Biomimetics and Conservative Porcelain Veneer Techniques Guided by the Diagnostic Wax-Up, Diagnostic Matrix, and Diagnostic Provisional


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ABSTRACT

The use of porcelain veneers for a conservative esthetic rehabilitation can lead to improvement in the biomechanical and esthetic properties of the tooth when the preparation is limited mostly to dental enamel. This article presents a predictable system to create the tooth preparations and porcelain veneer restorations based on the additive diagnostic wax-up. This system promotes a minimally invasive tooth preparation with the preservation of enamel and the fabrication of conservative and highly esthetic porcelain restorations.

Following the principles of biomimetics as applied to dentistry, the clinician should strive to restore or mimic the biomechanical, structural, and esthetic integrity of the tooth.

INTRODUCTION

Biomimetics is the study of the structure and function of biological systems as models for the design and engineering of materials. Following the principles of biomimetics as applied to dentistry, the clinician should strive to restore or mimic the biomechanical, structural, and esthetic integrity of the tooth.[1] When the patient and clinician's treatment of choice is a conservative esthetic rehabilitation with porcelain veneers, it is paramount to be respectful of the existing tooth structure, especially the dental enamel. The use of porcelain as an enamel substitute is an excellent application of the biomimetic principle due to

Figure 1: Initial presentation of the patient with orthodontic therapy. Note the reverse smile line and short central incisors.

Figure 2: Incisors after completion of orthodontic therapy. Note the poor length-to-width ratio of the central incisors.

the similar elastic modulus, thermal expansion, and optical properties of the two structures.[1] When the original tooth has a thinned-out or worn enamel surface and is restored to original volume with porcelain as an enamel substitute, studies have found that the tooth recovers much of its original structural, optical, and biomechanical properties.[1] Numerous retrospective studies that look at porcelain veneer longevity have also found that the veneer will have more predictable long-term success if the restoration is bonded primarily to enamel.[2,3] This is especially true at the facial-axial region of the tooth preparation, and care should be taken not to remove excessive enamel at this critical region.[4]

The traditional approach for porcelain veneer preparation was to use a depth-cutting diamond on the existing tooth surface and remove a fixed amount of tooth structure. This technique leads to an excessive loss of sound dental enamel with unnecessary dentin exposure, especially in patients that already have wear or thinning of the enamel surface that will be restored with the new veneers.[5] This preparation method has been replaced by newer techniques that attempt to relate the tooth preparation to the desired final outcome, as represented by the additive diagnostic wax-up. A variety of putty stents have been developed that aid the clinician in relating the diagnostic wax-up to the tooth preparations; this technique has proven very predictable in creating a more conservative porcelain veneer preparation. This article demonstrates a simplified technique to relate the diagnostic wax-up to the tooth preparations in an efficient and reliable manner. This approach also allows the patient to preview the case before any tooth preparation and anesthesia begins.

The additive diagnostic wax-up is a critical step in the biomimetic approach to preservation of enamel, and the clinician must be able to accurately relate this wax-up to the final tooth preparations.

Case Presentation

The patient, a 39-year-old male, presented prior to the completion of orthodontic therapy with the desire to enhance his smile with porcelain veneers (Fig 1). The initial assessments revealed a moderate to severe amount of tooth wear, with the central incisors displaying a length of 7.8 mm and a width of 7.1 mm (Fig 2). The patient also had a reverse smile line and diastema between the maxillary central and lateral incisors. The occlusal examination revealed no temporomandibular disorder, muscle pain, or tooth mobility, but the patient had a number of posterior centric relation (CR) interferences and group function guidance. The treatment plan, following the completion of orthodontic therapy, called for initial muscle deprogramming and equilibration with the aid of a Kois deprogrammer. This would be followed by 10 feldspathic porcelain veneers on the maxillary arch to lengthen the teeth, reestablish cuspid guidance, and create a more pleasing smile.

The diagnostic wax-up was completed after the initial equilibration on a new set of study models that were mounted in the CR position on a Sam 3 articulator (Great Lakes Orthodontics; Tonawanda, NY). The wax-up was completed using an additive technique that was designed to preserve the existing intact enamel and add wax to build up the new tooth form that would then be replaced with porcelain (Fig 3). The

Figure 3: Duplicate die-stone model of the diagnostic wax-up. Note the improved length and proportions of the central incisors.

Figure 4: The diagnostic matrix, spot-bonded into place. Note the correction of the reverse smile line.

Figure 5: Depth cut being placed in the cervical third of the diagnostic matrix. Note that the shank of the diamond is resting directly on the matrix material to ensure that the depth cut is accurate.

Figure 6: Depth cuts marked with a lead pencil for easy identification. The diagnostic matrix and a small volume of enamel can now be accurately and efficiently removed to the ideal preparation depth.

Figure 7: Rapid reduction to the level of the depth cuts is facilitated by larger round-end diamonds.

Figure 8: Inspection of the initial veneer preparation depth with the horizontal putty matrix created from the diagnostic wax-up.

Figure 9: Inspection of the final axial reduction with the vertical putty matrix created from the diagnostic wax-up.

Figure 10: Final conservative veneer preparations with the retraction cord in place.

additive diagnostic wax-up is a critical step in the biomimetic approach to preservation of enamel, and the clinician must be able to accurately relate this wax-up to the final tooth preparations.[6] A number of putty stents have been used to effect this but their use can be very time-consuming during the initial stages of the tooth preparation procedures. The technique advocated by Magne and Gurel uses a diagnostic resin matrix created from the diagnostic wax-up to preview the case prior to tooth preparation.[5,7] After the patient approves the results of this mock-up, the resin matrix can be used as the platform to create depth cuts to guide the initial preparation dimensions.[5,7]

In this case, a Copyplast (Great Lakes Orthodontics) stent was created from a duplicate die stone model of the diagnostic wax-up using a Biostar vacuum-forming machine (Great Lakes Orthodontics). The patient was not given local anesthesia prior to the mock-up creation, to allow for an accurate assessment of the new incisal edge position for esthetics and phonetics (Fig 4). The teeth were lengthened by 1.5 to 2.5 mm and missing facial enamel was augmented with the diagnostic matrix to produce better overall tooth form and contour. The patient was happy with the new esthetic result and the new incisal edge position, so the local anesthetic was administered and depth cuts were placed in the incisal and the cervical third of the matrix. If the patient is unsure about the esthetic or phonetic changes made with the diagnostic matrix, it can be altered immediately or left in place for a week or two and reevaluated.

Considerable knowledge, understanding, and artistic skill in porcelain layering techniques are prerequisites for creating the ceramic veneer restorations.

In order to preserve the maximum amount of intact enamel, the incisal depth cut measured 0.7 mm and the cervical depth cut 0.4 mm. The depth cuts were created with an 801-023SC (0.7-mm depth cut) and an 801-018SC (0.4-mm depth cut) round diamond (Axis Dental; Coppell, TX). A study by Ferrari and colleagues, which looked at the thickness of dental enamel in maxillary anterior teeth, found that the enamel thickness is approximately 0.3 to 0.5 mm in the cervical and 0.7 to 0.9 mm in the middle third.[8] In order to achieve the actual depth cut, the clinician needs to ensure that the shank of the diamond is resting directly on the resin matrix and not angled into the matrix, which would create a deeper depth cut than desired (Fig 5). Once the depth cuts are created, they are marked with pencil for easy identification (Fig 6). Any remaining resin material and the minimal necessary surface enamel are efficiently and quickly removed (Fig 7) with larger round-ended diamonds such as the KS2 (Axis Dental). This system of placing depth cuts into a resin matrix allows for the preservation of the maximum volume of healthy enamel and the creation of an even thickness for the ceramic; this leads to less potential for postbonding crack development in the porcelain veneer restoration.[9] The preparations are then completed and checked with vertical and palatal putty stents created from the diagnostic wax-up (Figs 8–10).

The provisional restoration was created on a duplicate Copyplast stent using an A1 shade of Protemp3 Garant (3M ESPE; St. Paul, MN) and removed to adjust and trim. Particu-

Figure 11: Diagnostic provisional restorations three days after tooth preparations. Note the correction of the reverse smile and the tooth proportions.

Figure 12: Lateral view of the diagnostic provisional restorations. Note the three planes to the facial surface of the central incisors.

Figure 13: Incisal matrix generated by the model of the diagnostic provisional restoration, to ensure proper incisal edge position and length during the ceramic build-up.

Figure 14: Refractory dies with marked preparations against incisal matrix.

lar attention was given to the embrasure form, especially in the cervical, so that a small space was created for the tissue and papilla to rebound after the preparation, retraction, and impression procedures. The provisional was spot-etched with a small amount of Ultra-Etch (Ultradent; South Jordan, UT) phosphoric acid solution in the incisal third of the preparation, and luted into place with Neo-Temp resin cement (WaterPik Technologies; Ft. Collins, CO). The provisional restorations were evaluated a few days after the preparation appointment (Figs 11 & 12) and a new facebow was created with the Kois Dento-Facial Analyzer (Panadent; Grand Terrace, CA). The upper provisional model was mounted on the Sam 3 articulator, the remaining models were cross-mounted to the upper provisional model, and the case was sent to the dental ceramist.

LABORATORY PROCEDURES

The porcelain layering technique presented here is specially designed for the use of fluorapatite leucite glass-ceramic material (d.SIGN, Ivoclar Vivadent; Amherst, NY) for direct application on refractory dies. The refractory die technique offers significant advantages over pressed veneers. Extremely sophisticated effects of color and translucency can be achieved through a full-thickness layering technique, resulting in highly esthetic and vital restorations.[10] Also, discolorations of underlying tooth substrate can be effectively masked with ultra-thin opacious layers without compromising the esthetics. Considerable knowledge, understanding, and artistic skills in porcelain layering techniques are prerequisites for creating the ceramic veneer restorations discussed here.

Figure 15: Deep dentin layer to smooth the transition between the incisal edge of the preparation and the incisal porcelain.

Figure 16: Dentin build-up carried out with three different types of dentins to enhance vitality.

Figure 17: Enamel covering with a combination of translucent and opalescent powders to mimic natural enamel.

Figure 18: First dentin enamel bake, indicating proper incisal edge position and length.

After the refractory dies have been degassed, margin material is applied in a thin layer up to the margins and fired. This layer provides a secure bond between the refractory die and the subsequent porcelain layers (Fig 13). The porcelain stratification begins with deep dentin, placed on the facial aspect of the prepared veneer and also interproximally and incisally (Fig 14). This dentin layer, with slightly more opacity, prevents excessive light absorption and also helps to smooth the transition from incisal edge of the prepared tooth to the porcelain. In cases where more than 3 mm of the incisal length is to be rebuilt, it is advisable to carry out a separate vacuum bake before starting with the dentin/enamel layering.

It is extremely important to maintain control during all stages of the porcelain stratification by using the matrices generated from the cast of the diagnostic provisional restoration (Fig 15). The incisal matrix is very useful during the build-up by raising the incisal guide pin around 1 mm before porcelain firing. A palatal matrix, however, is more reliable for designing the incisal edge and incisal embrasures since the precise fit can easily be ensured on the palatal aspect of the unprepared tooth surfaces. Subsequently, the veneers were built up to full contour with dentin layers of different values and degrees of translucency (Fig 16). For instance, a dentin layer blended with a chroma-intensive enamel layer was used on the cervical area, thus creating a pleasing chromatic effect on the cervical area of the veneer restorations. The incisal matrix was used to establish proper incisal length and edge position prior to cutback, for internal characterizations and the enamel covering.

In contrast to other ceramic materials, the dentin of the d.SIGN

Figure 19: Coating of the entire surface with silver powder for better assessment of symmetry and surface texture and morphology.

Figure 20: Definitive porcelain veneer restorations on the solid cast.

system is so translucent that it is possible to apply internal effects and characterizations directly onto the reduced dentin body.[11] The dentin lobes were enhanced slightly by using ivory and cream-colored intensives and feathered out toward the incisal edge with a brush tip. No stains should be used for this purpose (they have the tendency to appear as a single layer and not three-dimensional like the intensive powders with defined volume as used for this case). For the enamel covering the entire facial surface, a combination of translucent and opalescent powders are overlayed specially to simulate shaded enamel (Fig 17).

At this stage the volume of the build-up should be slightly high, especially toward the incisal, in order to compensate for the anticipated baking shrinkage. After the first dentin/enamel bake, the incisal edge should fit into the matrix with the incisal guide pin at the 0 position (Fig 18). A subsequent correction bake is necessary to optimize form and contours.

Final contouring and surface texturing were carried out using various diamond burs and green stones. It is helpful to coat the surface with silver powder for better assessment of contours and surface morphology of the restorations (Fig 19).

A combination of thermo-glazing and mechanical polishing was utilized to mimic the desired natural surface luster of the patient's natural dentition. The solid cast allows a proper assessment of the gingival contours and the closure of the gingival embrasures of the restorations (Fig 20). At this stage, small corrections can be made only with low-fusing material. The interproximal contacts were made shim stock-ready before delivery to the clinician

The system requires the ceramist to fabricate the porcelain veneer restorations with a homogeneous thickness of ceramic that has a favorable configuration to the luting composite thickness.

ADHESIVE LUTING AND FINISHING OF THE CASE

The case was received from the ceramist and inspected on the solid and die models (Fig 20). The provisional restorations were removed and the tooth preparations were pumiced and cleaned. The restorations were tried in individually to inspect the fit and then were tried in collectively to evaluate the contact areas. The veneers were then tried in with Prevue try-in gel (Cosmedent; Chicago, IL), and the patient approved the esthetics of the case. The veneers were then luted into place two at a time using the standard bonding protocol with OptiBond FL adhesive (Kerr; Orange, CA) and Insure resin cement (Cosmedent). The veneers were polished and the occlusion was checked and adjusted using red and black AccuFilm articulating paper (Parkell; Edgewood, NY) and the T-Scan II system (Tekscan Inc.; Boston, MA).

CONCLUSION

The ultimate goals for an esthetic rehabilitation are the biomimetic recovery of the tooth, as well as the esthetic enhancement of the smile. These goals can be achieved by following a minimally invasive preparation protocol guided by the additive diagnostic wax-up, diagnostic matrix, and the diagnostic provisional. With this system, the clinician has the ability to limit the majority of

Figure 21: Final esthetic and biomimetic rehabilitation for the patient with conservative porcelain veneers. Note the correction of the reverse smile line.

Figure 22: Macro view of the final layered feldspathic bonded porcelain restorations. Note the improved length and proportions of the central incisors.

the veneer preparation to enamel and minimize the potential for significant dentin exposures. It should also be stressed that the system requires the ceramist to fabricate the porcelain veneer restorations with a homogeneous thickness of ceramic that has a favorable configuration to the luting composite thickness. The potential for crack propagation within the porcelain restorations may be significantly reduced with a ceramic-to-luting composite thickness ratio above 3.[9] The dentist can also facilitate the ceramist's work by providing an excellent final impression and smooth preparations with rounded contours and the absence of any undercuts.[9]

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