Chairside Customization with CAD/CAM

Recreating a Mirror Image When Restoring a Single Central Incisor

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Introduction
Arguably one of the most esthetically demanding tasks a restorative dentist may encounter is restoring a discolored single central incisor with an indirect restoration that mimics nature and blends imperceptibly with the surrounding dentition. Typically, a significant part of that challenge is communicating the subtle details of the case to an off-site ceramist. With the advent of scanning digital impressions, in-office milling units, and small ceramic ovens, the clinician now is able to immediately design, fabricate, and customize the restoration chairside with the patient. Advances in technology and materials have made success with this type of case—an otherwise often challenging task—more predictable.

Patient Complaint and History
A 32-year-old male presented with the chief concern of a discolored front tooth (Figs 1-3). His work managing a local fitness center engaged him in close personal communication with clients, and he had become self-conscious about the displeasing look of the tooth. It had been broken in a traumatic incident when he was younger and subsequently bonded many years ago. The patient stated that his gums bled occasionally during brushing. He also admitted that it had been quite a few years since his last examination and cleaning. His medical history revealed no significant findings and his oral cancer screening was within normal limits.

Diagnosis
Upon clinical examination, periodontal infection was evident. Generalized moderate gingival inflammation, due to bacterial plaque, had left the gums puffy, red, and tender to the touch (Figs 4 & 5). There was no temporomandibular joint dysfunction, popping, clicking, or masticatory discomfort. A complete radiographic series was taken and evaluated. There was no radiographic or clinical evidence of active caries. With the exceptions of moderate gum disease and the esthetically displeasing front tooth, the patient was in overall good health.
Esthetic Evaluation
An esthetic evaluation of the front two teeth (Figs 6 & 7) revealed the following:

- tooth #9 had a much lower value than #8
- marginal gingival inflammation and redness
- the incisal edge of #9 was longer, compared to tooth #8
- the bonding on #9 had discolored and had begun to deteriorate
- tooth #9 had a subtle rotation and slightly overlapped tooth #8 on the mesial
- the incisal embrasures were generous, especially on the distal of the central incisors.

Discussion and Treatment
Two viable options to restore tooth #9 back into harmony with the rest of the anterior dentition were considered and discussed with the patient: direct resin bonding, or an indirect porcelain laminate veneer. The limitations and benefits of each option were thoroughly discussed. The patient expressed his desire to select a material that would disolor the least and would endure the best over time. It was determined that indirect ceramic restoration would be the treatment of choice to achieve the patient’s esthetic desires and restorative needs. A treatment plan was presented to the patient as follows:

- periodontal tissue management
- photographic workup, model analysis, and diagnostic wax-up
- indirect restoration of tooth #9.

Treatment Description

Initial Treatment
Initial treatment consisted of two parts: achieving gingival health, and collecting and organizing the appropriate records to adequately plan the restorative component of the case.

First, periodontal tissue management was immediately initiated; this consisted of localized deeper periodontal scaling and a general dental prophylaxis. Second, a detailed photographic documentation, incorporating AADC’s Accreditation photographic series and other detailed diagnostic images, was made. Polyvinyl silane (PVS) impressions were taken to create duplicate casts for model analysis and a diagnostic workup. A Kois Dento-Facial Analyzer (Pana- dent; Colton, CA) also was used to generate an earless facebow transfer, and served as a “T-reference” for mounting the casts and orienting the occlusal plane.

Subsequently, a wax-up was completed on the articulated models and Sil-Tech putty matrices (Ivoclar Vivadent; Amherst, NY) were formed as preparation reduction guides as well as a stent for the provisional veneer. The functional occlusion also was evaluated to ensure proper anterior guidance. Once the desired functional and esthetic outcome had been verified on the models, we were ready to begin the clinical restoration of tooth #9.

Restorative Phase
The preparation appointment began with a minor occlusal equilibration to establish and confirm centric holding contacts on all posterior teeth and remove any centric relation to maximum intercuspation slide or
interferences identified during the model analysis. Ensuring that there is a balanced and peaceful masticatory system is a key component to the longevity of any type of restorative work. Next, tooth #9 was roughly prepared to permit complete seating of the provisional stent, which was filled with temporary crown material (Luxatemp, DMG America; Englewood, NJ) and placed over the tooth. This was allowed to set for 1.5 minutes, locking it into place. Depth-cut burs (Brasseler USA; Savannah, GA) were then used to uniformly achieve the depth of preparation through the provisional material. This technique serves as a useful guide when preparing misaligned or crowded teeth. In this case, it helped to ensure that adequate restorative space was achieved to manage the color change of the darker tooth. Given that a ceramic thickness of about 0.2 to 0.3 mm is generally needed for each shade change, and that the original tooth shade to the desired final shade was the difference of about two shades, a 0.7-mm depth-cut bur was used across the mid-facial, providing uniform restorative space for the restoration while still maintaining the preparation in enamel.

**Final Impression**

Once the preparation had been refined, the tooth was cleaned and left moist so that a stump shade photograph could be taken for reference. A dual-cord technique was then used to prepare the teeth for the final impression. (Note that the use of an impression and a model are not always necessary. A digital scan can be done intraorally, and the use of the model can be skipped altogether. However, for scheduling purposes and for the clinician’s convenience, impressions and models were used in this case.) A final PVS impression was taken along with a bite and a T-reference record. The prototype-style temporary was created using the putty matrix from the diagnostic wax-up and temporary crown material. The prototype was trimmed, polished, and detailed, and the patient was rescheduled for the delivery of the restoration.

The impression was poured in die stone and prepared for scanning with the CEREC Bluecam (Sirona Dental; Charlotte, NC). The stone model of the prepared teeth and the stone model of the diagnostic wax-up were scanned. These digitally rendered models, with the help of the CEREC computer software, were merged to guide the digital design of the new restoration.

**Material Selection**

The material selection and computer-aided design/computer-aided manufacturing (CAD/CAM) fabrication of the restoration for this case were chosen to more predictably control the end result and achieve the goals set out for the patient. There are many types of materials on the market today that could have been used to restore this case, and certainly more than one of those options could have yielded a successful result. However, a monolithic, high-translucency lithium disilicate (IPS e.max, Ivoclar Vivadent) was selected for this partial-coverage restoration, offering the clinician the following advantages:

- **Strength**: Lithium disilicate offers a ceramic flexural strength much stronger than other leading esthetic ceramics such as leucite-reinforced or feldspathic glass ceramic. This additional strength can instill confidence in both the clinician and the patient in terms of durability, and consequently, in the overall inherent value of a final restoration that has an increased potential to endure over time.
- **Esthetics**: Lithium disilicate, as a monolith, can be a highly esthetic enamel replacement when planning for thin partial-coverage restorations on minimally prepared teeth with favorable color. Enamel, like monolithic porcelain, is uniform in color, but gives the perception of a gradation of character from the gingival to the incisal, due to the transition of its thickness from about 0.3 to 0.4 mm at the gingival, to 1.1 to 1.4 mm at the incisal. When the thickness of the monolithic restorative material is managed after the pattern of enamel, a very natural-looking result can be created.
- **Bondability**: Lithium disilicate can be easily prepared and successfully bonded to enamel in fashion similar to feldspathic or leucite-reinforced ceramic.

**Fabrication**

This material was selected for use in connection with CAD/CAM technology, allowing the final restoration to be created chairside with the patient. This combination offers the following advantages to the clinician indirectly restoring a single incisor:

- **Mirror-image predictability**: When the clinician is restoring a single central incisor, it is critical to the overall esthetics of the case that the restoration be a near-identical mirror image in dimensions and contours to the contralateral central incisor. CAD/CAM can digitally scan the adjacent central and precisely replicate its mirror image in form for the new proposed restoration. Mirror-image replication can be a huge advantage when striving for predictable esthetics in a case of this type.
- **Chairside customization**: With the introduction of CAD/CAM and small in-office ovens for the crystallizing, staining, and glazing of materials like lithium disilicate, clinicians can easily modify these restorations on site. Chairside customization, enhancing shade match by adding maverick colors and incisal characteristics, can help create predictable esthetic results. The added benefit of having the contralateral tooth as an immediate reference and guide aids the clinician in this artistic pursuit of a “natural” restoration.
- **Full control over the final restoration**: Careful management of the details important to the case, such as contact length, embrasure form, and surface texture during the design and finishing of the restoration, can also be very helpful to the clinician desiring predictability in the end result.
Given the esthetic demands and artistic challenges associated with restoring a single central incisor, especially one with a lower value than its contralateral counterpart, it behooves the clinician to draw upon all tools available that can increase predictability for success in these types of cases.

**CAD/CAM AND DIGITAL DESIGN**

The three-dimensional digital models acquired through scanning digital impressions were manipulated in a series of steps within the software, to create a proposal for the final restoration, replicating in form a near-identical mirror image of the contralateral central incisor (Figs 8-10). The interproximal contact strength and margins were refined and the final proposed design was carefully evaluated, approved, and submitted for milling.

**Ingot Selection**

Ingot selection in this case was made after carefully evaluating the incisal third of the contralateral tooth. The color of the middle and gingival third of the tooth is influenced more by the combination of the underlying tooth structure and the thickness of the final restoration. In these areas, the clinician has to do some “mental color mixing.” One must take into account the thickness of the restoration planned, the color of the prepared tooth, and the shade of the ceramic, blending the three together. Custom shade guides can be designed to make this easier to visualize. The thinner the restoration, whether 0.3 mm or 1.0 mm, the more the underlying color of the prepared tooth will affect the manifestation of its final value and hue. Given these parameters, a high-translucency BL2 ingot (IPS e.max) was selected for two reasons. First, the BL ingot series was favored in this case because it is slightly more opaque and less translucent than the B1 ingot series, which will block out a darker tooth underneath. Secondly, even though a BL2 by itself would appear brighter than the target color of the surrounding natural tooth, it is easier to tone down a tooth (as in this case with a sunset color stain) from a bleach shade down to an A1 or even an A2 than it is to take an A1 ingot up to a bleach shade.

**Milling and Refining**

The computer design was milled with precision out of a 14-mm, partially crystallized, lithium disilicate block. The block is only partially crystallized at the initial stage, because the milling would otherwise take significantly more time if the material were in its fully crystallized or “hardened” state. The milling process...
takes about 10 minutes to complete, after which the milling sprue is removed by hand with a fine diamond bur. The restoration can then be tried on a model or intraorally for marginal and proximal contact fit, verification of occlusion, and surface refinement prior to crystallization and customizing. Surface refinement can be accomplished with fine or very fine diamond burs, impregnated rubber wheels, and fine sanding disks. Slow speed, light touch, and water while refining the surface help to prevent fractures and also help to avoid overheating the ceramic material.9 In this case, for example, the definition in the facial lobes and the horizontal scribe lines that were seen as reflective surface texture in the 1:1 images (Figs 6 & 7) were added post-milling by hand, with fine diamond burs prior to crystallization and customizing with stains and glaze.

### Crystallization and Customizing

Some of the color customization can be done in this “lavender” partially hardened state prior to full crystallization in the oven. By using close-up photographic images viewed on a computer monitor, or chairside looking at the contralateral tooth for reference, gingival and incisal characterization can be applied. In this case, for example, note the white, grey, and orange/sunset colors, which were added at the incisal edge using a fine brush (Figs 4 & 5). Liquid mediums and clear glaze can be mixed into the stains to tone them down or to allow for a “watercolor-like” surface blending/bleeding technique. These colors can be baked in over multiple firings (multiple thin layers are preferred to fewer thick layers of glaze or stain) until the desired look is accomplished and previewed with the patient upon the final try in of the restoration.9 A final clear glaze over any characterization can help protect and seal in the subtle details in color previously added to “naturalize” the restoration.

For lithium disilicate, various firing cycle programs can be found for in-office ovens. Caution should be used with respect to “short” or “speed” firing times and parameters when customizing and crystallizing a restoration. Some shortened firing cycles (often faster than 19 minutes) can potentially leave a lithium disilicate restoration’s crystallization incomplete, making the ceramic more opaque than desired (Fig 11). Shortened firing cycles can also fail to fully evaporate the solvent in the “paint-on” stain and glaze, leading to premature breakdown of the surface finish and color. For this case, three different firings were done prior to cementation. An incisal wash with grey stain and a gingival and proximal warming with a sunset stain were incorporated into the restoration with the first firing. White characteristics were placed for the second firing, and for the final third firing a clear surface glaze was added, sealing the color in. All firings were performed at the standard 26-minute firing cycle recommended for IPS e.max CAD.9

### Delivery and Cementation

At the delivery appointment, the prototype was removed and the prepared tooth was cleaned thoroughly and micro etched. The restoration was then tried in dry to assess fit and contacts. The precision of the digital design and milling resulted in no adjustments being necessary. Prior
to the second firing, intraoral and chairside custom stains were tested and applied to further replicate the character of the adjacent tooth. Then, after try-in approval, the restoration was fired and glazed a third and final time.

After cooling, the restoration was cleaned, and prepared for bonding. It was internally etched with 4% hydrofluoric acid for 20 seconds, rinsed, and dried. The internal aspect was then treated with a silane coupler, Monobond (Ivoclar Vivadent) for 60 seconds, air-dried, coated with unfilled bonding resin, and air-thinned.

The tooth surface was also prepared for bonding. An Isolite (Santa Barbara, CA) was used for isolation and humidity control. Adjacent teeth were covered with white nonstick tape and only tooth #9 was etched for 15 seconds with 38% phosphoric acid, rinsed, and lightly dried with cotton pellets and vacuum so as not to desiccate the tooth. It was rewetted with chlorhexidine and blotted dry with cotton pellets. Bonding agent was applied to the tooth and air-thinned to remove solvent. Variolink B 0.5 cement (Ivoclar Vivadent) was applied to the internal aspect of the restoration and it was seated. Once proper positioning of the restoration was confirmed, a tack cure was performed with a Sapphire curing light with a 2-mm tacking tip (DenMat; Lompoc, CA) and the excess cement was removed with floss and a #12 scalpel blade. A final cure was then completed. The occlusion was optimized and the patient was rescheduled for a follow-up appointment and postoperative photographs (Figs 12-15).10
There are many aspects of computer-aided digital dentistry that prove advantageous when the clinician is indirectly restoring a single central incisor.
When comparing the before and after images side-by-side (Figs 16-20), the achievement of the two main goals of treatment can be visually evaluated. First, the resolution of the marginal inflammation and the return to gingival health is apparent. Second, the replication of a true-to-life tooth form and the harmonious blend of the ceramic with the natural dentition are evident.

Summary
There are many aspects of computer-aided digital dentistry that prove advantageous when the clinician is indirectly restoring a single central incisor. The symmetrical mirror-imaging contour, control of emergence profiles, surface texture, subtle color nuances and characteristics, and marginal fit can all be easily controlled, accomplished, assessed, and fine-tuned in the digital designing and chairside finishing steps inherent in this technological process. These advantages, when utilized and managed properly, can make creating a successful restoration, even with challenging cases, more predictable for the clinician and the patient.

References
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