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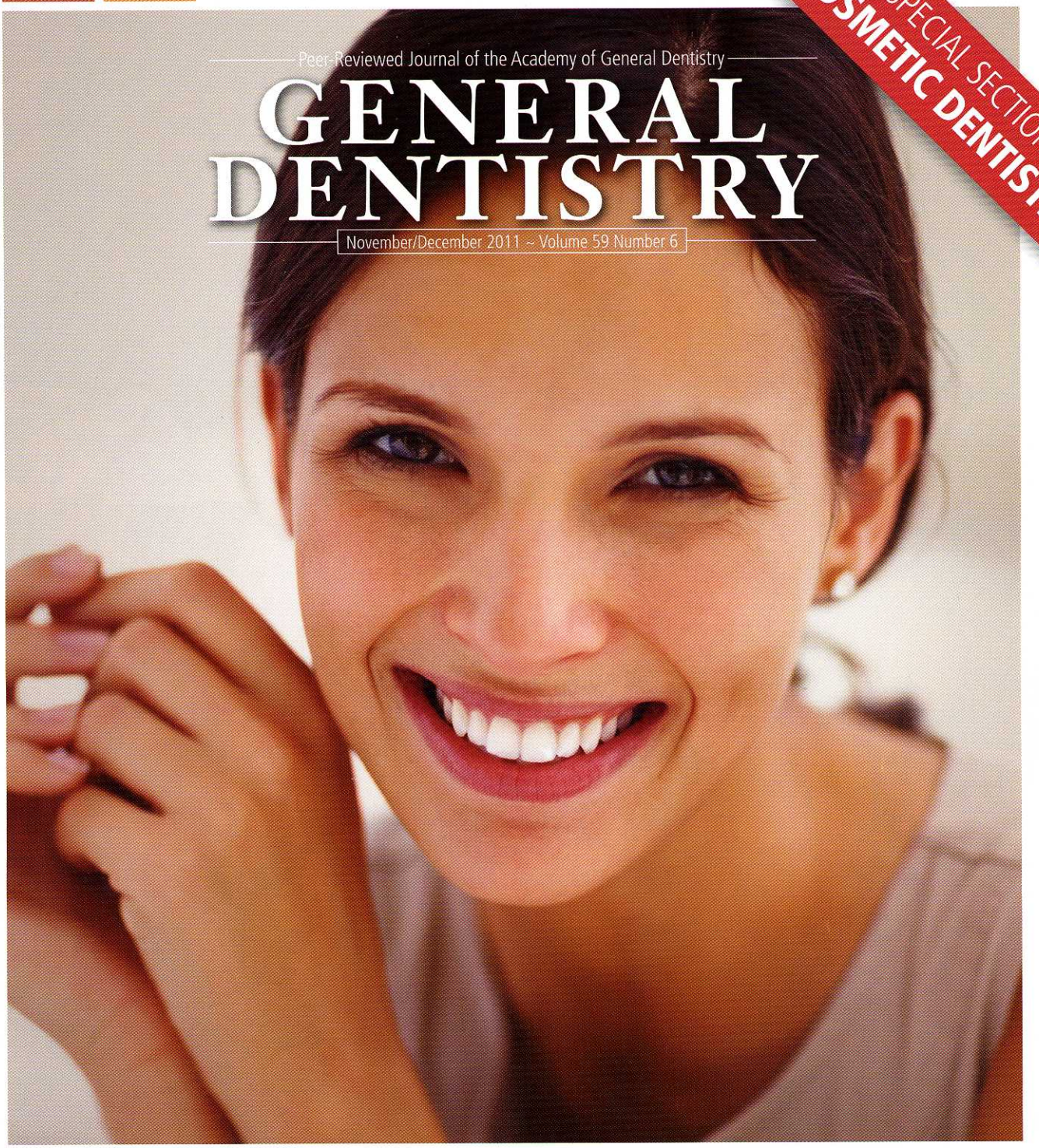

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Successful strategies for matching one or two indirect restorations to natural dentition

Michael R. Sesemann, DDS

One of the most difficult and noble undertakings of a dental restorative team is to provide an indirect restoration for a compromised tooth surrounded by otherwise healthy, natural dentition. Matching one or two indirect dental restorations to adjacent healthy teeth is a herculean task for both the dentist and laboratory technician. The team must be knowledgeable of the natural dentition's characteristics to best mimic and recreate those same characteristics in a man-made restoration. Knowledge of principles in smile design, dental anatomy, color, characterization, material selection, doctor-technician communication, and clinical acumen are necessary to achieve a successful outcome when matching one or two indirect restorations to natural dentition.

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Achieving natural esthetics by harmoniously matching the shape and color of a single anterior restoration is perhaps one of the greatest challenges in restorative dentistry.[1] The advent of lifelike restorative materials has made it possible to supply an indirect restoration that provides optical properties that mimic those of natural teeth.[2] However, the dentist and laboratory technician must work synergistically to identify significant details of the adjacent natural dentition to create an artificial unit that will blend perfectly with its native neighbors.

Not too long ago, when a patient presented with a single anterior tooth problem requiring a restorative solution, the suggested treatment plan would have included the restoration of an adjacent natural tooth or teeth so that all of the anterior teeth in an arch would have matching optical properties. Restoring all of the maxillary incisors when only one tooth was the problem was not unheard of, and the inclusion of a perfectly healthy contralateral central incisor to help disguise the restoration of another central incisor by itself was all too common. One of the greatest benefits of the lifelike materials currently available is the ability to implement a much more conservative treatment plan for the health benefit of patients.

Having improved materials is only one of the important components of success. A successful protocol begins with an accurate examination and diagnosis for a full accounting of the problem. After that, elements of smile design, dental anatomy, color, characterization, material selection and dentist/laboratory communication must be analyzed and applied with a high level of efficiency and effectiveness for the restoration to fulfill esthetic objectives.

Examination, diagnosis, and treatment plan

The value of a comprehensive examination and data collection is well-established and accepted.[3] If a patient has a multitude of issues, data collection will include a full set of radiographs and a photographic survey with impressions and a bite registration for providing mounted study models for analysis. When a patient needs only one restoration, there is a tendency for the clinician to believe that the usual data collection can be scaled back and that the restorative team should be able to get by with less. However, clinical experience has convinced the author that doing so compromises the team's ability to have all of the data needed to match one or two restorations to the patient's natural dentition.

Whether a patient needs one restoration or a full-mouth rehabilitation, complete data collection with a full series of initial images is extremely important.[4] The images should be taken in a timely manner with an effort made to keep the teeth hydrated between frames so that desiccation does not cause a perceptual distortion from how the dentition normally appears. A black background for 1:1 close-up images will help individual tooth characteristics stand out, such as areas of translucence, hypocalcifications, and maverick colors (Fig. 1). A dual flash attachment also prevents light reflection from obscuring the image.

The exposure of the image must be perfect and should never be overexposed, because all of the tooth's characteristics will be concealed in an overly bright image (Fig. 2). In fact, intentionally underexposed

Fig. 1. A close-up image taken at 1:1 magnification with proper exposure and a dual flash apparatus.

Fig. 2. An image of the patient in Figure 1 taken with a ring flash that is overexposed does not show dental characterizations.

Fig. 3. This underexposed image, taken from a side perspective, shows a shade guide with a tooth to be replicated that exhibits diffuse whitish hypocalcifications.

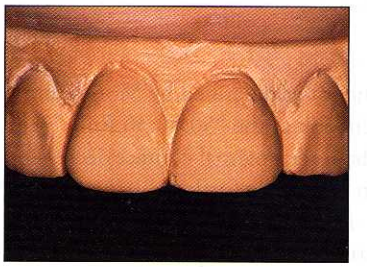

Fig. 4. Study casts of a proposed restoration for tooth No. 9 illustrate a perceived difference in width to the contralateral central incisor.

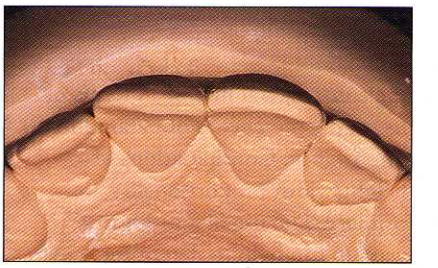

Fig. 5. Occlusal view illustrating the difference in anatomy. Tooth No. 9 is a restoration whose line angles have been carried far into the interproximal contact area, and the facial profile is convex.

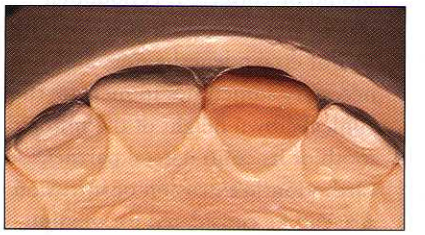

Fig. 6. Occlusal view of a wax-up showing that the restoration can match the contralateral tooth if the line angles and facial contour are replicated.

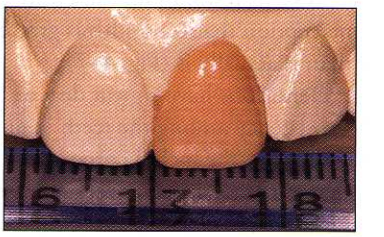

Fig. 7. Straight-on image with millimeter ruler showing the duplicate widths of the tooth and proposed restoration.

images can help the ceramist see distinguishing characteristics that do not appear with images with normal exposure. When taking this shot with a shade guide included for laboratory communication, it is beneficial to have the images of the teeth in the arch taken from an angle on either side and above and below the "straight on" perspective (Fig. 3).

Smile design

When restoring a single tooth in the maxillary arch, smile design principles may or may not come into play. There certainly are healthy smiles considered esthetic without being consistent with a "default application" of smile design principles. This is particularly true when the tooth being restored is a lateral incisor, where bilateral differences between contralateral partners lend an aura of naturalness.[5] Not providing contralateral symmetry can be pertinent when it is not desirable to copy certain characteristics of wear, chipping, or cracks; however, if the tooth being restored is a central incisor, more often the objective is to provide a mirror image of the contralateral natural incisor in terms of its shape, shade, and character.

Smile design principles routinely in play are evident in bilateral spatial considerations, especially between the central incisors. Whether the tooth to be restored lends itself the capability to mimic

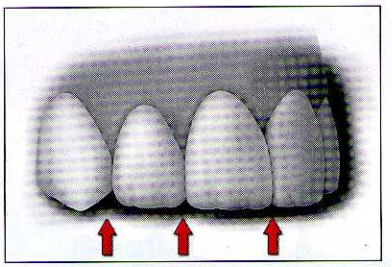

Fig. 8. Incisal embrasures of the anterior sextant should get progressively larger the further they are located from the midline.

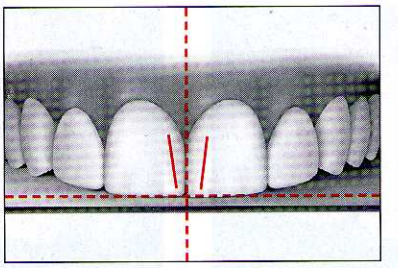

Fig. 9. The mesial line angles of the central incisors frame the most important 18 mm² in anterior smile design. Bilateral symmetry is critical.

the contralateral incisor in terms of its spatial presence is of paramount importance. Considerations of height/width proportionality are primary. The use of a diagnostic wax-up can help to determine whether a mirror image of the contralateral central incisor is possible. This is particularly helpful when anatomic differences, such as aberrantly positioned line angles of a previous restoration, can create the perception that the width is greater than it actually is (Fig. 4–7).

Dentitions have a great deal of consistency among the teeth in an arch when the incisal corners of unworn teeth are analyzed and the incisal embrasures are categorized. For maxillary incisors, the respective incisal corners of a given tooth (mesial to distal) can be categorized as square/square, square/round, or round/round. When lined up next to each other, incisal embrasures should become progressively larger when proceeding distally, with the central/central incisal embrasure being the smallest and the lateral incisor/canine being the largest of the anterior sextet (Fig. 8).

Commensurately, the size of the incisal embrasure affects the length of the interproximal contact. As the contacts are analyzed, they can be related to the length of the central incisor as described by Morley and Eubank as the "50:40:30 Rule," with the interproximal contact decreasing in length the further distal one goes.[6]

Management of the periorestorative interface is paramount for controlling height issues.[7] Though the symmetry need not be ideal for all cases, a pleasing gingival architecture can and should be a goal of treatment, and extreme differences should be corrected. Periodontal procedures, including gingivoplasty and/or crown lengthening, are necessary sometimes to increase the clinical crown height of the restored tooth or its contralateral partner.[8] Orthodontic extrusion or intrusion also can be considered for manipulating the tooth's relationship in the arch to shorten or lengthen the clinical crown height as desired.[9]

Dental anatomy

Fabricating a restoration that matches the shape of the adjacent dentition is a vital requirement. Controlling line angle placement, embrasure development (cervical, facial, and incisal), contours, and deflecting/reflecting surfaces are key to mimicking adjacent anatomy. A space for a restoration unequally matched contralaterally can be given that appearance by varying the position of the line angles and controlling the reflective/deflective surfaces.

The cervical embrasures are the primary area of importance in initiating interproximal emergence profiles and line angle development. An interesting presentation occurs with the maxillary lateral incisor: Most of the time, the mesial line angle of the maxillary lateral incisor is located toward the median facial aspect of the tooth at the gingival crest, allowing for a distinctive "opening" of the mesial cervical embrasure. This differs from the line angles of the central incisors.

When restoring a maxillary central incisor, it is extremely important to provide symmetry between the midline and the mesial line angles of the contralateral central incisors.

The line angles must be equidistant to the midline and diagonally similar to provide symmetrical balance (Fig. 9). The midline will appear canted if the line angles are at a different angle or distance from the midline, even if the midline is perfectly aligned with the mid-sagittal of the face. The positioning of the mesial line angles of two adjacent central incisors at the patient's midline might be the most important 18 mm² in the maxillary arch, from an esthetic perspective. Also, the line angles of a tooth have a defining relationship to the reflective and deflective areas. The facial surface area between the mesial and distal line angles of a tooth is the reflective surface. The area of the tooth from the line angle to the interproximal contact is the deflective area. If there are differences in the reflective/deflective surfaces of contralateral teeth, they will appear dissimilar.

Reflective and deflective surfaces play a role in the perceived width of a single tooth.[10] Moving the line angles closer to the interproximal contact can make a tooth appear

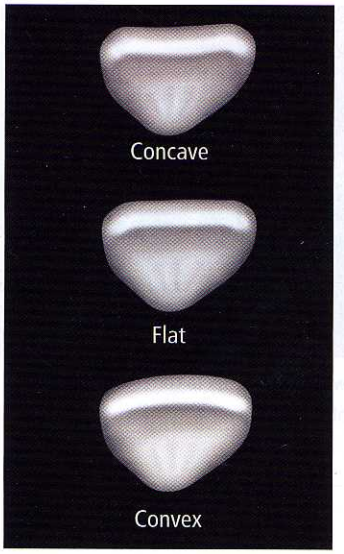

Fig. 10. Perspective of three generalized facial tooth contours for the maxillary incisors.

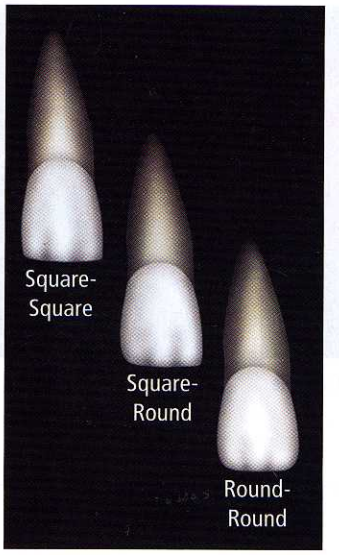

Fig. 11. Illustrations of the three incisal corner presentations of maxillary incisors.

Fig. 12. Before image of a discolored tooth No. 9 and diastema.

Fig. 13. Image showing the different preparation types for a cored restoration (tooth No. 9) versus thinner, more translucent porcelain restorations.

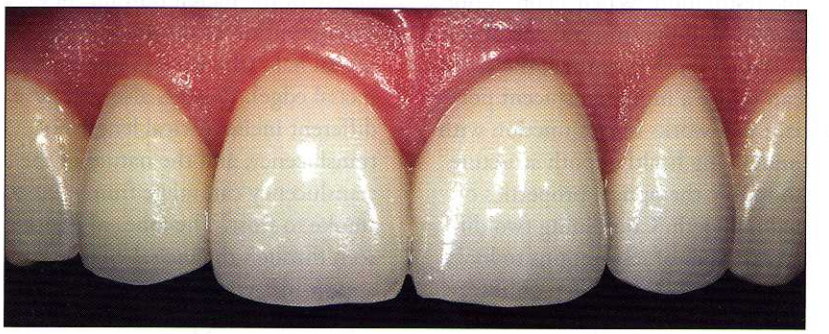

Fig. 14. After image demonstrating the significant laboratory expertise necessary to match a cored restoration to a thin veneer.

wider, because its reflective surface is broader. Conversely, bringing the line angles more medial can narrow the reflective surface, increasing the area of the deflective surfaces and therefore making the tooth appear narrower. There are times when intentional control of these interdependent anatomic details can be used by the restorative team to make restorations appear to be wider or narrower. In a different context, changing the line angles of a faulty restoration can make it match a contralateral natural tooth perfectly.

The contour of the facial surface of a maxillary incisor can be convex, flat, or concave (Fig. 10). When the facial contour is related to the variations of incisal corners, restorations can have completely different "attitudes" in their presentation (Fig. 11). For example, for a bold look, a restoration could exhibit square/square corners and a concave profile. For a softer appearance, round/round corners with a convex facial surface would be the best choice. Of the nine different variations that can occur when the three facial contours are combined with the three different incisal corner variations, the one most often seen and utilized is the combination of square/round corners and a flat facial contour.

Color

Most dentists practice analyzing color in the 3-D modalities of hue, chroma, and value.[11,12] However, a fourth dimension is particularly important in achieving success. The optical properties of opacity must be duplicated for a restoration to mimic a natural tooth accurately. In addition to being a primary element of how a restoration appears, controlling the opacity is critical to blocking out underlying tooth structure, particularly if there is an unwanted discoloration, so that it does not influence the restoration's final "shade" (Fig. 12–14).

Fig. 15. A patient with a tetracycline-stained dentition in need of a single central incisor restoration.

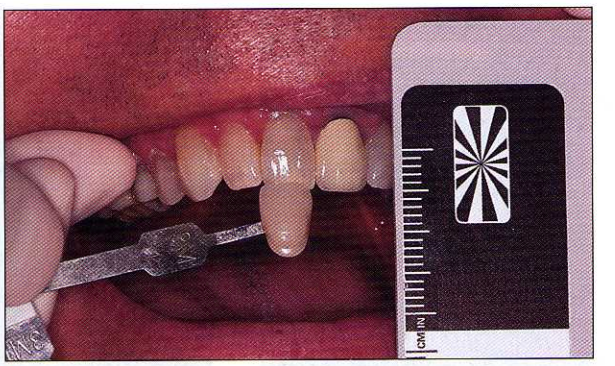

Fig. 16. A digital grey card allows the technician to correct an image to neutral grey with a variety of software options.

The dental team must be fully aware that if a core is provided, the restoration will have to provide 100% of the optical appearance of the restoration. When a core is not needed and the stump shade of the prepared tooth is normal, the team can utilize a more translucent porcelain that works in conjunction with underlying healthy tooth structure to mimic the optical properties of natural teeth. Combining two different types of restorations to look alike while side by side requires extreme skill and expertise on the part of the laboratory technician and diligent communication between the dental office and the laboratory.

Characterization

Incisal translucency, the incisal halo, hypocalcifications (white and discolored), maverick colors, and anatomic irregularities all play a role in the characterization of a restoration.[13,14] The inclusion of characterizations in a restoration helps it to blend sublimely with its natural neighbors, while an absence of proper characterizations spotlights the restoration as an imposter.

Translucency must be incorporated into the varied optics of the tooth to duplicate the gradual thinning and ultimate elimination of dentin in the incisal third of the tooth. Of particular importance is identification of the nature and degree of the incisal translucency and definition of the amount of the incisal halo (the whitish line at the incisal edge). Patients also will have different incisocervical lengths of translucency, and the nature of the translucency can range from clear to smoke to frost. The lobes of dentin seen through the incisal enamel can appear in a variety of ways, including a tri-lobed appearance. In other presentations, the main lobes can be divided further into smaller entities, giving the dentin component an appearance similar to the tines on a comb. There also could be a gradual thinning of the dentin, yielding little detail beyond a simple fade.

For a vast majority of the time, less is more when incorporating characterizations into a restoration. Hypocalcifications can vary from a diffuse "netting" to deeper blotching with varying intensities. Maverick colors of brown, amber, or orange may be present, or seen only during a magnified examination. However microscopic their size, the presence of maverick colors contributes to the tooth's overall appearance.

There are times when maverick colors can become dominant in their appearance, such as in a case of matching a central incisor in a tetracycline-affected dentition. Hues of grey, violet, amber, and brown become primary instead of secondary because of their dominance. In cases like these, communication with the laboratory technician must include details such as duplicate custom provisionals, with one of these being photographed on the patient and sent with the case to the dental laboratory for the ceramist to see exactly what was in the image (Fig. 15–18).

Material selection

There has never been a greater range of material choices available for the practitioner and the laboratory technician/ceramist. This is both a blessing and a curse, because finding the perfect material requires the restorative team to eliminate potential materials through their knowledge of each product's characteristics, attributes, and potential shortcomings. At times, the choice of material might simply reflect what the restorative team does best—it is the product with which the team is most familiar and believe they do their most predictable work.

Fig. 17. A shade tab image for the laboratory includes a custom-made acrylic veneer to enable the technician to have a replica of the one shown in the image.

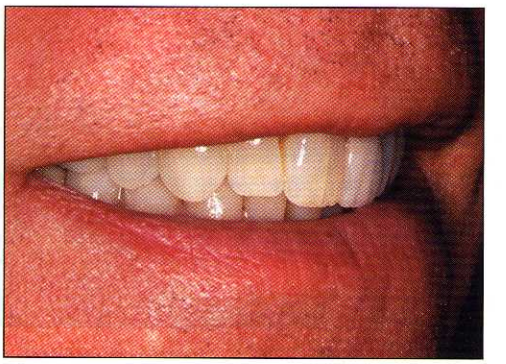

Fig. 18. Post-treatment image of the crown restoration of tooth No. 9.

However, the patient is best served when the team is accomplished in multiple material applications and can choose the material that is best for the case.

The range of materials can include feldspathic, leucite-reinforced, and lithium disilicate porcelain, along with zirconia and porcelain-fused-to-metal (PFM) options. Due to the intricacies of the esthetics needed in the anterior region, the restoration likely will include ceramic layering so that finite esthetics and characteristics can be built into the appearance. Notable differentiating factors for the restorative team would include the restoration's thickness upon completion and the color and shade of the prepared tooth that will reside underneath the restoration.[15]

At one end of the spectrum, where conservative preparation and normal tooth stump shade are factors, feldspathic, leucite-reinforced, and lithium disilicate porcelain can work. At the other end of the spectrum, where a conventional preparation is made and/or the shade of the underlying tooth needs to be prevented from showing through, a cored product like lithium disilicate or a zirconia would be the best choice. In addition, PFM restorations can work to block out a darkened tooth; however, the expertise of the laboratory ceramist and the chosen final shade must be taken into consideration. A laboratory technician must possess considerable expertise to make a PFM mimic the optical characteristics of a natural tooth. When 100% block-out is warranted and the final shade of the restoration is darker than an A3 value, it might actually work to the technician's advantage to build off a darker core of metal than from a zirconia product that is inherently bright, even with color modification.

Dentist-laboratory technician communication

In addition to the dentist/laboratory technician team being a collaborative partner in material selection, there are communication needs to minimize errant attempts at fabricating the restoration. Protocol requirements include adequate preparation for the type of material chosen, accurate impressions, good photography of the patient's initial conditions, shade images, and provisional models that illustrate an approximate final result.

As stated earlier, it can be beneficial to control the exposure of shade images so that they are not overexposed and, sometimes, to provide underexposed images. The images should be in an RAW format to provide the fullest tonal spectrum possible. An important addition when taking shade images is the use of a digital grey card. With a "neutral grey" hue in one or all of the images, the ceramist has the opportunity to correct the temperature and tint of the image with iPhoto (Mac) or Adobe Photoshop (Mac or PC) on the monitor to calibrate the entire tonal range of the image to the known neutral grey tone included (Fig. 16). This can make the image seen at the laboratory more closely approximate what the teeth and gingiva look like in the operatory.

Clinical acumen

As stated earlier, it remains a key challenge to achieve natural esthetics by harmoniously matching the shape and color of a single anterior restoration. This challenge requires the restorative team to be fully cognizant of nature and the patient's presenting conditions to fabricate a restoration that appears

Fig. 19. A young patient seeking a conservative treatment option to replace an unpleasant restoration on tooth No. 9.

Fig. 20. 1:2 magnification view of the patient's natural smile.

Fig. 21. 1:2 magnification of the patient's upper and lower arches.

Fig. 22. 1:1 magnification of patient's maxillary incisors, revealing anatomic differences between the defective restoration and the contralateral natural incisor.

similar to natural teeth. To match one or two restorations successfully to natural dentition, the restorative team must pay more attention to detail than when fabricating a row of restorations where everything is made to match. To do otherwise is setting up the team and the patient for frustration, failure, or both.

Case report

A 19-year-old woman in excellent health came to the dental office seeking to have a restoration for tooth No. 9 replaced (Fig. 19 and 20). Reportedly, the crown had been in service for only three months. Clinically, there was a great shade disparity between the crown and the adjacent natural teeth; however, the crown was closer to the shade of the mandibular teeth, raising suspicion of localized, unsupervised bleaching of the upper arch after the prior dentist had seated the restoration (Fig. 21). The patient denied that any such actions had taken place and maintained that the crown's current appearance was similar to how it appeared the day it was seated.

A complete examination and data collection revealed the current crown to be a full-coverage crown. There seemed to be more of a potential space for a restoration on tooth No. 9, especially in width, than was present on the contralateral natural central incisor (Fig. 22). A diagnostic wax-up revealed that a new restoration indeed could mimic the contralateral central tooth perfectly (Fig. 4–7).

Both the maxillary and mandibular dentitions were bleached under supervision to control the outcome and to more closely align the value (brightness) of the upper and lower arches. The tooth was prepared for a full crown and supporting data were collected and sent to the dental laboratory for restoration fabrication. At the try-in for the first attempt, further photographic images were taken and sent to the laboratory with the crown so that characterization could be completed (Fig. 23). At the second try-in, the esthetic objectives of the doctor, laboratory technician, and patient were realized and the crown was bonded utilizing a three-step etch and rinse bonding system

Fig. 23. First try-in attempt of the restoration. New images were obtained to allow the laboratory technician to more definitively customize the restoration.

Fig. 24. Facial view of the patient's new smile three weeks after bonding of the restoration.

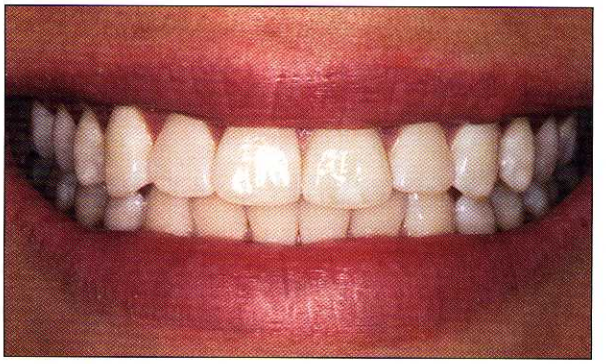

Fig. 25. 1:2 magnification of patient's natural smile.

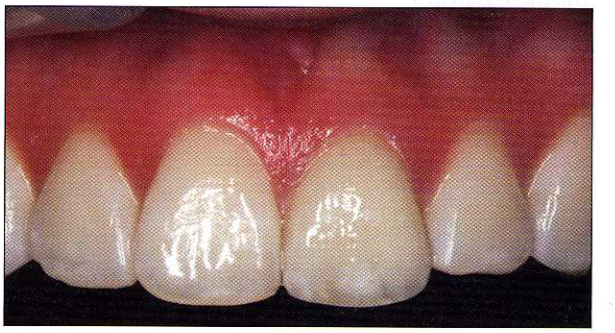

Fig. 26. 1:1 magnification of the new crown, exhibiting hypocalcifications, maverick colors, translucencies, and anatomic detailing.

(Optibond FL, Kerr Corporation) and a photocure-only resin cement (Variolink, Ivoclar Vivadent Inc.). Three weeks after cementation, the patient returned for the restoration to be checked and photographed (Fig. 24–26).

Summary

One of the greatest benefits the dental profession can provide patients is the ability to restore a single tooth to match an otherwise healthy and esthetic dentition. The chances of a successful outcome for these challenging cases can be improved by approaching the case with a complete knowledge of anatomical considerations and a predetermined protocol to maximize efforts.

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Author information

Dr. Sesemann is in private practice, Omaha, Nebraska, and a clinical instructor, Kois Center for Advanced Dental Education, Seattle, Washington.

References

1. Fahl Junior N. The aesthetic composite anterior single crown restoration. Pract Periodontics Aesthet Dent 1997;9(1):59-70.
2. Spear F, Holloway J. Which all-ceramic system is optimal for anterior esthetics? J Am Dent Assoc 2008;139 Suppl:19S-24S.
3. Dawson, PE. Evaluation, diagnosis, and treatment of occlusal problems, ed. 2. St. Louis: Mosby;1989:1-13.
4. American Academy of Cosmetic Dentistry. Photographic documentation and evaluation in cosmetic dentistry. A guide to accreditation photography. Madison, WI: American Academy of Cosmetic Dentistry;2009.
5. Rosenstiel SF, Ward DH, Rashid RG. Dentists' preferences of anterior tooth proportion: A web-based study. J Prosthodont 2000;9(3):123-136.
6. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc 2001;132(1): 39-45.
7. Rufenacht C. Principles of esthetic integration. Landshut, Germany: Quintessence Publishing Co.;2000:37-60.
8. Kois JC. Altering gingival levels: The restorative connection. Part 1. Biologic variables. J Esthet Dent 1994;6(1):3-9.
9. Camargo PM, Melnick PR, Camargo LM. Clinical crown lengthening in the esthetic zone. J Calif Dent Assoc 2007;35(7):487-498.
10. Rufenacht C. Fundamentals of esthetics. Chicago: Quintessence Publishing Co.;1990:67-127.

11. Munsell AH. A color notation, ed. 2. Baltimore: Munsell Color Co.;1961:15-20.
12. Wood DJ, Shiraishi T, Shinozaki N, van Noort R. Spectral reflectance and color of dentin ceramics for all-ceramic restorations. Dent Mater 2008;24(12):1661-1669.
13. Muia P. Paul Muia explains his four dimensional color system. Quintessence Dent Technol 1983; 7(1):57-62.
14. Muia P. The fourth-dimensional tooth color system. Carol Stream, IL: Quintessence Publishing Co.;1985.
15. Baltzer A. All-ceramic single-tooth restorations: Choosing the material to match the preparation—Preparing the tooth to match the material. Int J Comput Dent 2008;11(3-4):241-256.

Manufacturers

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