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Clinical Technique/Case Report

Using Cross-Polarized Photography as a Guide for Selecting Resin Composite Shade

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Clinical Relevance

Cross-polarized photography is a simple technique that may improve the shade selection for the stratification of resin composites, especially when veneering discolored teeth.

SUMMARY

The restoration of single discolored maxillary anterior teeth is still a difficult task, as not only shape and surface characterization play an important role in the success of the treatment, but the propagation of light throughout the restorative material does as well. In some cases, small changes in morphology, color, and brightness will be noticeable. These factors are sometimes very tricky, and shade guides alone are difficult to use for color selection. This article proposes a protocol of employing cross-polarization imaging for improving the accuracy of the shade selection of resin composites. The step-by-step technique is presented for the restoration of a single discolored tooth.

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INTRODUCTION

Discolored teeth are classic problems that impair the esthetics of anterior teeth. When affecting multiple teeth, systemic etiologies are usually associated, and ceramic veneers are good treatment options.[1] On the other hand, a single discolored tooth is often related to root canal treatment,[2] and severely discolored teeth require the combination of walking bleach and external whitening treatments for the bleaching to be more effective.[3] However, a major problem is the recurrence of discoloration. In this case, the esthetic solution is frequently to cover the discolored tooth with dental crowns or veneers. While crowns should be precisely indicated to avoid unnecessary dental preparation,[4] more conservative treatments, such as indirect and direct veneers, have become alternatives for patients with esthetic problems with their anterior teeth.[5-7]

Direct veneer resin composites associated with adhesive systems have shown good mechanical properties and color stability as well as excellent esthetic results.[8] The current assortments of resin composites with different hues, chromas, and values make it possible to use the layering technique to

create restorations that are indistinguishable from the natural dentition.[9] However, one of the greatest challenges when employing resin composites for veneering single discolored teeth is the shade selection of natural teeth. Although some methods have been suggested in the literature, the success is considered subjective and highly dependent on the clinical experience of the operator.[10,11]

Different alternatives have been developed to facilitate the color selection, such as the use of spectrophotometers or colorimeters (devices for color measurement). However, these devices have some disadvantages related to high cost. Moreover, sometimes the device does not properly indicate the correct color, or the selected shade may not be compatible with the resin composite to be used.[12,13]

An interesting approach that can be very helpful for selecting the shade of resin composites is the use of polarizing filters associated with digital photography, known as cross-polarized photography.[14] This technique uses two linear polarizing filters: one in front of the lens and the other in front of the flash (light source). If the two filters are placed in the same plane of polarization, they are parallel and do not eliminate all reflections. However, when one of the filters is rotated 90 degrees to the other, providing crossed planes of polarization, near-to-zero light interference is produced, and the clinician can then observe the teeth in a new way, without reflections.[14-16] The advantage of this technique is that it allows a better understanding of the depth, details, characteristics, and transparencies of the dental structure. Additionally, the characteristics of the underlying dentin can be evaluated. In other words, this technique enables easier and straightforward appreciation of color.

The purpose of this case report is to describe a step-by-step clinical case in which the patient had a discolored maxillary anterior tooth restored with a resin composite veneer. The use of cross-polarized photography for choosing dentin, enamel, and incisal shade is described.

CLINICAL REPORT

A 30-year-old female patient was referred for treatment, complaining about the esthetic appearance of her maxillary right central incisor. The clinical evaluation showed a single discolored tooth and unsatisfactory old resin composite restorations (Figure 1). The main cause of the discoloration was attributed to endodontic treatment. No sensitivities to percussion were detected horizontally or vertically. However, radiographic evaluation revealed inadequate endodontic treatment with an alteration in the periapical area (Figure 2).

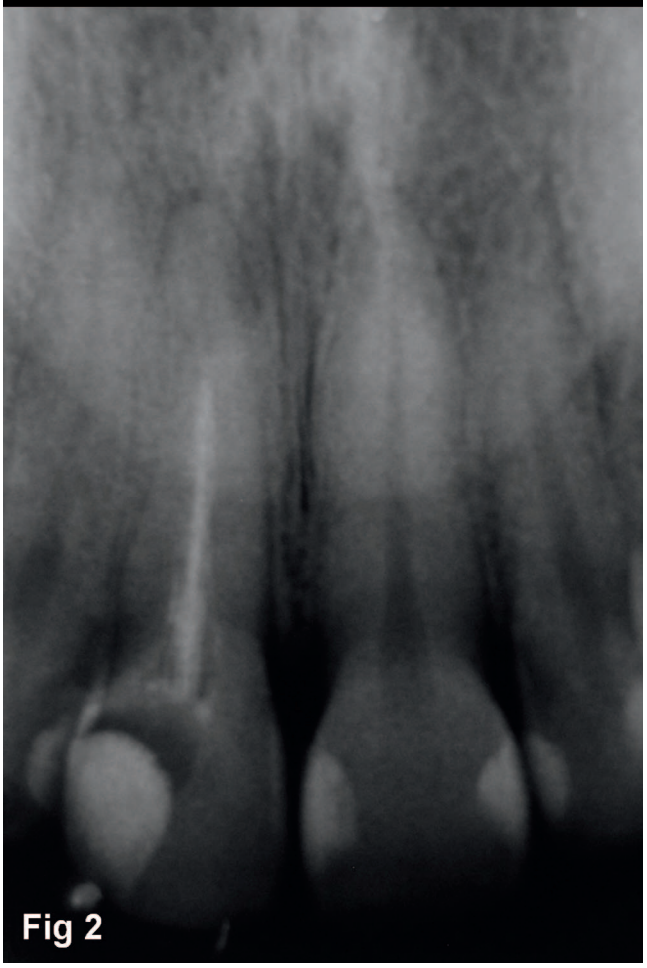

Figure 1. *Preoperative frontal view showing a discoloration on maxillary right central incisor.*
Figure 2. *Radiographic evaluation revealed an inadequate endodontic treatment with an alteration in the periapical area.*

The treatment plan included the following phases: 1) root canal retreatment, a nonvital tooth bleaching using a combination of walking bleach and in-office bleaching techniques; 2) cementation of a fiber-reinforced post and a resin composite buildup on the palatal surface; and 3) direct resin composite veneer.

Figure 3. *Initial color of the discolored tooth evaluated with cross-polarization imaging. An A4 shade was observed with a Vita shade guide.*

Figure 4. *Different setups for obtaining cross-polarized photography. Left: a single flash with a polarized filter on the camera; right: a twin flash using two polarizing filters. Both options always had a polarized filter adapted in front of the lens.*

Phase 1

After root canal retreatment, the initial shade of the discolored tooth was selected using cross-polarized photography and a Vita Classic shade guide (Vita, Vita Zahnfabrik, Bad Säckingen, Germany). An A4 darkened tooth shade was observed (Figure 3). In contrast, the natural shade of the patient's teeth was B1. For cross-polarized photography, polarizing filters were adapted to both a Sigma Macro 105-mm lens attached to an SLR Nikon D5300 camera and the built-in flash in a way that the filters were rotated 90 degrees to one another to provide crossed planes of polarization. The camera was adjusted in manual mode to f/11, 1/100, and ISO 400. Figure 4 shows different setups for obtaining cross-polarized photography.

After rubber dam isolation, removal of coronal endodontic sealer until 1 mm apical to the cement–enamel junction, and resealing of the obturated canal with a glass ionomer cement (Vidrion R, SSWhite, Rio de Janeiro, RJ, Brazil), the walking bleach agent was prepared with a mixture of 100% carbamide peroxide and glycerin (Endoperox, Septodont, Saint-Maur-des-Fossés Cedex, France). This bleaching agent was applied to the pulp chamber, and a temporary restorative material was used (Coltosol F, Coltene, Vigodent SA, Rio de Janeiro, RJ, Brazil). The walking bleach product was replaced every seven days for three weeks. In the third week, external/internal in-office bleaching using 35% hydrogen peroxide (Lase Peroxide Flex, DMC, São Carlos, SP, Brazil) was applied only on the affected tooth.

Phase 2

Two weeks after bleaching, a post space was prepared, a fiber-reinforced post (White Post DCE,

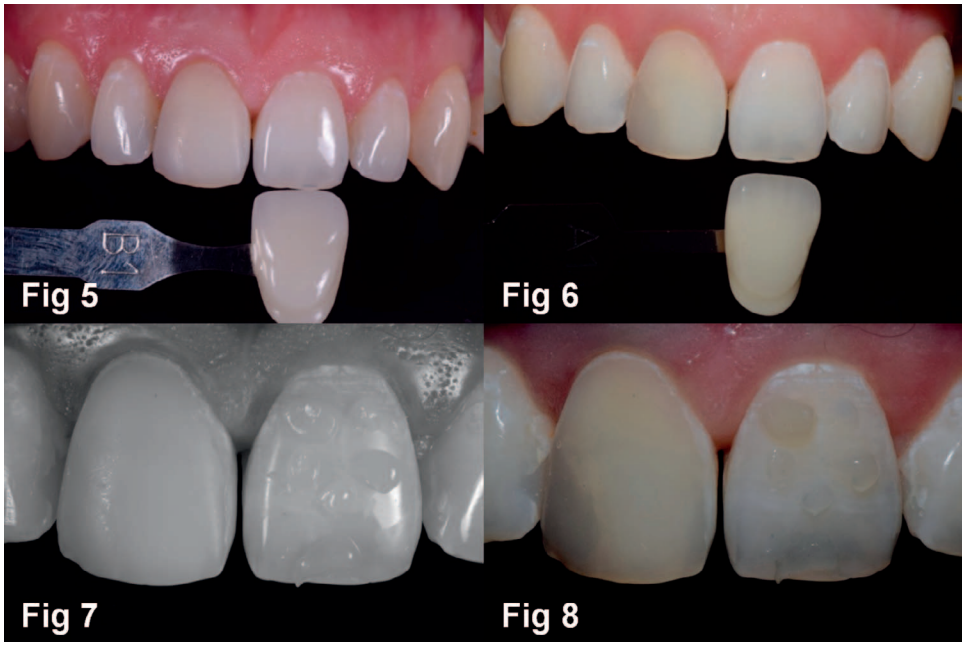

Figure 5. *Final appearances after bleaching treatment.*
Figure 6. *Evaluation of the shade of the sound central incisor with cross-polarized photography. It is possible to note an A1 shade for the dentin.*
Figure 7. *Grayscale photography used for evaluation of value of the resin composites to be used in the stratification.*
Figure 8. *Cross-polarized photography used for evaluation of the shade of the resin composites to be used in the stratification.*

FGM, Joinville, SC, Brazil) was cemented using a self-adhesive resin cement (U200, 3M ESPE, St. Paul, MN, EUA), and a resin composite reconstruction of the palatal surface was made with B1 dentin and enamel shades (Opallis, FGM). This selection of shades was based on the color of the sound teeth and was made to avoid any possible decrease on brightness due to the thickness of the remaining facial dentin.

Phase 3

The final postbleaching shade of the maxillary right central incisor was evaluated, and A1 was selected. Cross-polarized photography and a Vita Classic shade guide were used as previously described. The conventional shade selection of the sound maxillary left central incisor using a Vita Classic shade guide showed a B1 shade (Figure 5). Wave-shaped white bands could be detected in the cervical and middle thirds, while an opalescence effect was observed at the incisal third. With cross-polarized photography, it was possible to observe that the dentin of the sound maxillary left central incisor had an A1 shade (Figure 6). The shade selection for the resin composite was made on the sound central incisor. Small portions of resin composites were applied and light activated on the tooth's facial surface. During the shade selection, grayscale and cross-polarized pictures were taken (Figures 7 and 8). The grayscale picture was taken to evaluate the value of the resin composite to be used. These photographs were also used as a reference in the stratification of the final restoration.

Afterward, modified rubber dam isolation and the silhouette technique were used for tooth preparation. A round #1014 diamond bur (KG Sorensen, Cotia, SP, Brazil) was used at high speed under water cooling to create cervical and proximal grooves. A tapered, round-ended #2135 diamond bur (KG Sorensen) was used for preparing vertical grooves and reducing the incisal edge. These grooves were used as depth cuts to facilitate the facial and incisal reduction of the veneer preparation. In order to facilitate the cervical finishing, a #000 retraction cord (Ultradent, South Jordan, UT, USA) was used for gingival displacement (Figure 9). The tooth was etched with 35% phosphoric acid for 15 seconds. After rinsing with water, an adhesive (Ambar, FGM) was applied and light activated according to the manufacturer's guidelines.

Initially, an opaque white flowable resin composite (Kolor Plus, Kerr Corp, Orange, CA, USA) was applied over the discolored dentin substrate to match the value of the patient's natural tooth (Figure 10). After this step, a thin layer of an opaque resin composite (OP, Opallis) was applied. Afterward, a small layer of dentin shade (A3, Opallis) was applied to the cervical and middle thirds, and the dentin shade (A2, Opallis) was placed in the middle and incisal areas (Figure 11). These two procedures were performed separately, and both increments were light activated for 40 seconds.

Figure 9. *Dental preparation finished.*
Figure 10. *An opaque flowable resin composite was applied over the discolored dentin substrate to match the value of the natural tooth.*
Figure 11. *A3 dentin shade applied in cervical and middle thirds and A2 dentin shade applied in middle and incisal areas.*

Before adding the enamel layer, the intrinsic characteristics and high-intensity hue of the adjacent teeth were accomplished with the aid of tints (Kolor Plus). In this stage, a white stain was used to reproduce wave-shaped bands in the cervical and middle thirds, and a blue stain was applied between dentin lobes to create an opalescence-like bluish effect at the incisal third. All tints were applied with a thin brush (Figure 12). The last layer of artificial enamel was made with B1 enamel shade (EB1, Opallis) for the cervical third and bleached enamel shade (E-Bleach, Opallis) for the middle and incisal thirds. The two portions of resin composite were applied from the cervical to incisal area with a flat spatula to completely cover the underlying resin layers in one step (Figure 13). The facial surface was light activated for 40 seconds.

After the restoration was completed, finishing was accomplished with a #12 surgical blade (Lamedid, Barueri, SP, Brazil) to remove resin composite excess in the cervical area. A pencil was used to highlight line angles of both central incisors, and a caliper was used to analyze light-reflecting areas (Figure 14). Sharp transitions between line angles were softened with a coarse finishing disc (TDV, Pomerode, SC, Brazil).

The restoration was polished with a sequence of polishing discs from coarse to superfine (TDV) and a silicone disc (TDV). The final polishing was accomplished with a felt disk and a 40-μm diamond-based paste (TDV). The final restoration can be observed in Figure 15.

DISCUSSION

The presented clinical situation reports an approach to a common problem when restoring maxillary anterior teeth and how to evaluate the inner characteristics of the dentin. While dentin has a role in the reflection and absorption of light, being responsible primarily for the shades of natural teeth and saturation, enamel is rich in minerals and behaves like a translucent glass-like object that allows light to pass through it.[17] This phenomenon results in light dispersion and scattering. Other determining factors of a successful restoration include the tooth shape, surface characterization, and propagation of light inside the restoration.[18] As demonstrated in the present case report, these last factors can be more easily observed and corrected using a pencil to highlight line angles of both central incisors and a caliper to analyze light-reflecting areas.

Shade selection of natural teeth is a complex process because it involves subjective factors that depend directly on the observer, light source, and reflection of light by the object. Moreover, the time employed for color observation, observer's experience, and type of shade guide, as well as the material's composition, are other subjective factors that critically influence the shade selection. In general, shade guides for use in dentistry follow Munsell's color parameters,[19] in which three dimen-

Figure 12. *Color characteristics were established using white stain in cervical and middle areas to reproduce wave-shaped bands. A blue stain was applied between dentin lobes to obtain an opalescence effect at the incisal third.*
Figure 13. *Application of the enamel layer.*
Figure 14. *A pencil was used to highlight the line angles, and a caliper was used to check the symmetry between central incisors.*
Figure 15. *Two-month follow-up showing the final result of the restored tooth.*

sions are defined: hue (basic color), chroma (saturation), and value (brightness). In the case of direct restorations, employing resin composite shade guides, although recommended for the initial evaluation of color, may be confusing and, despite several attempts to define a protocol for use, still rely on the clinical experience of the observer and the in-office illumination. Moreover, due to the optical phenomena occurring on natural teeth, it is necessary to select colors for dentin, enamel, and incisal translucent areas to obtain a better layering technique.

Over the past decade, there has been an increasing interest in illumination techniques for use in dental photography. Digital pictures can help minimize errors in clinical practice, especially during the shade matching of natural teeth. The protocol based on cross polarization, eliminating the superficial enamel light reflection, allows unobstructed visualization of surface and subsurface enamel characteristics. This technique enables easy and more accurate selection of the hue and chroma of the dentin.[20] Moreover, as demonstrated, the use of polarizing filters associated with digital photography is a simple and straightforward method for better understanding the color of natural anterior teeth.[21] For a better use of this resource, the authors recommend three pictures: the maxillary anterior teeth with a black background, the maxillary anterior teeth with a black background and the shade guide, and the maxillary anterior teeth with a black background and small portions of cured resin composites. The first picture of this protocol enables the evaluation of the characteristics of both enamel and dentin, providing an understanding and estimation of how opaque each structure is. The second picture is taken after the usual color selection, employing shade guides, and serves to compare the general color selected for the entire tooth with the estimated color of the dentin. The third picture is taken after selection of the specific resin composites for each layer and serves to check if the selection is appropriate. It should be noted that not every resin composite system is equal, and, despite the shade specification made by each manufacturer, the color itself may vary. This means that the A1 dentin shade specified by one manufacturer may not correspond to the A1 dentin shade specified by another. Moreover, the shade selection using only shade guides may be misleading if custom-made shade guides produced with the actual resin composite are not used. For this reason, this third additional step will help the selection of the correct shade of a specific system. In the present case report, in the evaluation of the color of the sound central incisor with cross-polarized photography (Figure 6), the A1 shade was selected with a shade guide originally designed for ceramics, which is not specific for the resin composite system used in the restoration. For the specific resin composite system employed, after the application of the two opaquers (ie, a first layer of a white opaque flowable resin composite and a second layer of a conventional opaque OP resin composite), the A1 dentin shade would have an artificially bright effect instead of reaching the desired color. Thus, A3 and

A2 dentin shades were used to reproduce the color variation of the dentin from cervical to incisal thirds.

Another interesting use of digital photography to help the clinician improve predictability when restoring discolored teeth is the provisional application of a thin layer of an opaque resin composite after dental preparation followed by the evaluation of the change in brightness using grayscale photographs.[22] This technique can help reproduce the brightness (value) of the adjacent teeth and could be added to the photographic protocol proposed in the present case report. However, one should take care not to overdehydrate dental tissues during restorative procedures, as brightness is elevated.

When taking digital photographs, the reflection of the flash on the enamel of the adjacent teeth may increase the brightness, especially when ring flashes are used. For this reason, twin flashes are better for taking pictures of anterior teeth. Bouncers adapted to twin flashes are other interesting accessories that can modify tooth chromaticity[21] as well as perceivable changes of brightness on the tooth. For this reason, their use is recommended, except for in cross-polarized photography.

As suggested in the present case report, the use of cross-polarized photography to assess the chromaticity and brightness (value) should be done as soon as possible (ie, in a short time) during the restorative procedure due to the natural dehydration of teeth. In addition, photographs with polarization modalities can improve the evaluation of the level of brightness of resin composites and teeth when taken in gray scale because they remove the interferences of both environmental light and photographic equipment.

CONCLUSIONS

The evaluation of hue, chroma, value, and color characteristics exhibited by natural dentition using cross polarization may help achieve more predictable outcomes during the stratification technique with resin composites.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Bauru School of Dentistry, University of São Paulo, Brazil.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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