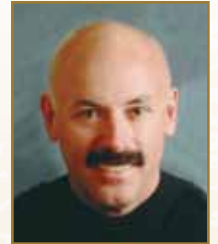


Aesthetic Treatment of Dark Root Syndrome

— ARTICLE and PHOTOS by
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■ INTRODUCTION

The aesthetic results of anterior full-coverage restorations are often compromised by myriad clinical factors. The inherent aesthetic inadequacy of ceramometal crowns is their inability to transmit and reflect light naturally, which often results in an inability to truly match the natural dentition, as well as a darkening of the area around the root and surrounding periodontal tissue. If the clinician is also dealing with a tooth that has received endodontic treatment, the sealer used can darken the root, and the coronal and root portion of the tooth loses its natural ability to transmit light when filled with gutta-percha. When a nonvital tooth has been restored with a cast or metal post, the metal in proximity to the gingival interface frequently creates shadows and discolored gingival tissues due to the shine-through that can adversely affect aesthetic results.¹

Often when preparing extremely broken-down anterior teeth for full-coverage restorations, the remaining core structure is severely compromised. The small amount of tooth structure remaining, which is subject to vertical and lateral shearing forces, is often too weak to adequately resist these forces. Post placement is therefore indicated in these clinical situations.² One of the reasons fiber post usage has increased is that, in highly aesthetic, demanding cases, their color and translucency allow for their use with translucent all-ceramic restorations.³ Strassler,^{4,5} in his article, discusses that “in the anterior aesthetic zone, a translucent fiber post will likely be a better choice if the tooth is being restored with translucent, aesthetic restorative materials — composite resin, porcelain veneers or an all-ceramic crown.” Fiber posts also enhance the aesthetic results of the coronal restoration as a result of their light transmission property.⁶ In his 2000 article on fourth-generation intraradicular posts, Martelli⁷ has also described the rationale and application of translucent glass fiber posts and their ability to diffuse

light through a restoration, thereby enhancing their natural appearance.

To assess post systems used to treat endodontically treated teeth which may be functionally and structurally challenged, Boudrias et al.⁸ state that “the ideal post system should: complement minimal conservative preparation; reduce or eliminate stresses transferred to the tooth; approximate the taper of the canal walls; be resistant to dislodgement during function; and be retentive and possibly micromechanically attached to the tooth.” In another paper looking at the same clinical variables, Gluskin et al.⁹ state that “in selecting an appropriate post system, treatment should attempt to establish: a stable post system that transfers the stress of mastication throughout the radicular root and into the periodontal attachment uniformly; a post system that does not focus stress in function or create it during placement; a post system that resists permanent deformation to protect the integrity of the crown margins and cement seal; a cementation process that provides optimal luting of the dowel to the radicular dentin; and a conservation of the coronal tooth structure that allows adequate encasement of the dentin by overcasting the ‘ferrule’ effect.” A high-quality, adhesively bonded quartz fiber post fulfills all these criteria.

The excessive removal of radicular dentin, which is often the result of preparation for parallel-sided posts, compromises root strength and creates significant reduction in radicular toughness, especially at the apical terminus of the post.^{10,11} In contrast, an anatomical fiber post, such as the Macro-Lock Illusion (RTD), requires minimal tooth structure removal during canal shaping and allows greater post-to-canal adaptation in the apical and coronal half of the canal.¹² Because fiber-reinforced posts have an elastic modulus that more closely approaches that of dentin,¹³ fiber

posts produce less stress on the root dentin around the post tip than do metal posts,¹⁴ and the stress fields around glass fiber posts are quite similar to that of the natural tooth.¹⁵ When fatigue loading post-and-cores, studies have shown that bonded composite cores supported by bonded fiber posts have better retention than cemented gold post-and-cores and cemented metal posts mated to composite cores.¹⁶ These nonmetallic fiber posts comply more satisfactorily with the requirements necessary to provide a mechanical behavior more similar to that of the dental structure, with the compatibility among the mechanical properties found in these systems and the dentin providing a biomimetic behavior that reduces the risk of failure or fracture of the root.¹⁷ It has been a long-held belief that posts are used mainly to retain the core and have little effect on the strength of the remaining tooth structure. However, a 2009 article states that there is growing evidence that fiber posts provide the additional benefit of increased fracture resistance.¹⁸

It is critical to understand that not all fiber posts are the same, and they do not all perform similarly in clinical situations. In a study by Seefeld et al.¹⁹ that looked at eight types of fiber posts, the fracture load of the tested systems ranged from 60 to 96 N, and the flexural strength from 565 to 898 MPa. The differences in fiber diameter ranged from 8.2 to 21 μm , and the fiber:matrix ratio from 41 to 76 percent. The fiber posts can be glass fiber, quartz fiber, glass fiber-zirconia enriched, and glass fiber and carbon fiber,²⁰ with quartz fiber posts recording significantly higher failure loads.²¹ They can be translucent, white, dentin or color-changing translucent,²⁰ and for light transmission, they can be excellent, good, fair or poor.²² Fiber posts can be tapered, double-tapered, parallel, parallel with a tapered end, parallel-tapered and serrated,²⁰ with the parallel-tapered post also closely imitating the post-endodontic shape of the radicular canal, leaving a thin uniform thickness of cement at the post/canal interface. Flowable resin cements are essentially diluted composite resins so that flow is increased to allow insertion of the post, but this negatively affects the mechanical properties of the material. A highly loaded quartz fiber post has better mechanical properties than luting resin, and therefore it is best to minimize the amount of resin cement around the fiber post with improved adaptation to the canal shape.²³ The quality, type and volume of fibers, the way the fibers are silanated, and the type of resin used all affect the mechanical performance of these fiber posts, with some failing in cyclic fatigue to fracture in a few cycles, and others (DT Double Taper Light-Post radiopaque [RTD]) surviving more than 2 million cycles.²⁴

A next-generation fiber post, the Macro-Lock Illusion X-RO, has been added to the RTD family of fiber posts. It is fabricated with a high-percentage loading (80 percent wt) of a new pretensed long continuous translucent unidirectional quartz fiber with epoxy resin, and is 50 percent more radiopaque than the Macro-Lock Illusion. This addresses the

relative lack of radiopacity found in previous generations of fiber posts. Quartz crystal is the world's purest form of silica. These quartz X-RO fibers are coated with a proprietary silane coupling agent that is specially formulated to optimize the bond between the X-RO fiber and the hybrid epoxy resin, together resulting in an improvement in the flexural strength from 1,800 to 2,000 MPa, which is approximately 20 percent stronger than the original. This post allows for microretention and macroretention of the bonded core and cement. The surface area of the new Macro-Lock Illusion X-RO has been enlarged by increasing the surface roughness, which eliminates the need for chairside silanization. Due to the added radiopacifiers, the light transmission capacity of the post is less than the previous version, but it is still very high, with enough light being transmitted even at 12.5 mm to adequately cure dual-curing resin cements. The color-changing technology of this post allows for the post to "disappear" when seated at oral temperature, as well as for it to be visible under water spray if retrieval is necessary. A study by Baldissara et al.²⁵ showed that the Macro-Lock post, with its macroretention, reached generally higher results when testing against the retention of microretentive quartz fiber posts.

It has been a long-held belief that posts are used mainly to retain the core and have little effect on the strength of the remaining tooth structure. However, a 2009 article states that there is growing evidence that fiber posts provide the additional benefit of increased fracture resistance.

The clinician should be aware that not all dental adhesive systems are compatible with dual- and self-cure cements or composite resins, and that a meticulous clinical protocol and technique is critical for success. A highly acidic bonding agent will interfere with the chemical amine reaction of self-cure and dual-cure cements and therefore results in an incomplete setting reaction. The three-step etch-and-rinse systems are compatible. Of the etch-and-rinse one-bottle systems, those that are not highly acidic, such as SealBond Ultima (RTD) and ONE-STEP (BISCO), are a couple of the most predictable available for use. The self-etch primer systems should not be combined with chemically (self-) or dual-cured cements because of the remaining acidic components of the primer.²⁶ An etch-and-bond system, MP Direct (CLINICIAN'S CHOICE), shows high bond strengths



Figure 1: Close-up preoperative view of the patient's anterior maxillary dentition. Note the disproportionate shape and discoloration of tooth #8.



Figure 2: Preoperative radiographic view of the root canal therapy that had been performed 20 years prior for tooth #8.



Figure 3: VITA's linear shade guide (Vident) was among the shade-taking tools used to obtain an accurate shade assessment.

to chemically (self-) cured composite materials when the oxygen-inhibited layer is removed with alcohol.²⁷

■ CASE REPORT

A 43-year-old female presented with concerns about the appearance of tooth #8 (*Fig. 1*). She had undergone root canal therapy and subsequent placement of a PFM crown to restore the tooth 20 years prior. However, she was increasingly self-conscious about its discolored and mismatched appearance. Being conservative in her philosophy about dental treatments, she was seeking to enhance the appearance of tooth #8 without any unnecessary removal of tooth structure. She also did not want to alter the adjacent teeth. Therefore, the patient sought a dentist who would provide a naturally aesthetic porcelain crown without a metal substrate, but that would be sufficiently durable and not break off at the gumline.

The patient underwent a thorough examination that included radiographs (*Fig. 2*), photographs and periodontal probings. Additionally, the patient was carefully evaluated in terms of her occlusion and the morphologic, histologic and optical characteristics of her anterior maxillary tooth, the decided focus of treatment.

It was determined that the patient's existing PFM restoration could be replaced with an aesthetic, metal-free zirconia-based restoration (Lava [3M ESPE]) veneered with an aesthetic porcelain (VITA VM 13 [Vident]). However, to enhance the aesthetic effects of this restoration, as well as to strengthen the tooth and improve its longevity,^{28,29} the patient was informed of the need to stabilize this tooth by placing an aesthetic post and subsequent core buildup before the aesthetic restoration could be placed.

The patient was assured that a minimal intervention approach in terms of the amount of natural coronal dentin that would be removed — as well as what would be placed to support the tooth — would be followed. Studies have indicated that maintaining an increased amount of coronal dentin significantly increases the fracture resistance of endodontically treated teeth when prefabricated posts are used.^{28,30} Root fracture is one of the most serious complications following a restoration of endodontically treated teeth.^{28,30} Therefore, in order to maintain the principles of minimal intervention — which essentially mandate that the restoration and re-restoration cycle be curtailed and/or limited³¹ — prevention of the need for further restoration of tooth #8 was necessary. Since these principles were to be maintained, the patient approved the treatment plan.

■ Shade Selection and Preliminary Work

A shade of the patient's teeth was taken using a combination of traditional shade tabs (VITA 3D Master Shade Tabs [Vident]), an innovative system of linear shade tabs (*Fig. 3*),

and a spectrophotometer (VITA Easyshade [Vident]). Using a combination of these shade-taking methods enabled excellent collaboration with the dental ceramist with the goal of obtaining the most accurate color assessment. Ultimately, this would facilitate the creation of a restoration reflective of the patient's desired tooth shade in terms of value (i.e., brightness), chroma (i.e., color intensity) and hue (i.e., basic color based on wavelength of visible light).³² In this case, additional shade-taking was also performed at the dental laboratory.

A preoperative impression of tooth #8 was taken using a customizable metal temporary tray (TempTray [CLINICIAN'S CHOICE]) and a fast-setting matrix material (Template [CLINICIAN'S CHOICE]). This single-use disposable aluminum tray is designed for sectional arch impressions and resists distortion during insertion and removal. The silicone matrix material sets in 30 seconds and, when cured, provides an accurate, stable and detailed matrix for use in temporary fabrication.

To obtain the impression, the silicone matrix material was rapidly injected into the customizable temporary tray, after which the tray and matrix material were inserted intraorally. The matrix material was able to flow into the embrasure areas, as well as into the finest morphology. Yet, when removed after 30 seconds of curing, the tray and material released easily, with the matrix maintaining its form (Fig. 4). The matrix was set aside for later use in fabricating the temporary restoration.

■ Preparation: Post Placement and Core Buildup

The decision was made to reinforce tooth #8 using the innovative Macro-Lock Illusion post. Its color-changing technology enables it to disappear when placed. Further, the post demonstrates high translucency for good light transmission, so its placement in this case would enhance the aesthetic and optical properties of the restorative treatment.¹²

The previous restoration was removed, and suitable isolation was achieved. Minimal reduction of the remaining tooth structure was performed in order to facilitate endodontic access. The appropriate post space then was created using the Macro-Lock Illusion post drill (Fig. 5), after which the post measurement was taken. The selected post was then trimmed to size using a diamond disc.

The adhesive sequence was initiated by etching the canal by inserting the etchant (Ultra-Etch [Ultradent Products]) into the canal for 15 seconds from the apex coronally using an Endo-Eze tip (Ultradent Products) (Fig. 6). Then the post space was thoroughly rinsed from the bottom of the post space coronally, after which a Capillary tip attached to a Luer vacuum adaptor (Ultradent Products) was used to dry the canal.

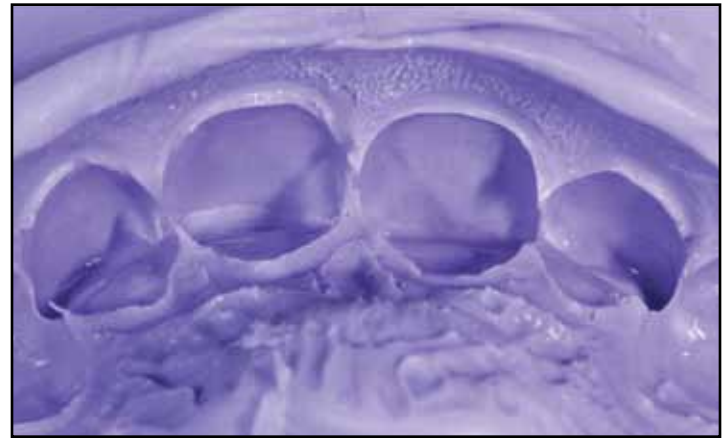


Figure 4: The silicone matrix material remained stable after removal from the mouth and demonstrated exceptional morphological detail.



Figure 5: As part of the post-and-core preparation sequence, existing gutta-percha was removed to length, and the post space created with the appropriate post drill.



Figure 6: The adhesive sequence was initiated using an etchant (Ultra-Etch [Ultradent Products]) injected from the bottom up, thereby eliminating the possibility of air entrapment below the etchant.

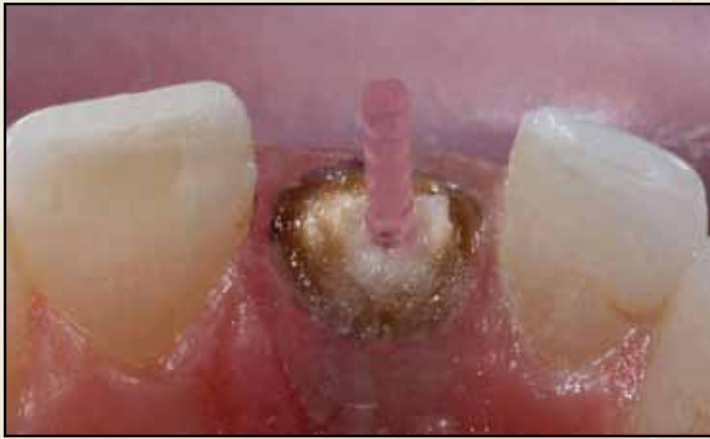


Figure 7: The Macro-Lock Illusion post (RTD) and resin cement complex were light-cured for 20 seconds.



Figure 8: The core for tooth #8 was built up using a radiopaque composite material in an Opaque Snow shade (Amelogen Plus [Ultradent Products]) that eliminated the need for too much opaque in the all-ceramic restorations. Note that the color of the post reappears when the core is trimmed or rinsed with cold water. This facilitates removal if retreatment is needed.



Figure 9: A viscous, yet spreadable, aluminum chloride hemostatic gel (Tissue Goo [CLINICIAN'S CHOICE]) was applied along the gingival margins of tooth #8 to facilitate hemostasis.

Next, a fifth-generation adhesive bonding agent (Sealbond Ultima [RTD]) specifically designed for post cementation was applied in two consecutive coats to the canal using a tapered brush that was long enough to reach the bottom of the post space. Simultaneously, this highly light-sensitive adhesive also was applied in one coat to the post. Excess solvent was evaporated with a light flow of air, after which the bonding agent was light-cured in the canal and also on the post for the manufacturer's recommended time.

A dual-cured resin cement (Corecem [RTD]) was injected into the canal from the apex coronally, after which the post was seated into the dual-cure cement. This cement, in particular, was developed for use in reconstructing nonvital teeth with fiber posts as part of a durable, monobloc core buildup. The post and resin cement complex was light-cured for 20 seconds (Fig. 7).

The core for tooth #8 was built up using a radiopaque composite material (Amelogen Plus, Opaque Snow shade [Ultradent Products]) according to the manufacturer's instructions. The Opaque Snow shade allowed the dentist to create a stump shade that was as light as possible, thereby eliminating the need for too much opaque in the all-ceramic restoration (Fig. 8).

The decision was made to reinforce tooth #8 using the innovative Macro-Lock Illusion post. Its color-changing technology enables it to disappear when placed. Further, the post demonstrates high translucency for good light transmission, so its placement in this case would enhance the aesthetic and optical properties of the restorative treatment.

■ Impression Taking

In anticipation of the final impression-taking process, a viscous, yet spreadable, 25 percent aluminum sulfate hemostatic gel (Tissue Goo [CLINICIAN'S CHOICE]) was applied along the gingival margins of tooth #8 to facilitate hemostasis (Fig. 9). When placed prior to packing retraction cord, this hemostatic agent also acts as a lubricant. Then a 100 percent cotton-braided retraction cord (First String [CLINICIAN'S CHOICE]) with a tight weave for easy handling was packed through the hemostatic gel to enable the reproduction of greater detail in the final impression.

Radiographically, the post-and-core complex appears as an opaque monobloc entity (Fig. 10), achieving an optimal seal and fit with the canal and remaining coronal dentin. This complex was then treated with a pre-impression cleansing gel (Detail [CLINICIAN'S CHOICE]) in order to clean and decontaminate the core buildup to ensure an accurate impression. In particular, this conditioning gel lifts organic debris and contaminants like sulfur and methacrylate residue from the preparation site in 7 to 10 seconds. Also, Detail decreases the surface tension of the prepared tooth, allowing for better wettability and adaptation of the vinyl polysiloxane (VPS) impression material.

The retraction cord was removed, and the final impression was taken using a third-generation heavy body/light body VPS impression material (AFFINITY Heavy Body and Light Body [CLINICIAN'S CHOICE]), which has matched rheology so as not to over-displace the light body from the preparation, resulting in more accurate detail (Fig. 11). An alginate substitute, multipurpose replication silicone (COUNTER-FIT [CLINICIAN'S CHOICE]) was used to impress the opposing arch. This material is an addition silicone with a short setting time in the mouth; it demonstrates easy removal, has long-term stability and is highly detailed. This increased detail reproduction over an alginate ensures better mounting of opposing casts when using a VPS bite registration material, thereby minimizing the amount of adjustments needed at the cementation appointment. As a result, it is an ideal substitute for alginates.

To obtain the bite registration, a fast-setting (45-second) impression material was used (AFFINITY Quick Bite [CLINICIAN'S CHOICE]). In particular, this VPS material was chosen for capturing the bite registration based on its high tear strength and dimensional stability, and its ability to capture details with rigidity without brittleness.

■ Provisionalization

Endodontically treated teeth can have an improved prognosis when the canals are sealed and leakage of oral fluids and bacteria into the periradicular areas is minimized as soon as possible after the completion of endodontic therapy.³³ The core buildup was treated with a lubricant designed to prevent the formation of the oxygen inhibition layer (DeOx [Ultradent Products]). Then, the previously made matrix was used to create a provisional restoration for tooth #8. In particular, a self-curing hard bisacryl temporary material (Temptation NOW [CLINICIAN'S CHOICE]) in shade A1 was used. This provisional composite material demonstrates an initial cure of one minute or less, with a complete cure in fewer than five minutes. Therefore, resulting provisionals can be trimmed sooner.

The provisional material was injected directly into the matrix from the handheld syringe, after which it was placed in the mouth for a preliminary 45-second set. The matrix



Figure 10: Radiographically, the post-and-core complex appears as an opaque monobloc entity, achieving an optimal seal and fit with the canal and remaining coronal dentin.



Figure 11: The final impression was obtained using the third generation AFFINITY Heavy Body and Light Body VPS impression material (CLINICIAN'S CHOICE) to capture exacting details of the preparation.



Figure 12: Temptation NOW (CLINICIAN'S CHOICE) was applied to the entire surface of the provisional by brushing smoothly and evenly in one direction, and then fully light-cured.



Figure 13: Excess temporary cement was removed from the margins with an explorer.



Figure 14: Characterization was added to the provisional restoration to enhance its lifelike appearance.



Figure 15: View of the bisque bake VITA VM-13 porcelain-layered zirconia restoration (Vident) on the model at the laboratory.

and provisional were removed from the mouth and allowed to final cure. Minimal flash was removed with a diamond bur, after which a methyl methacrylate glaze (Tempglaze [CLINICIAN'S CHOICE]) was applied to the surface of the provisional with smooth, even brush strokes in one direction (Fig. 12). The glaze was then light-cured for 30 seconds per surface with a curing light that produced in excess of 1,000 mW/cm², eliminating the need for polishing of the provisional restoration and increasing its wear resistance.

The provisional restoration was then cemented into place using a resin-optimized temporary cement (Cling2 [CLINICIAN'S CHOICE]) that enables easy removal of excess from the margins, produces a good marginal seal to minimize sensitivity, is antibacterial, and demonstrates good retention — yet easy removal — of the temporary. The internal aspect of the provisional was completely dried, after which the internal aspects were lined with the noneugenol, automix temporary cement.

The provisional restoration was immediately seated over the core buildup preparation, after which a 2 x 2 cotton gauze was placed over it and the patient instructed to gently close into centric occlusion. The patient held this position for 60 to 90 seconds, after which excess cement was removed with an explorer once firm (Fig. 13). Characterization was added to the provisional restoration to enhance its lifelike appearance (Fig. 14).

Endodontically treated teeth can have an improved prognosis when the canals are sealed and leakage of oral fluids and bacteria into the periradicular areas is minimized as soon as possible after the completion of endodontic therapy.

■ Restoration Fabrication

The laboratory ceramist was provided with study models, preoperative photographs and shade maps, and impressions of the core buildup preparation. In addition, custom shade-taking with the patient in the laboratory also occurred. Using this information, the ceramist fabricated the zirconium oxide coping (Lava) for the crown restoration for tooth #8. Then, based on the patient's shade selection, the base

dentin and enamel porcelains (VITA VM-13) were applied in a two- and three-powder cutback and buildup technique. Effect and enamel powders over the dentin, incisal corners, and facial line angles were applied where appropriate and baked (Fig. 15). Custom stains were applied by the ceramist, after which the restoration was glazed and fired (Fig. 16).

■ Final Cementation

At the final cementation appointment, the provisional restoration was removed (Fig. 17) and the preparation was cleaned with an antimicrobial scrub (Consepsis Scrub [Ultradent Products]). The antimicrobial effects of the Cling2 temporary cement — which facilitates adhesive cementation — were evident in the healthy gingival tissue that emerged following the temporization phase (Fig. 18).

The all-ceramic crown was tried in to verify the interproximal and centric contacts, as well as marginal adaptation. The restoration was seated using a self-etching adhesive resin cement (G-CEM [GC America]). The selected resin cement was loaded into the restoration, and it was then seated onto the core buildup preparation. After the release of excess resin cement, a glycerin gel (DeOx) was placed along the gingival margins to prevent the formation of an oxygen inhibition layer.

Once the restoration was definitively cured into place, excess cement was removed from the margins, and the patient was given the opportunity to evaluate her smile. The final aesthetic restorative outcome completely satisfied her expectations (Figs. 19, 20).

■ CONCLUSION

Developing treatment strategies for the restoration of anterior maxillary dentition in need of endodontic support can be challenging. When faced with such cases, a detailed diagnosis and thorough understanding of the patient's needs are required to ensure that the most appropriate materials and techniques are considered. In the case presented here, such knowledge contributed to the selection of restorative materials that, collectively, would enable a conservative and aesthetic approach to the preservation and re-restoration of the patient's central incisor.

The significance of this case is the fact that the dark root syndrome with which the patient presented with her previously placed PFM restoration disappeared following treatment with the aesthetic fiber post (Macro-Lock Illusion) and a metal-free (all-ceramic) crown. This suggests that an added benefit of fiber posts is that they carry light down into the root when there is light transmission through the crown, thus helping to eliminate the dark root appearance.⁷ **CM**

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Figure 16: View of the more characterized restoration for tooth #8 on the model.



Figure 17: At the cementation appointment, the provisional restoration was removed, revealing a suitable core buildup for placement of the final zirconia-based restoration.



Figure 18: Note the excellent tissue health of the gingiva around the preparation due to the antibacterial effect of the Cling2 (CLINICIAN'S CHOICE) temporary cement, facilitating adhesive cementation.



Figure 19: Close-up postoperative view of the patient in natural smile. Note the enhanced aesthetics produced by the use of an aesthetic fiber post in combination with a metal-free all-ceramic restoration.



Figure 20: Close-up 1:1 postoperative view of the restoration on tooth #8. Note the indistinguishable appearance with adjacent tooth #9 as a result of using the aesthetic fiber post.

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