is important to ensure friction-free but not excessively divergent walls of the central box preparation. Otherwise, the occlusal inside/outside line angle of the ceramic inlay is too acute, and the restoration may fracture during try-in (Figures 1 and 2).[19] The aesthetic appearance and harmony are evaluated at the try-in stage (Figure 3). Once the correctly fitting inlay is placed, a scalpel is used to remove the excess composite resin (Figure 4), since the use of rotating instruments may weaken the ceramic surface. A well-prepared and well-fitting all-ceramic restoration ensures long-term success. To illustrate, a restoration is presented 3.5 years postplacement (Figure 5); it remains integrated with the adjacent natural dentition.

When preparing the tooth for an onlay, the cusps should be rounded and dome-shaped to avoid friction. Circumferentially, a pronounced shoulder should be prepared with a well-rounded internal angle, which ensures that the ceramic restoration will end in an obtuse angle at the margin, thereby increasing its stability.

When preparing the tooth for a veneer restoration, it is important to ensure a stress-free fit of the ceramic restoration, which is often thin and fragile. An additional shoulder in the palatal incisal region may create undesirable stresses in the ceramic. This precaution is especially important if the decidedly convex labial surface of the maxillary incisors is to be prepared in enamel only. Such undesirable stress in the ceramic material will be further increased if, for aesthetic reasons, the preparation is extended far to the palatal aspect in the cervical third on both interproximal surfaces.

Once the palatal shoulder has been prepared incisally, and the veneer is placed, care should be taken to avoid apical pressure to the restoration. Such pressure may disturb the precise fit of the veneer, ie, its full contact with the cervical shoulder (Figure 6). In order to ensure a stable incisal margin and develop a natural translucency, the vertical dimension of the tooth is reduced incisally (Figure 7). To achieve incisal reduction, the diamond is held at an approximate right angle to the long axis of the tooth (Figure 8). The final preparation design for a veneer should be incisally reduced (Figure 9).

FIGURE 2. Occlusal view of the fully prepared cavity for an OD ceramic inlay restoration.

FIGURE 3. Aesthetics and accurate fit evaluated at the try-in stage. Occlusal view.

FIGURE 4. Postoperative view of the perfectly fitting inlay restoration. Scalpel is used to remove the excess composite resin; rotating instruments weaken the ceramic surface.

FIGURE 5. Occlusal view of a restoration that is still indistinguishable from natural dentition 3.5 years postplacement.

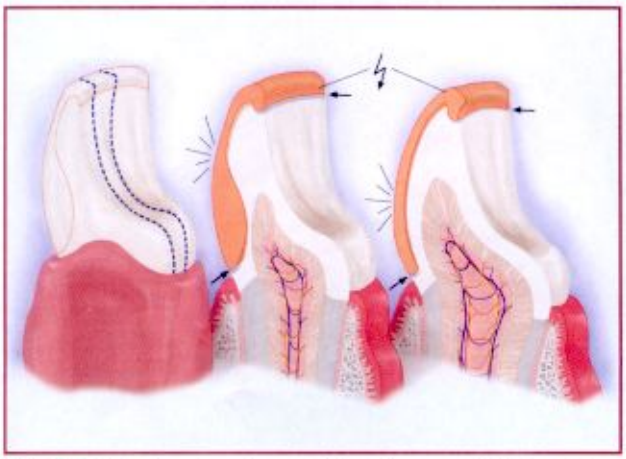

FIGURE 6. The drawing demonstrates that a palatal incisal shoulder may cause stresses in the restoration, resulting in an inaccurate fit in the cervical area.

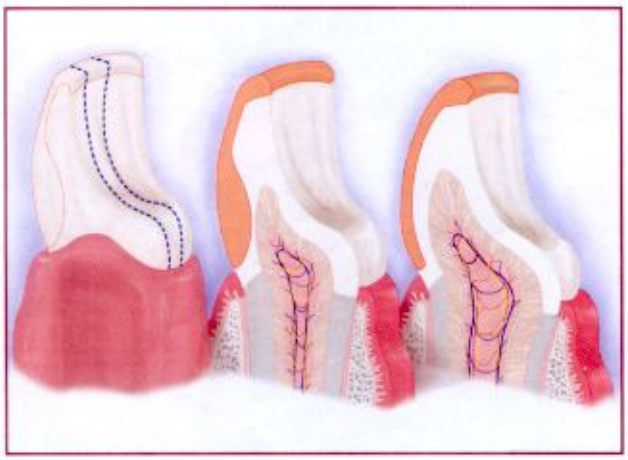

FIGURE 7. A drawing of the optimal preparation design for a veneer — a stress-free restoration with all aesthetically relevant areas duly considered.

At the onset of polymerization, strong finger pressure is applied to affix the veneer cervically and labially. The excess composite resin is removed with a scalpel.

The enamel-to-dentin ratio is far more favorable for a veneer than it is for an inlay restoration. When it appears desirable to slightly incline the tooth to the palatal aspect, more than 50% of the labial surface can be prepared into the dentin. If a single tooth is to be restored with a veneer, the labial surface must be smoothed, since a rough surface results in a diffuse refraction of light, which cannot be controlled by the laboratory technician. If all anterior teeth are to be treated with veneer restorations, the labial surfaces may remain rough, since in such instances the aesthetic effect will be uniform across the anterior segment. At the try-in of a maxillary central incisor veneer, different shades of dual-cure composite resin (eg, yellow, neutral, and blue) are utilized (Figure 10). In this particular case, the shades were used to demonstrate that the aesthetic effect of the restoration is influenced by the hue of the composite resin. The aesthetic quality of the restoration is evaluated approximately 5 years postcementation with a dual-cure composite resin (Figure 11).

In building up cuspid guidance, if the incisal margin of a palatal veneer is visible from the labial aspect, the effect of the minute transverse ridges on the surface of the enamel must be replicated at the transition from the veneer to the tooth in order to achieve an optimal aesthetic result (Figures 12 and 13).

When the following requisites are observed in tooth preparation, all variations (from inlays to veneers) and all hybrid forms preserving tooth structure can be achieved:

- The margin of the ceramic restoration must be stable, without feather edging.
- The restoration must be placed without stress or friction.
- The restoration must be placed in an unequivocal position and fit.

ALL-CERAMIC RESTORATIONS

The base shade of the all-ceramic restoration must match the shade of the surrounding dentin to avoid unnecessary color discrepancies. If the ceramic system utilized relies on the "chameleon" effect, compliance with this requirement is essential. Appropriate shade selection, preparation, placement of provisional restorations, and the appropriate measures for a functional analysis should be performed in the usual manner.

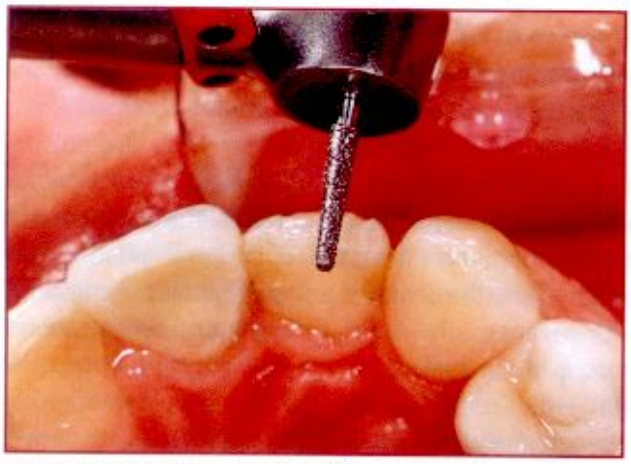

FIGURE 8. For incisal reduction of the tooth, a diamond bur is held at approximate right angles to the axis of the tooth.

FIGURE 9. In incisal reduction of the tooth, the incisal/interproximal "corners" are well rounded. The veneer preparation is completed with clear finish lines.

At the try-in stage, the all-ceramic restoration is neither silanized nor etched. Accurate fit and shade selection of the ceramic material and the remaining tooth substance are evaluated. Shade selection must be evaluated in a moist environment. In the posterior region, it is sufficient to wet the internal aspect of the restoration at try-in; in anterior restorations, the base material (without catalyst) of the dual-cure composite must be utilized during shade selection. When extremely thin veneer restorations are indicated (eg, for inclining a maxillary anterior tooth to the palatal aspect), the aesthetic result can be significantly influenced by the shade of the composite resin utilized (Figures 10 and 11).

FIGURE 10. Aesthetics of the maxillary left central incisor is evaluated and refined at try-in, using 3 different colors of dual-cure composite resin (yellow, neutral, and blue).

ISOLATION, ETCHING, AND SILANIZATION

To achieve isolation, a dental dam must be utilized during placement of the restoration;[19,20] this principle is particularly applicable to the placement of veneer restorations. The most critical area encountered is the cervical finish-line of the preparation for a veneer which does not lie in the enamel.[20] Therefore, it is essential that this region be accessible to visual control and fully isolated (Figure 9). Etching and silanization of the internal surfaces of the ceramic restorations are performed.

BONDING

Careful etching of the enamel is followed by dentin bonding. The author prefers to use a particular bonding agent, based on its exceptional initial bonding strength.

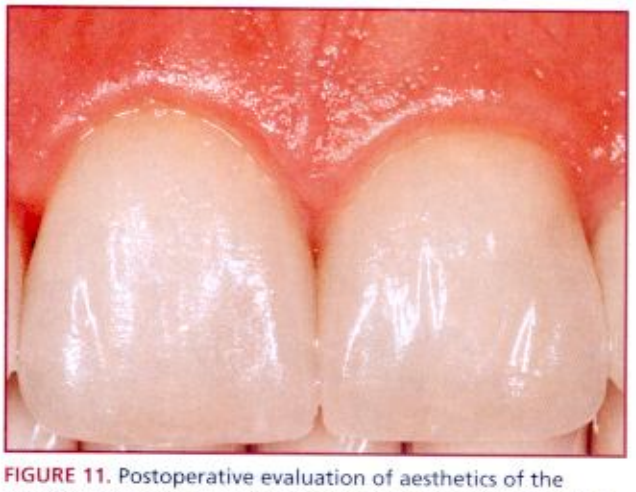

FIGURE 11. Postoperative evaluation of aesthetics of the maxillary left central incisor 5 years after cementation with a dual-cure composite resin of neutral color.

FIGURE 12. Lateral view of the maxillary right canine with a palatal veneer restoration providing canine guidance.

FIGURE 15. Palatal view of a complete rehabilitation of the maxilla, involving 7 all-ceramic restorations, at 3 years postplacement.

FIGURE 13. Occlusal view. Maxillary right canine — palatal veneer; maxillary right first premolar — MOD inlay; maxillary right first molar — veneer partial crown.

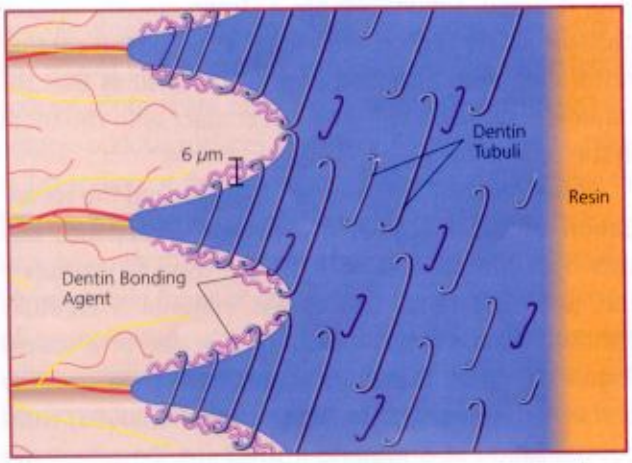

FIGURE 14. Schematic representation of the hypothesized intertubular micromechanical bond between dentin bonding agent and dentin.

The third stage of this system can be combined with most dual-cure composite resins.

When exposed to acid, the openings of the dentin tubules are funnel-shaped (without parallel walls), leaving a collagen network-like pattern with little retentive potential; yet, the cumulative effect of many composite resin tags in the open dentin tubules might lead to a certain, although low, mechanical retention. It has also been observed that the retention is perhaps created by penetration of the intertubular dentin by the resin tags to a depth of up to 6 microns (Figure 14).[21]

A micromechanical bond can be achieved only if the bonding agent (ie, the fluid resin) is cured directly after application, ie, prior to placing the ceramic restoration. Adhesion in the dentin tubules is possible only if the tubules have been cut at the appropriate angles. Curing the dentin bonding agent prior to placing the ceramic restoration does not appear to effect the increase in the vertical dimension of the restoration.[22,23]

Due to the manner in which the dentin tubules are cut on the interproximal shoulder, it is difficult to achieve a mechanical bond. Neither is the concept of the cumulative mechanical retention effect very convincing, since it resists horizontal forces but does not withstand vertical forces. In addition, this area is not readily accessible either to visual inspection or to the maintenance of adequate oral hygiene. In the opinion of the author, based on these observations and evaluations, the ceramic inlay should terminate at the end of the enamel.

FIGURE 16. Aesthetic maxillary restoration during natural smile. Right canine, left central and lateral incisors — veneer; right lateral incisor — all-ceramic crown.

FIGURE 19. Right lateral view of premolar guidance (maxillary right canine is missing due to a cleft palate).

FIGURE 17. Occlusal view of maxillary hybrid preparation, saving natural tooth substance, to create premolar guidance.

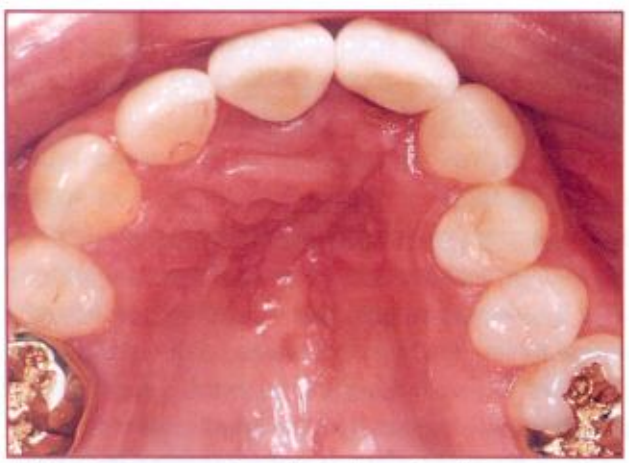

FIGURE 18. Postoperative occlusal view of an all-ceramic onlay restoration of the maxillary premolars in Figure 17.

Several high-quality dual-cure composite resins are available. For approximately 2 years, the author has used a particular bonding system with excellent success. The combination of this material with the previously discussed bonding resin has been of significant clinical value. It is important to use a sufficient quantity of the dual-cure composite resin, so that the excess material is forced out at the margins, thereby precluding any residue of air inclusions in the bonding agent.[19,24]

At the initiation of light polymerization, pressure is applied with an instrument to the center of the ceramic restoration. This is particularly important when placing a veneer restoration. In this case, the pressure was applied by a fingertip, spreading it evenly over the entire labial surface. The fingertip is sensitive and, therefore, serves better than any instrument in judging the pressure level required. Simultaneously, a strong apically directed pressure is applied on the incisal edge of the ceramic restoration with a second finger. This ensures that the ceramic restoration will have full contact with the tooth in the cervical area.

After removal of the excess material and the reevaluation of the marginal fit, glycerin is applied, and two opposite sources of light are used to complete the cure. The remaining excess material is carefully removed with a spoon excavator, a scaler, or a scalpel (Figure 4). When these procedures have been correctly performed, the excess material can be removed, without utilization of a rotating instrument. Despite water cooling, the use of a rotating instrument appears to weaken the ceramic restoration.

FIGURE 20. Preoperative view of the maxillary right central incisor after repeated fracture of a composite restoration.

FIGURE 21. Postoperative close-up of maxillary central incisors; the right incisor was rehabilitated with an all-ceramic microveneer restoration.

CONCLUSION

The following conclusions are established from 8 years of clinical experience: Restorations that are indistinguishable from natural dentition can be predictably achieved (Figures 5, 11, 12, 15, and 16). The stability of modern ceramics (eg, polychrome sintered ceramics: Duceram, Degussa, South Plainfield, NJ; IPS Empress, Ivoclar Vivadent, Amherst, NY) is clinically adequate.

When using polychrome sintered ceramics, the gap at the margins is so narrow that it is clinically irrelevant. With adhesive bonding, the ceramic inlay strengthens the remaining cusps of the tooth. Therefore, a ceramic inlay restoration is still indicated in cases where an overlay would have to be placed if gold were used (eg, weak outside walls of the remaining natural tooth substance). At present, secure adhesive bonding on the interproximal shoulder is possible only in enamel; therefore, the ceramic inlay restoration should end where the enamel ends. Since interfering occlusal contacts are still difficult to identify and correct on ceramic occlusal surfaces, and since ceramic material, prior to fabrication of the restoration, is far more susceptible to fracture than gold, use of the partial gold crown restorations is usually the treatment of choice in the molar region. Various hybrid forms of restorations (eg, buccal broadening of premolars, palatal build-up of canines, microveneer restorations, or the correction of malpositioned teeth) can be successfully utilized (Figures 17 through 21), while preserving the natural tooth substance (Figures 22 through 26). The critical scientific analysis of the chemical composition of dentin bonding agents must continue.

FIGURE 22. Occlusal view of premolar and molars at inlay try-in stage.

FIGURE 23. Postoperative occlusal view of completed all-ceramic premolar and molar restorations.

FIGURE 24. Postoperative anterior view of maxillary and mandibular dentition restored with all-porcelain veneer and crown restorations.

FIGURE 25. Postoperative incisal view of the maxillary anterior dentition, restored with all-porcelain material.

FIGURE 26. Postoperative anterior close-up of all-ceramic veneer restorations on both maxillary incisors and all-ceramic crowns on both lateral incisors.

ACKNOWLEDGMENT

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