Fluorescence of Composite Resins: Clinical Considerations

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The main objective of restorative dentistry is to replace damaged tooth structure with materials that possess biological, physical, and functional properties similar to those of natural teeth. The esthetic restoration of the anterior dentition presents one of the greatest challenges in daily practice since any slight disparity can be immediately noticed every time the patient smiles. Numerous composite systems have been developed in recent years offering a multitude of shades, translucencies, opacities and effects, and when used in conjunction with innovative placement techniques, they make possible the fabrication of restorations that faithfully emulate the polychromatic variations and optical characteristics of natural teeth. However, in order to achieve a truly natural-appearing direct composite restoration, a clinician must have comprehensive knowledge of the optical characteristics for both natural teeth and composite resins, and thorough training in the proper selection and application of current restorative systems. The optical characteristics of natural teeth are determined by the interaction of light with dentin, enamel, and the underlying pulp, and include varying degrees of translucency and opacity of enamel and dentin, of opalescent and iridescent effects, and of fluorescence.

FLUORESCENCE OF NATURAL TEETH AND COMPOSITE RESTORATIONS

In dentistry it has been traditionally assumed that fluorescence is the absorption of energy in the nonvisible spectrum (ie, ultraviolet light) and, when in the presence of ultraviolet illumination (ie, black light), the emission of longer wavelengths visible in the white-bluish spectrum (ie, glow). Natural teeth emit a strong blue fluorescence when exposed to black light (Fig 1). This property makes natural teeth look brighter and more alive, and the reproduction of this characteristic has a dramatic effect on the level of vitality and brightness exhibited by restorations.
measured with fluorescence spectrophotometers, the fluorescence spectrum of natural enamel presented luminescent peaks at 450 nm, while the fluorescence spectrum of dentin, whose intensity is three times higher than that of enamel, presented peaks at 440 nm or 430 nm.

The fluorescence of composite resin restorations is independent of their perceived color under white light and, though minimally perceptible under normal viewing conditions, it is clinically significant because truly esthetic restorations should match the color of natural teeth in daylight as well as under different light sources. This issue is especially relevant when treating patients in the public eye (eg, actors, performers, musicians, models, and newscasters) or those who often go to the theater, dance clubs, and other nightspots where they can be exposed to black light. Under this source of illumination, restorations fabricated with nonfluorescent materials will appear as black areas/spots in the smile line, causing embarrassment not only to the patients, but also to the clinicians, who might be asked to substitute such restorations for fluorescent ones. Therefore, when designing restorations, clinicians should take into consideration form and color reproduction as well as the emulation of other intrinsic characteristics of natural teeth, creating restorations in keeping with the personality, expectations, life-style, and occupation of their patients.

When trying to mimic nature, restorative materials should ideally have fluorescent properties similar to those of natural teeth. Most dental material manufacturers have overlooked this important property, even though esthetic materials should simulate the fluorescence of natural teeth to avoid the problem of metamerism.

**OBSERVATIONS OF RESTORATIVE MATERIAL**

The fluorescence of natural teeth and composite resins can be easily tested and compared with the aid of a black light. Such observations can assist the practitioner to select the materials best suited for enhanced esthetic results. When observing composite resin disks under ultraviolet illumination in a dark environment, the different fluorescent properties of each restorative system can be seen. Using a natural tooth as a point of reference (Fig 2), the fluorescence of composite resins can be qualitatively classified as absent (low fluorescence); ideal (near natural-tooth fluorescence); and exaggerated (more fluorescence than natural tooth).

Figure 3 shows composite resin disks that presented low levels of fluorescence and Fig 4 shows examples of how restorations fabricated with these composites look under black-light illumination. Composite resin disks that presented fluorescence similar to that of natural tooth are shown in Fig 5 and examples of how restorations fabricated with them appear under black-light illumination are shown in the Fig 6. Figure 7 shows composite resin disks that presented exaggerated fluorescence and Fig 8 shows examples of how restorations fabricated with these composites look under black-light illumination.
Fig 2  Extracted tooth illuminated under black light can serve as a point of reference for natural fluorescence.

Fig 3  Composite resin disks that presented low levels of fluorescence: (a) Durafill, (b) Charisma, (c) Glacier, (d) Micronew, (e) Palfique Estelite, (f) Matrixx (Microfill), (g) Filtek Supreme, (h) Venus, (i) Filtek Z250.

Fig 4  Restorations fabricated with low-fluorescent composites, under black-light illumination: (a) Charisma, (b) Filtek Z250, (c) Filtek Supreme, (d) Venus.

Fig 5  Composite resin disks that presented fluorescence similar to that of natural tooth: (a) Renamel, (b) Enamel Plus, (c) Amelogen, (d) 4 Seasons, (e) Vit-l-scence.

Fig 6  Restorations fabricated with high-fluorescent composites, under black-light illumination: (a) 4 Seasons, (b) Vit-l-scence, (c) Renamel, (d) Amelogen.

Fig 7  Composite resin disks that presented high levels of fluorescence: (a) Herculite XRV, (b) TPH, (c) Miris, (d) Matrixx, (e) Tetric Ceram, (f) Esthet-X.

Fig 8  Restorations fabricated with high-fluorescent composites, under black light illumination: (a) Miris, (b) Herculite XRV, (c) Esthet-X, (d) Tetric Ceram.
Table 1 summarizes the observed resin composites and their fluorescence classification. These observations have been corroborated by results of recent research that determined the quantitative differences in fluorescence among some of the cited composites using a color-measuring spectrophotometer.\textsuperscript{19,21}

### INCREMENTAL LAYERING ISSUES

It has been stated that in order to create a restoration that truly resembles the natural dentition, a high-fluorescence dentin material and a low-fluorescence enamel material would be required.\textsuperscript{9} However, unlike natural teeth where the dentin is responsible for the greater part of the fluorescence,\textsuperscript{21} in composite restorations the fluorescence is primarily defined by the final enamel layer. If the dentin portion of a restoration is built up with a high-fluorescence material (Fig 9) and subsequently covered with a low-fluorescence material, the result would be a nonfluorescent restoration (Fig 9), as the last nonfluorescent layer covers and blocks the fluorescence of the underlying layers. It has been demonstrated that even a very thin layer of a nonfluorescent surface sealant can block the fluorescence of composite resins.\textsuperscript{22} Conversely, if the dentin portion of a restoration is built up with a nonfluorescent material (Fig 10) and covered with a fluorescent material, the result would be a fluorescent restoration (Fig 10), as the overlying layer is only slightly influenced by the nonfluorescence of the underlying layers. When both dentin and enamel composites are fluorescent, they can be built up in such a way to achieve a fluorescence similar to that of the natural teeth.\textsuperscript{20} Therefore, clinicians have to keep in mind that, fluorescence should be present in at least the enamel composite resin, and that ideally, both the dentin and enamel composite resins should present fluorescence.
CASE PRESENTATION

A 24-year-old male actor/performer presented with an unsatisfactory Class IV restoration of the maxillary left central incisor (Fig 11). His complaint was that the restoration appeared black when he was on the stage and caused him embarrassment. The nonfluorescence of the restoration was confirmed when using a black light to illuminate his smile (Fig 12). Despite the fact that the restoration did not present fluorescence, it was well adapted and adjusted, exhibiting a satisfactory color match, but lacking in surface texture, anatomic morphology, and luster (Fig 13).

A silicone-putty matrix was made to facilitate the reconstruction of the palatal surface, minimize the amount of finishing, and allow the development of an accurate incisal-edge contour. After anesthesia was administered, the restoration was removed, and as no bevel was present, the fracture line was smoothed with a polishing disk (Supersnap, Shofu) (Figs 14 and 15). Shade selection was performed before field isolation to prevent inaccurate color matching due to tooth dehydration. It was begun using a shade tab (Fig 16) and completed after the positioning and polymerization of small increments of the selected composites over the remaining tooth structure. This is an essential step, as the shade of composite resins changes after polymerization. A mock-up was prepared to confirm composite resin selection (Fig 17). Any necessary corrections were charted on a color map used to diagram the selected shades and tints and their appropriate positioning so that they could be accurately applied at the restorative stage (Fig 18).

Field isolation was accomplished with a lip and cheek retractor, Teflon tape, and retraction cord. A 37% phosphoric acid (Ultratech, Ultradent Products) was applied to enamel and dentin for 15 seconds (Fig 19), rinsed with an air-water spray for the same amount of time, and slightly dried with a mild air stream to prevent dentin dehydration. A one-bottle adhesive system (PQ1, Ultradent Products) was applied according to the manufacturer’s instructions (Fig 20) and light cured for 20 seconds (Fig 21). The initial artificial palatal enamel layer of Pearl Frost–shaded hybrid–composite resin (Amelogen, Ultradent Products) was positioned on the silicone matrix with a spatula and smoothed with a sable brush (no. 4, National Keystone), according to the direction of the fracture (Fig 22). This layer was no thicker than 2 mm buccolingually to offer better control over the desired anatomic stratification and to ensure complete polymerization.
CASE PRESENTATION

Fig 11 Unsatisfactory Class IV restoration of the maxillary left central incisor.

Fig 12 Under black-light illumination, the restoration appears black, compromising the esthetics of the smile.

Fig 13 Well adapted and adjusted restoration presenting a satisfactory color match but lacking in surface texture, anatomic morphology, luster, and fluorescence.

Fig 14 After removing the restoration, the fracture line was smoothed with a finishing disk as no bevel was present.

Fig 15 Note that no bevels were placed after restoration removal.

Fig 16 Initial shade selection with the aid of a shade tab.

Fig 17 Mock-up to confirm shade selection.

Fig 18 Color map was used to diagram the selected shades and tints and their appropriate positioning for accurate application at the restorative stage.
Once the silicone matrix was positioned, the composite resin was carefully adapted to the internal tooth structure (Fig 23) and then light cured for 20 seconds. After removing the matrix, the composite was light cured through the palatal surface for another 20 seconds. The buccal and distal views of the artificial palatal enamel layer demonstrate the available space for the subsequent layers (Figs 24 and 25).

To blend the composite restoration into the tooth structure and to disguise the fracture line, an increment of a high-chroma–shaded composite resin (A2-O, Amelogen, Ultradent Products) was lightly feathered between the palatal enamel layer and the buccal enamel (Figs 26 and 27). The artificial dentin layer was then reconstructed with a high-chroma–shaded composite resin (A2-O, Amelogen) and dentin lobes were sculpted with a
The artificial enamel was built up in two composite layers to impart a more realistic depth of color. After application of a thin artificial internal enamel layer (A2, Amelogen), horizontal grooves were created with a razor-sharp composite instrument (96043, Almore International) (Figs 29 and 30).

**Fig 26** Imperceptible fracture line. A high-chroma–shaded composite resin was used to blend the composite restoration into the tooth structure.

**Fig 27** Light feathering of the high-chroma–shaded composite resin between the palatal enamel layer and the buccal enamel.

**Fig 28** Positioning of artificial dentin layer and sculpting of dentin lobes with a composite-contouring instrument.

**Fig 29** Creation of horizontal grooves with a razor-sharp composite instrument, after application of a thin artificial internal enamel layer.

**Fig 30** Distal view of created horizontal grooves.

**Fig 31** Application of white tint on horizontal grooves to mimic the craze lines on the adjacent tooth.

**Fig 32** Completed restoration after application of the artificial buccal enamel layer and prior to the finishing and polishing procedures.
These horizontal grooves provided room for the application of a white tint (Kolor+Plus, Kerr Sybron) (Fig 31) to mimic craze lines present on the adjacent tooth. The artificial buccal enamel layer was recreated with a Pearl Frost–shaded hybrid–composite resin (Amelogen), applied and contoured with a long-bladed instrument (IPCL, Cosmedent) and smoothed with a no. 4 artist brush.

The restoration was additionally light cured through an oxygen-inhibitor gel (De-Ox, Ultradent Products) for 1 minute from both the buccal and palatal aspects. Figure 32 shows the completed restoration prior to the finishing and polishing procedures. Excess composite was removed, and the occlusion was checked and adjusted before the patient was dismissed.

At a subsequent appointment, the surface texture, anatomic morphology, and luster were defined. Initial contouring was performed with a long, tapered extra-fine diamond bur (Fig 33) to recreate the depression areas present on the contralateral incisor. These areas were polished with a silicon rubber point (Flexi-Point, Cosmedent) to minimize undesired accentuation (Fig 34). The buccal, proximal, and incisal angles were finished with an extra-fine aluminum oxide disk (Flexi-Discs, Cosmedent) (Fig 35). Surface texture was recreated with an extra-fine straight-edge diamond bur (Fig 36) to produce horizontal lines from the cervical third to the incisal third of the crown (Fig 37). A buff wheel (Flexi-Buff, Cosmedent) was used with a polishing paste (Enamelize, Cosmedent) to impart light reflectance and a high luster, while maintaining the established texture and surface morphology (Fig 38). Silver powder was used to highlight teeth morphology and check the final texture (Fig 39). Figures 40 to 42 show the final polished restoration. The patient’s smile was again illuminated under black light to observe the achieved fluorescence (Fig 43).
Fig 37  Horizontal lines prior to polishing.

Fig 38  Buff wheel used with polishing paste to impart light reflectance and a high luster while maintaining the established texture and surface morphology.

Fig 39  Silver powder used to highlight teeth morphology and check the final achieved texture.

Fig 40  Mesial view of the final restoration showing surface details, contour, and texture.

Fig 41  Distal view of the final restoration. Note the harmonious integration despite the absence of any bevel on enamel.

Fig 42  Postoperative appearance of the finished and polished restoration.

Fig 43  Achieved fluorescence under black-light illumination.
SUMMARY AND CONCLUSION

Fluorescence is an important optical property of natural teeth and its reproduction is necessary when highly esthetic restorations are desired. Trying to match natural fluorescence with composite resins can become a complicated task of trial and error, most often because of inadequate material selection. Knowledge of fluorescent characteristics of the available composite resins is imperative until proper fluorescence is present in every restorative system.

REFERENCES