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CLINICAL ARTICLE

Nature-mimicking layering with composite resins through a bio-inspired analysis: 25 years of the polychromatic technique

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Abstract

Objectives: For decades, the dental community has discussed which materials would be the ideal substitutes for lost tooth structure. Initially, the biomimetic approach advocated that feldspathic ceramics would be the material of choice for enamel. However, given the complexity of obtaining excellent dental technicians and the financial cost, are composite resins a suitable replacement? The optical properties with opalescence and fluorescence effects, as well as this material's high fracture toughness, indicate it as a long-lasting restorative material. However, because this material depends on the operator's expertise, knowledge of layering techniques and the selection of each material for the different layers is required. Thus, knowledge of the polychromatic technique through a bioinspired approach is necessary to obtain results of life-like restorations. This article aims to review the polychromatic layering technique (PLT), considering the optical and mechanical properties of dentin and enamel and correlating these properties with current composite resins to guide clinicians in selecting the most suitable restoratives for their clinical challenges.

Clinical Considerations: The polychromatic layering technique is revisited, cross-referencing the properties of dentin and enamel with current composite resin restoratives and their biomimetic properties. The effectiveness and predictability of the PLT are corroborated in clinical cases of varying degrees of difficulty requiring different layering strategies.

Conclusion: After the bio-inspired analysis, using nature as a model to be understood and followed, it is possible to note how the polychromatic technique remains current and viable in mimicking nature, providing esthetic and natural results in the layering of composite resins.

Clinical Significance: Composite resins effectively replicate the optical and mechanical characteristics of natural dentin and enamel through the bioinspired approach presented by the polychromatic layering technique.

KEYWORDS
bioinspiration, biomimetic, composite layering, dental tissues, light propagation

1 | INTRODUCTION

Restorative dentistry, for decades, has been looking for materials and techniques to replace the tooth structure affected by injuries. In the research of developments for new products, countless alternatives are presented with the promise of being ideal substitutes. As a result, the industry has periodically introduced restoratives combining optimal mechanical and nature-mimicking properties. In addition, numerous in vitro and in vivo studies have scrutinized materials and methods to establish scientific and clinical grounds for consistently creating restorations that emulate dental tissues.[1–5]

Skilled ceramists use elaborate stacking techniques to artistically achieve high-quality results that mimic the living tissues (Figure 1). In the same way, composite layering techniques have been introduced with significant clinical acceptance and application, aiming at the quest for restorations that go unnoticed by the most attentive observer[6–8] (Figure 2A,B).

The clinician's critical challenge has consistently been producing restorations that mingle natural tissues' characteristics with synthetic restoratives according to biomimetic principles. Biomimetics is an interdisciplinary field in which principles from engineering, chemistry, and biology are applied to the synthesis of materials, synthetic systems, or machines that have functions that mimic biological processes.

In this scenario, ceramics are considered the materials closest to dental structures by the biomimetic dental school of thought—feldspathic porcelain, particularly—as they closely emulate dental enamel's mechanical and optical characteristics.[9] Because enamel is very similar to glass due to its high mineral content, the calcium phosphate crystals (hydroxyapatite) and other constituent minerals of this acellular layer give it an anisotropic behavior and a light dispersion like that found in porcelain[10] (Figure 3A–D). However, the definition of an ideal synthetic substitute can only be defended with deeper pondering. Porcelain is credited with being more abrasive to opposing enamel than composite resins. Additionally, its manufacturing technique also requires more invasive tooth preparations and a more complex and costly workflow due to the increased time and cost of the laboratory process.

Although immersing in materials science per se seems fascinating, the choice of a substitute synthetic material prompts reasoning that extends beyond mechanical and optical properties found in biomimetics to consider the overall scope of restorative dentistry as a field of health promotion.

Whether with resins or ceramics, the restorative process depends on the technical skill of the human being; in other words, it is operator-dependent.[11] However, ceramic works are more expensive and depend on an experienced ceramist who, in most cases, is not the dentist himself. Thus, the purpose of this article is to carry out a conceptual analysis not only through biomimetics but through the broader look of bioinspiration for the choice of materials and techniques that can be introduced more simply in the daily lives of clinicians. Furthermore, this article aims at understanding the natural tissues and the characteristics of currently available composite restoratives while scrutinizing and revisiting a logical pathway for their selection and application according to a widely accepted technique published by one of the authors in 1995—*the polychromatic layering technique*.[12]

FIGURE 1 Single unit ceramic crown on maxillary left central incisor.

FIGURE 2 (A and B) Single unit composite restoration on maxillary right central incisor.

2 | THE CHOICE OF COMPOSITE RESIN AS A RESTORING MATERIAL

In many countries, academic discussions argue about the best restorative material when comparing composites versus ceramics. Often

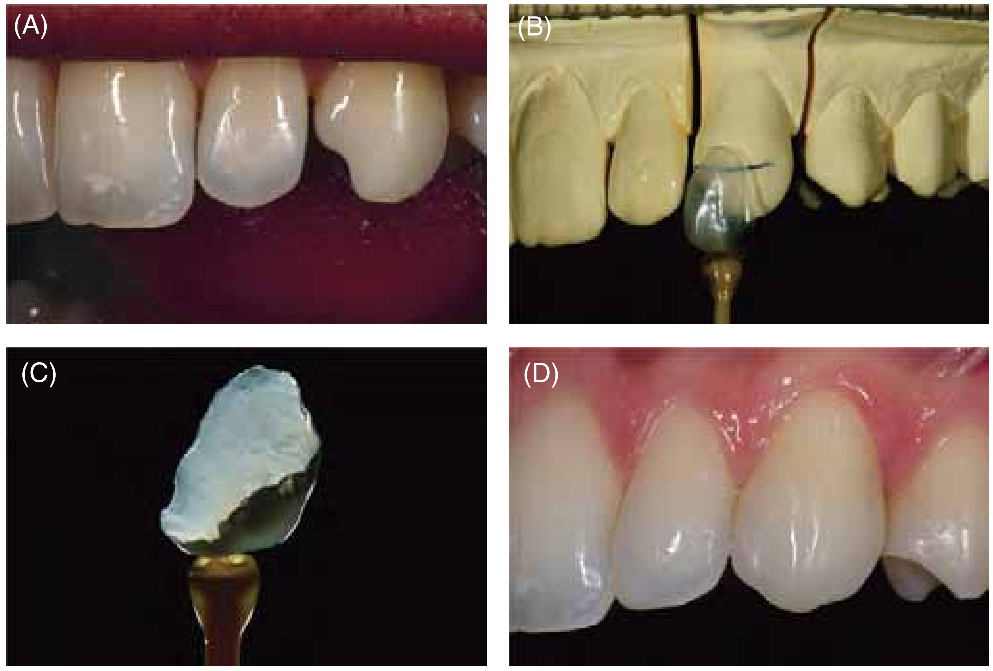

FIGURE 3 (A–D) Add-on feldspathic ceramic contact-lens type fragment.

defended even passionately, this analysis makes no sense when the focus is on the patient. Longevity studies demonstrate that both materials can be used successfully in dental restoration for decades, benefiting people in terms of esthetics and function.[11,13] Mechanically, the physical properties of composite resins have historically been optimized by the often ceramic filler particles of this composite (hybrid) material. With this, a perfect balance can be obtained in the proportion of the organic and inorganic components. In this way, even with simple layering techniques using a single shade and opacity, esthetic and functional results can be achieved with resins, unlike ceramics, which invariably depend on complex implementation techniques (Figure 4A–C).

Another favorable factor for using composite resins is their additive application technique. Because composite resins are directly applied in the mouth, creating a path of insertion, as in the case of indirect restorations, is unnecessary. This direct approach implies more significant preservation of healthy dental structures, keeping Contemporary Dentistry in an additive and not amputative era.[14]

Finally, the high operational cost of ceramic works and the need for an outsourced laboratory service—only sometimes readily available across different countries and their socioeconomic realities—make resins an attractive proposal that places the clinician as the protagonist of a successful esthetic/functional restoration.

3 | THE NATURAL TOOTH IN THE CONTEXT OF BIOINSPIRATION

Dental biomimetics is a concept that seeks to imitate the structure to be restored in the choice of replacement materials.[15] With this, the natural element is studied, and substitutes of similar characteristics are selected whenever eligible. However, when dealing with living beings, this may be a challenging task. Plain logic indicates that the best substitute for enamel should be tissue-engineered enamel itself. Without this possibility, a deep study of the element to be copied must be done, and the search for how to restore it can have a deeper meaning when nature is analyzed more broadly. Bioinspiration analyzes the target element and looks for other forms of intelligent design present in nature (Figure 5). For example, suppose the tooth presents a dentin/enamel junction with a stable and long-lasting chemical and micromechanical bond. Why can adhesives not be produced by studying glues synthesized by mussels that can attach them to the mineral content of rocks even when submerged in water?[16] Dental bioinspiration seeks answers in nature to restore nature itself when damaged. Thus, it does not focus only on the target element but analyzes beings from other specimens and classes to offer viable repair alternatives. However, like biomimetics, studies should always be initiated by the natural object, which is the focus of the copying process.

3.1 | The enamel

This acellular tissue is the hardest in the human body. Its formulation and formatting are intriguing. Its chemical base is mineral, consisting of approximately 95% calcium phosphate and 5% organic matter, which gives it high resistance to friction, demonstrated through tribology analysis.[17] However, it has little ability to withstand plastic deformation before fracture. So, this is a tissue of low fracture toughness. Toughness is the ability of a material to resist crack propagation. Despite the sigmoid prisms arrangement and the presence of proteins associated with a combination of diversely oriented prims in the interprismatic area, its fracture toughness is about four times lower than that of dentin[18] (Figure 6). Thus, the primary function of this outer layer that covers the tooth is to be a protective barrier to the

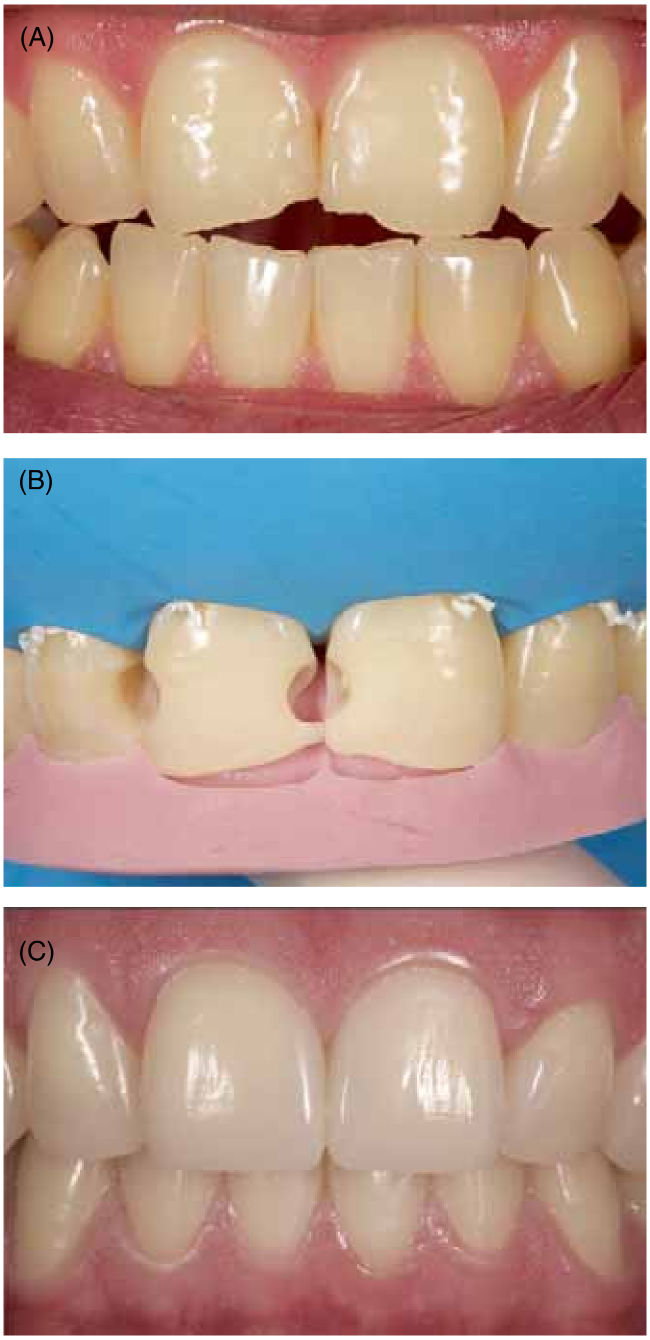

FIGURE 4 (A–C) Monochromatic composite resin restoration showing excellent esthetic results.

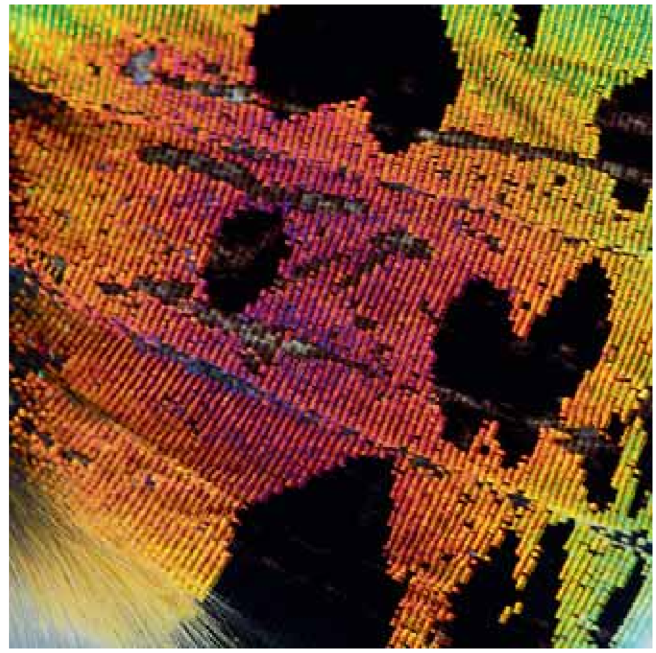

FIGURE 5 Bioinspiration example. Study of the wing of a butterfly to produce lenses and even cosmetics with an unrivaled light dispersion.

FIGURE 6 Enamel cracks demonstrating its low fracture toughness.

underlying cell layers, allowing masticatory efficiency due to coronal rigidity and protecting the dental organ from wear over a lifetime of occlusal service. The organized morphological aspect of this tissue grants it an anisotropy, not behaving equally depending on the direction of the applied load.

An essential aspect of the optical context of this layer is the molecular weight of hydroxyapatite, which is 502 g/mol with an approximate size of 20–70 nm. Despite being a birefringent structure, its average refractive index is 1.63.[19] The light scattering on this substrate will be of the Rayleigh type.[20] The small size of the mineral molecules that compose it will scatter the light with a wavelength of a bluish appearance. The wavelength of visible light is between 400 and 700 nm. If the size of the particles that make up an object is greater than the wavelength, the light does not decompose into its chromatic components. All wavelengths are equally dispersed, which is why it is seen as white when passing through a cloud. When the components are smaller, the light assumes a predominance of blue. For compositions greater than one-tenth of the wavelength, the scattering described as Mie will occur, where blue is no longer predominant, yellow and red becoming more evident. This physical phenomenon makes it possible to explain the opalescent effect in enamel. The

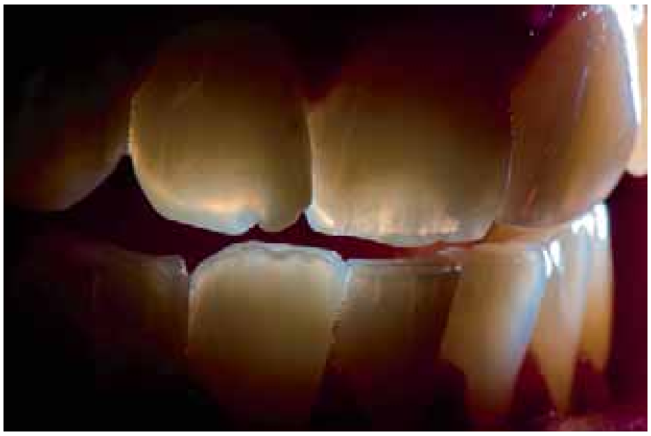

FIGURE 7 Opalescent effect.

FIGURE 8 Enamel cracks barred in dentin.

FIGURE 9 Dentin yellow color.

incident light demonstrates the blue in this layer. On the other hand, the reflected light will present an orange tone since the blue scattering has already occurred during the passage of light inside the enamel (Figure 7).

3.2 | The dentin

Dentin is the tissue that presents a mixture of organic and inorganic components in a balanced way to promote fracture resistance. About 70% of this tissue is of mineral origin (calcium phosphate), and 18% comprises collagen fibrils. This organic material has high resistance to plastic deformation, making dentin approximately 10× more resistant to bending than enamel. This behavior is due to an intriguing network formed by collagen types I, III, and V. Due to this more elastic characteristic, dentin offers high resistance to crack propagation (high fracture toughness).[18] As a result, the cracks formed in the enamel will lose energy as they pass through the junction and reach the dentin (Figure 8). The directional behavior of the load is complex in dentin. The peritubular region presents isotropic behavior, and the orientation of the tubules shows probable isotropy.[21]

The optics of this tissue is related to collagen molecular weight of approximately 300,000 g/mol and size between 180 and 280 nm; the intertwining of fibrils creates collagen networks with sizes in μm. The refractive index is 1.54. In this context, Mie-type scattering will occur, as previously mentioned. This higher molecular weight of the dentin components will not allow the sensation of the blue hue but the visualization of the reddish-yellow hue (brown), which explains the tones of group A of the Vita Classical shade guide as the most frequently found in dentin[22] (Figure 9). It should also be noted that this increased amount of protein creates an effect called fluorescence in this substrate, which is more intense in areas close to the dentin/enamel junction than close to the pulp. With age, the deposition of higher mineral content as secondary and tertiary dentin will decrease this effect[23] (Figures 10 and 11).

4 | BIOINSPIRED ANALYSIS

When the target element (the natural tooth) is studied, it becomes apparent that enamel and dentin are tissues with very different physical (mechanical and optical) behaviors. Despite the similarity in its primordial constitution, dentin resists fracture, presenting a greater optical density and a perception of warmer tones of the visible light spectrum. Enamel, on the other hand, has the function of resisting

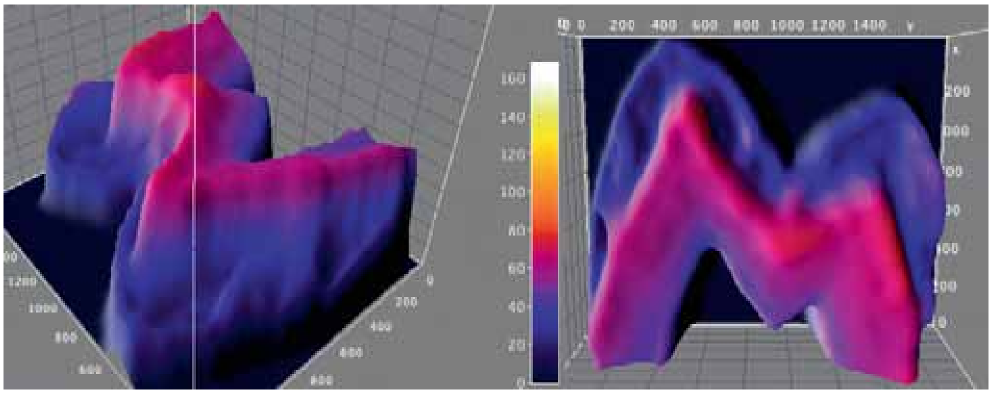

FIGURE 10 Tooth crown fluorescence 3D chart. Note how the effect is more intense from JED to the pulp.

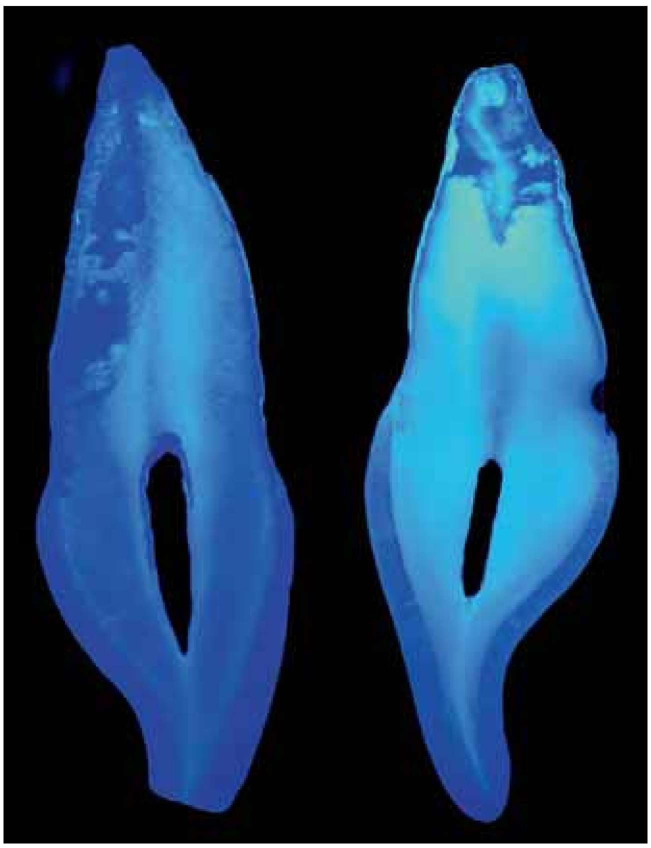

FIGURE 11 Comparison of fluorescence between old (left) and young (right) teeth.

attrition and increasing masticatory efficiency through coronal rigidity, scattering cooler shades of visible color. Within a biomimetic concept, considering the restorative materials currently present in dental practice, resins would be substitutes for dentin, while feldspathic ceramics would be substitutes for enamel. However, despite natural dentin having low wear resistance and natural enamel having low fracture resistance and low toughness, studies of hybrid systems help us to understand that in bioinspiration, an intermediate design model could supply the structural loss of these two materials with only a single restorative material. We have examples of natural bone composites, dentin, and even wood. The latter present specimens with hardness compared to metals depending on the direction and constitution of their fibers. They may also undergo industrial transformations creating materials of very high density and resistance.[24] In this scenario, when dental hybrid composites are processed to balance their organic and inorganic phases, materials can be produced with superior mechanical characteristics. An increase in density can be obtained by balancing different sizes and compositions of the inorganic phase and improving properties and bonds in the organic mesh. Historically, the first composite resins had low abrasive resistance. The modification in the size and composition of the loads provided materials with high resistance to fracture and wear. Studies show composite resins behave like enamel when annual wear rates are verified in vivo.[25]

Moreover, their flexural strength and elasticity bring them closer to the mechanical characteristics of natural dentin. With this, a composite resin can be categorized as a unique replacement for lost tooth structure, fulfilling the mechanical strength role of dentin and the abrasive strength role of enamel. On the other hand, their fragility lies in the potential of longitudinal chemical instability since these materials present a leaching process by hydrolytic degradation in water.[26] However, advances in light curing devices, especially formulations with industrial conversion (prefabricated CAD/CAM blocks), tend to improve the chemical stability of this material.

5 | THE CHOICE OF COMPOSITE RESIN AS A SINGLE SUBSTITUTION MATERIAL FOR LOST NATURAL TISSUE AND ITS MECHANICAL AND OPTICAL INTERACTIONS

5.1 | Mechanics

Even though composite resins have very similar base formulations, their mechanical behavior can vary dramatically depending on brand names due to the different uses of filler particles. This approach is so impactful that the current ranking factor for resins is particle size.[27] Two factors must be considered in this analysis. (1) Particles at the nanometer scale present an industrial deficiency in the silanization process, compromising the mechanical properties of these materials. For this reason, fillers smaller than 50 nm were grouped into clusters patented for a specific brand of resin (Figure 12) (Filtek Supreme

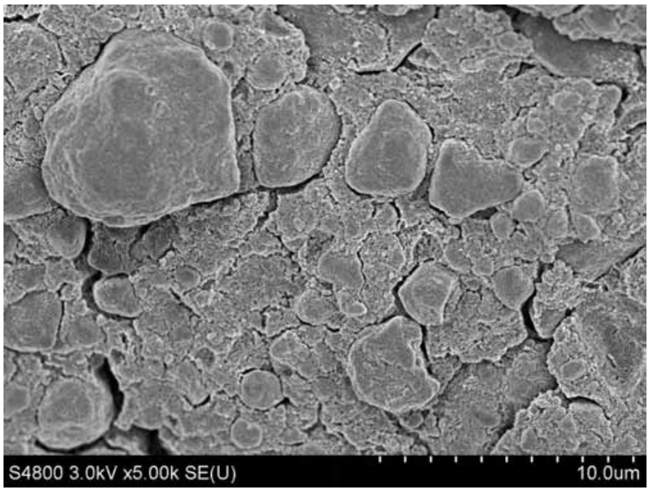

FIGURE 12 SEM of a nanofill clustered composite resin. Courtesy: Marcos Vargas.

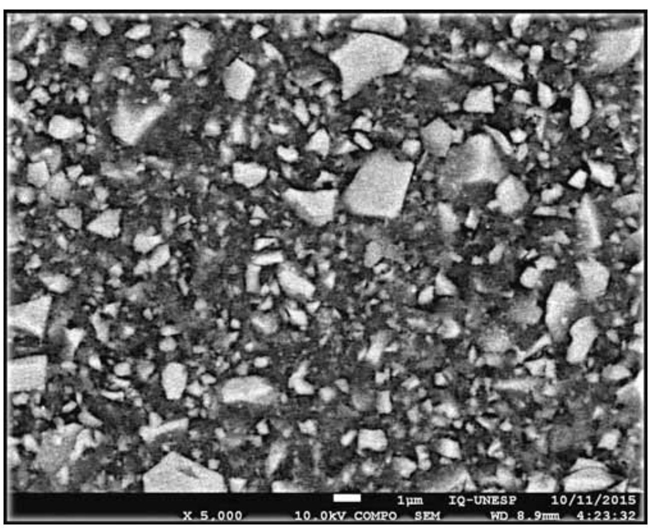

FIGURE 13 SEM of a nanohybrid composite resin.

Ultra, 3 M, Minnesota, USA). (2) Large particles considerably increase the fracture resistance but reduce the wear resistance, the polish, and, to a lesser degree, the flexural strength, which could be improved by increasing the small particle content of the organic phase.[28] Therefore, as the portion that will reconstitute dentin and enamel has different individual characteristics, it would be more logical to choose materials with different constitutions for each layer. The innermost portion of a resin buildup represents the structural reinforcement designated by natural dentin. In this constitutive layer of the restorative core, resins with high mechanical properties, especially fracture toughness, should be chosen. On the other hand, the outer layers need a smoothness provided by polishing, avoiding increased biofilm retention, improving chromatic stability, and high wear resistance.

5.2 | Optics

Following the principles of light scattering in natural teeth, the dentin layer has higher density and, therefore, Mie-type scattering, emphasizing reddish-yellow hues.[20] Thus, most studies analyzing the natural color of dentin indicate a high predominance of the hue of Group A on the Vita shade designation, as mentioned above. This phenomenon occurs when light is scattered in particles larger than 450 nm, increasing the chromatic effect of longer wavelength colors. However, particles with sizes within the visible light spectrum must be present for light decomposition in the material to occur. By this analysis, resins with characteristics suitable for dentin should contain particles ranging from nanometer to micrometer scale, with a predominance of medium-sized than micro or nanoparticles (Figure 13). This concentration will give the dentin layer a higher optical density, making it more opaque. This phenomenon happens in the natural model. However, it suffers variations according to a greater or lesser degree of dentin mineralization in the different areas of the crown and aging. Thus, the dentin will become more opaque from the cervical to the incisal third and from the outermost area to the area closest to the pulp (Figure 14A,B). With aging and increasing mineralization of the dentin structure,[29] fluorescence and opacity will decrease due to protein loss,

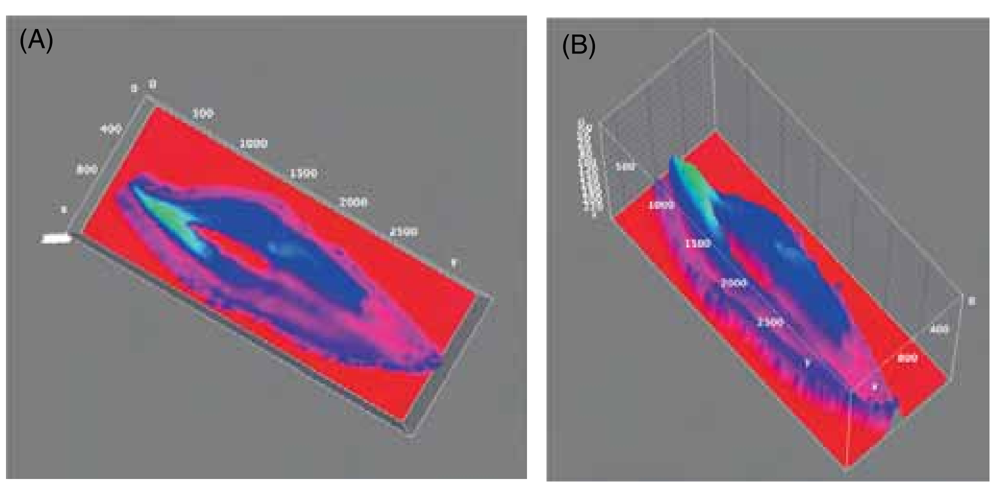

FIGURE 14 (A and B) Tooth crown opacity 3D chart. Green area is the most opaque part, follow by blue tones (medium opaque) and pink (transluscent area).

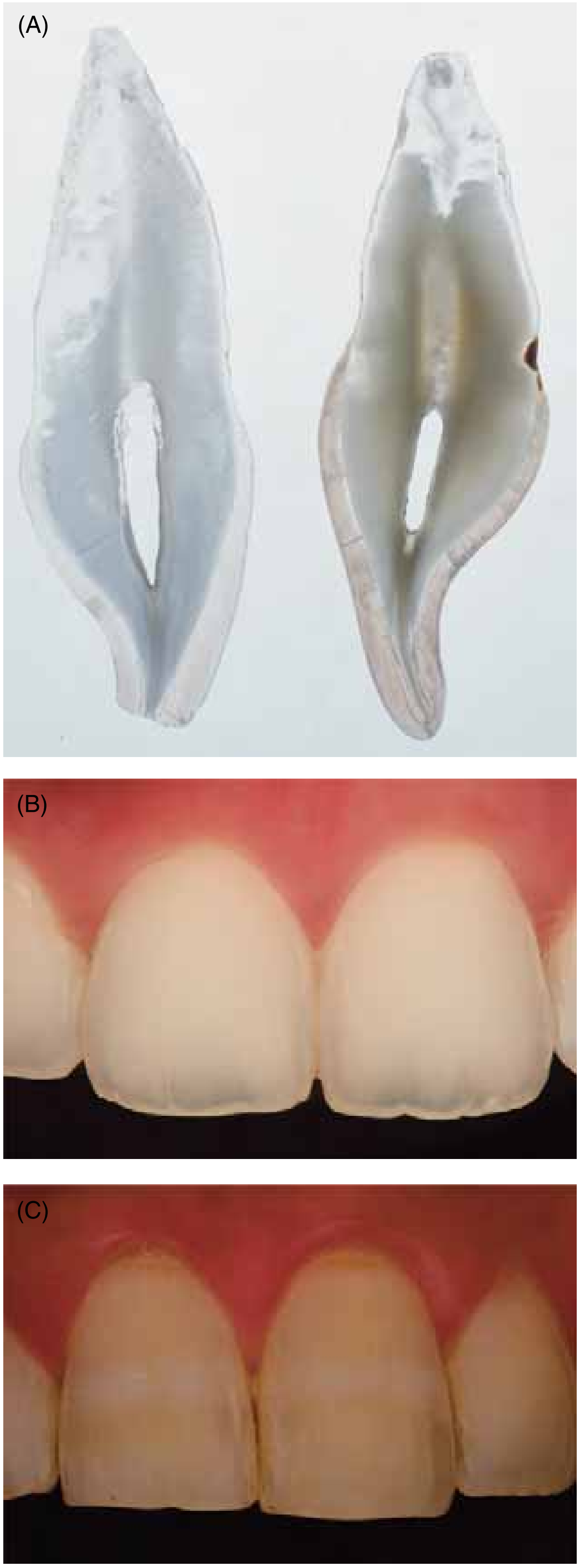

FIGURE 15 Comparison of opacity by age. (A) Extracted teeth (photographed with transmitted light) of older adult (left) and young (right). The older tooth is more translucent. Young and aged teeth show distinct opacity/translucency levels. (B) The young tooth is brighter. (C) The older tooth lost the luminosity.

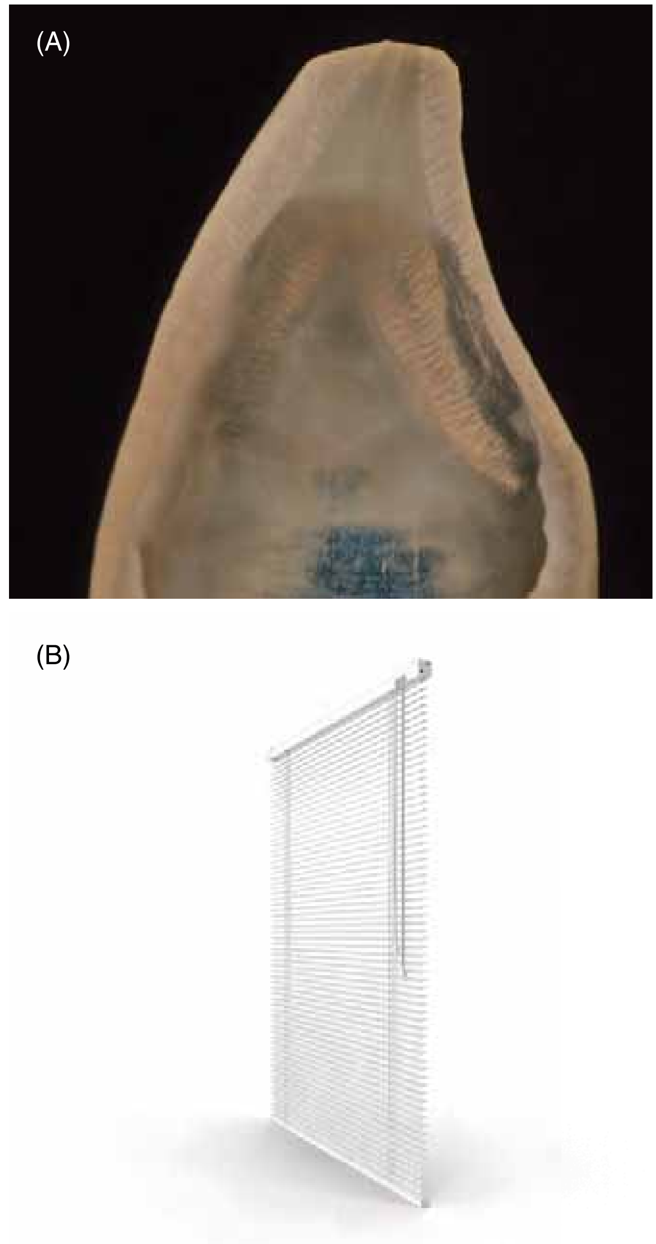

FIGURE 16 (A and B) Images demonstrating the translucent and opaque enamel lamellae and the blind analogy.

making the aged tooth more translucent in the dentin layer. It will also become less reflective of visible light, generating a grayish appearance of low luminosity (Figure 15A–C).

When the enamel is analyzed, a curious situation can be noticed. Enamel is not a translucent material as commonly advocated by clinicians. Instead, it presents an organized arrangement of opaque and highly translucent lamellae in horizontal layers to the crown—when viewed from a facial perspective—compared analogously to a partially open blind. Therefore, the enamel will function as an optical fiber in the hypermineralized prismatic lines capturing the color of the dentin underneath. In addition, the enamel will have a highly opaque behavior in the protein-rich interprismatic areas (Figure 16A,B). If this were not, the tooth would seem bluish even in the face of warmer dentin

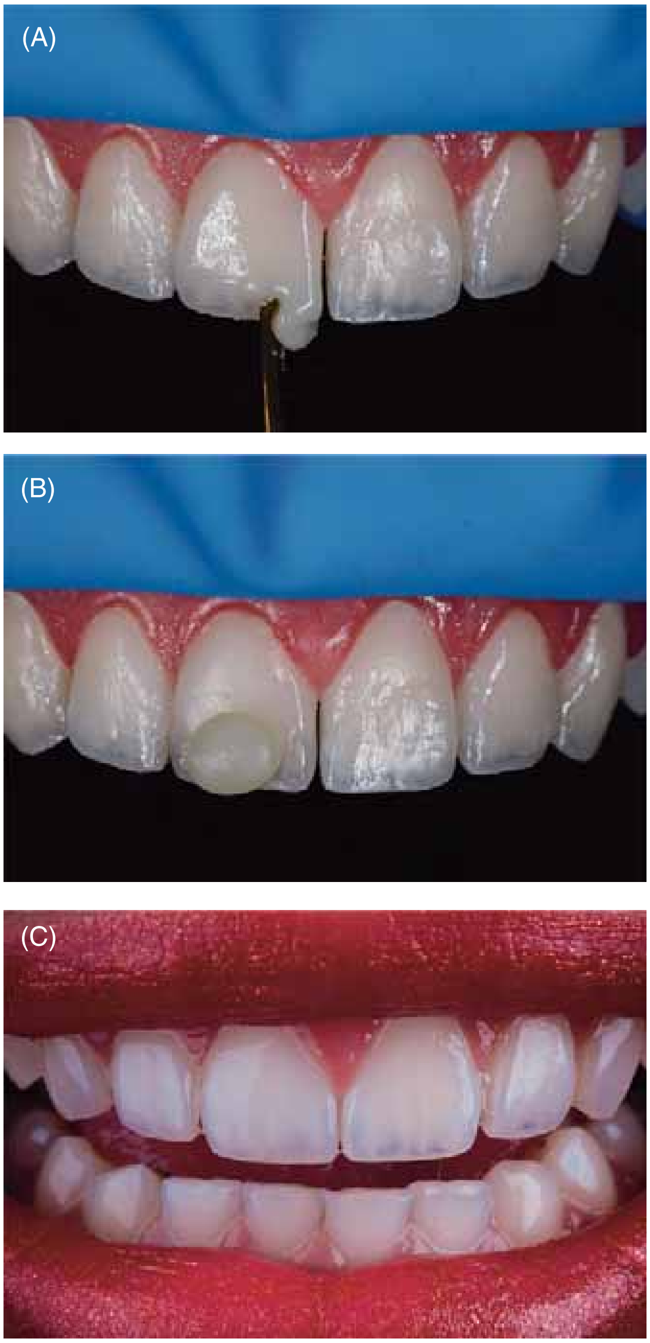

FIGURE 17 (A–C) Cutback being performed and a value-modifying achromatic composite resin layer applied. Post-operatory result.

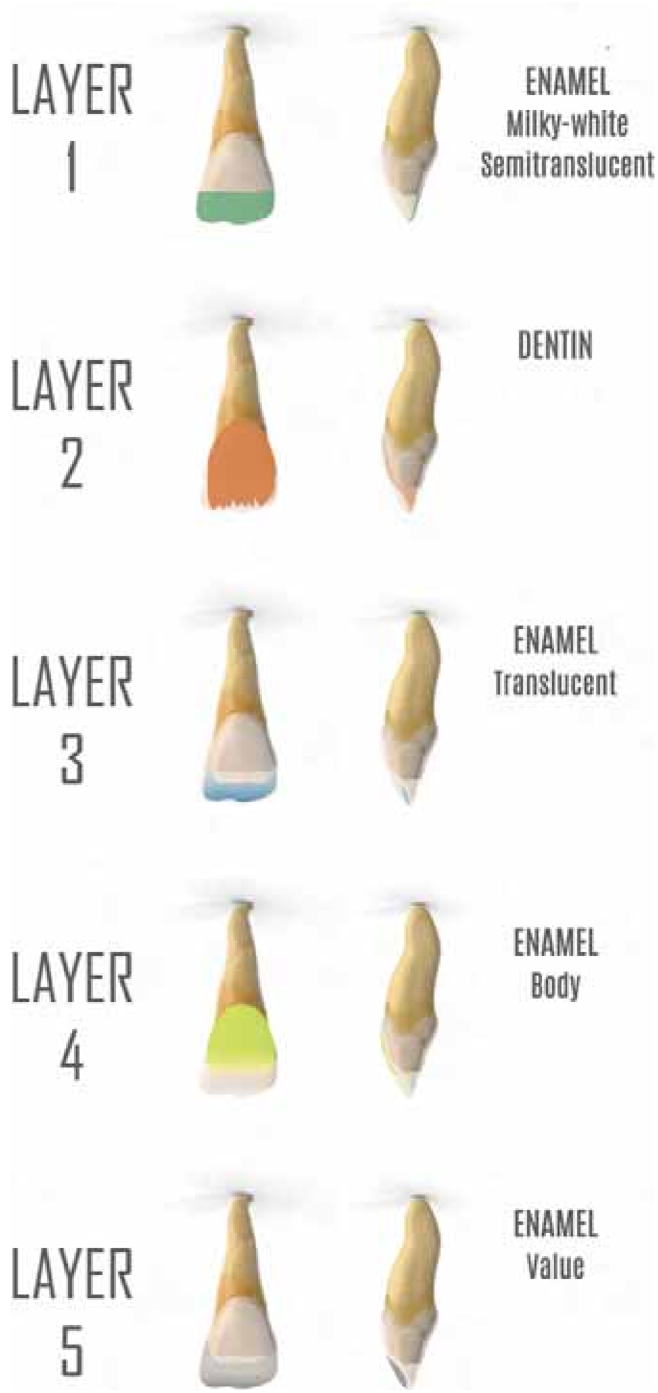

FIGURE 18 Layering diagram in the polychromatic layering technique.

colors. This constitution explains the enhanced light reflection in young patients due to the thicker layer of this tissue. Abrasion and attrition decrease this characteristic with age, making the enamel more translucent overall and exacerbating the teeth' low luminosity with aging. Another essential factor is that composite resins cannot perfectly reproduce this unique characteristic because the material does not present an organized distribution of phases. The latter is one of the factors that most corroborates the naturalness of the polychromatic technique compared to other techniques described in the literature. A single layer of enamel with only one opacity will only be able to reproduce some of the nuances of opacity and translucency visible along the crown. Therefore, enamel shades of higher opacity, that is, higher value, should be used in the middle third area, giving high luminosity to this region, especially in young patients. However, a cutback and the use of enamel shades that reproduce the optical aspect produced by the junction of the buccal and palatal translucent lamellae will provide adequate luminosity and a natural appearance to the restoration (Figure 17A–C). For this purpose, inner opalescent and external resin masses of varying opacities are recommended.

6 | SELECTION OF COMPOSITE RESIN BRANDS FOR THE DIFFERENT AREAS OF THE POLYCHROMATIC TECHNIQUE

Initially described by one of the authors of this article, the polychromatic layering technique (PLT) is based on the rationally organized distribution of five layers that reproduce the optical characteristics of the natural tooth. The conceptual diagramming of the arrangement of the layers by the polychromatic technique is represented in Figure 18.

7 | LAYERS IN THE POLYCHROMATIC TECHNIQUE

Layer 1: In this palatal/lingual layer, the resin must elicit high abrasion/attrition resistance, as it is the path for anterior and canine guidance. High fracture toughness is also required, significantly increasing the resistance of this area to functional loads. As it is a region that challenges the reproduction of natural enamel, the material must have a milky-white semitranslucent characteristic. The milky-white halo along the incisal edge and the bluish opalescent halo internally to it can be achieved by adjusting the thickness of this milky-white semitranslucent layer to allow optical changes. The choice should fall on micro-hybrid and nano-hybrid materials whose particle size composition encompasses nanometric and micrometric scales. The significant filler size variation will allow the correct scattering of light and dispersion into blue wavelengths when these types of particles are present. Thus, variations between 20 and 180 nm (blue effect) and particles within the visible light spectrum will favor natural optics, high fracture toughness, and abrasive resistance.

Layer 2: This is the core layer, the most important for the fracture resistance of the tooth/restoration compound. Because it is an inner layer, fracture toughness is far more critical than wear resistance. This layer defines the primary hue and chroma of the tooth. One chroma more saturated than the desired final shade should be chosen for the cervical and middle third. The most prevalent hue for this dentin layer is A in the VITA Classical shade guide. The opacity should block the mouth's dark background and allow for proper mamelon design and morphology. In this zone, classic microhybrids and larger-particle nanohybrids, predominant in their composition, will generate a high resistance and a Mie-type dispersion, providing a reddish-yellow hue.

Layer 3: This layer fills the depressions in-between, around, and over the mamelons and has little influence on the final strength due to its small quantity. However, it significantly contributes to the occurrence of opalescence. The beauty of incisal layering depends on this layer. A correct opalescence allows a through-and-through transmission of light, like the natural enamel's translucent lamellae, accentuating the Rayleigh type's blue dispersion. For accentuated Rayleigh scattering, the material must have nanometric particles and particles that promote light scattering (between 180 and 700 nm). Its refraction in the organic matrix stands differently than in the inorganic phase. High translucency nanocluster and hybrid resins produce the best results for this area.

Layer 4: This layer must be resistant to abrasion due to the sliding of food during cutting and hygiene techniques through brushing. The area of the cervical and middle third primarily covered by this layer will define the final color of the tooth. In this zone, the sum of the dentin and the thickness of the enamel, with its opaque and translucent lamellae acting as an optical fiber bringing the dentin color, will generate the zone of higher light reflection in the crown. In order to achieve high wear resistance and

TABLE 1 List of commercially available composite resin brands categorized according to filler and colorimetric characteristics.

Layers	Composite classification	Color characteristics	Brands
1	Nanohybrids (medium and large fillers)	Achromatic, translucent, milky	Vita-l-escence PF; Estelite Posterior PCE; Forma Incisal or WE; Miris 2 NR; Inspiro Skin Neutral SN; Renamel Nano Incisal Light; Venus diamond I; Essentia LE; Gradia Direct NT or WT; Filtek Supreme WE
2	Microhybrids or Nanohybrids (large fillers)	O, Opaque, Dentin, D	GrandioSO O colors; Enamel HRI UD colors; Herculite XRV D colors; Vita-l-escence Vita colors; Empress Direct D colors; Inspiro I colors; Renamel Microhybrid Vita colors; Miris S colors.
3	Nanohybrids (micro fillers)	Colors with high translucency and effects	Filtek Supreme GT; Harmonize Incisal Blue; Essentia OM; Vita-l-escence IrB; HRi OBN
4	Nano, micro or nanohybrids (micro fillers)	Body colors or semi-opaque enamels	Renamel microfill Vita colors; Estelite Sigma O colors; Estelite Omega E colors; Harmonize E colors; Herculite Ultra E colors
5	Nano, micro or nanohybrids (micro fillers)	Achromatic (incisal)	Renamel microfill IM; Estelite Sigma CE; Harmonize Clear; Herculite Ultra Incisal; Filtek Supreme CT

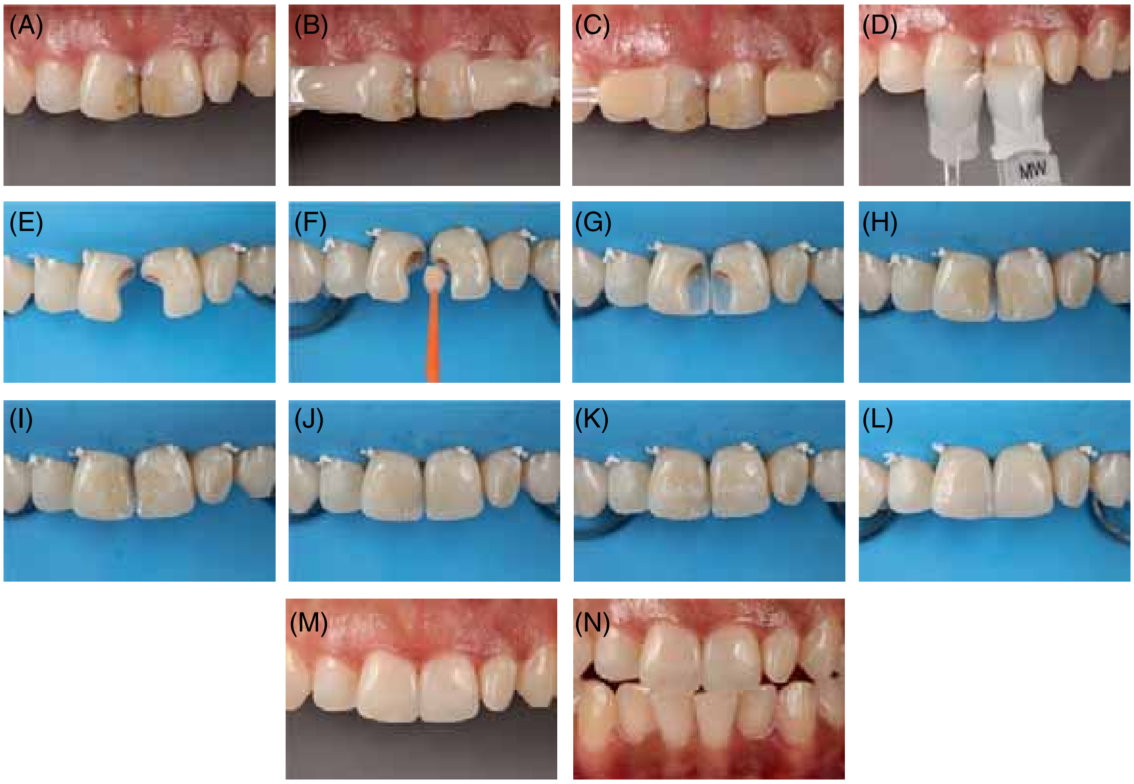

FIGURE 19 A step-by-step clinical case demonstrating the polychromatic layering technique for Class IV restorations. As part of a clinical trial, brands of similar properties were used for each layer on each central incisor. No differences can be perceived between the two restorations in the result. (A) Pre-operative condition. (B–D) Dentin and enamel shades are selected according to their distinct properties. (E) Bevel. (F) Adhesive protocol. (G) Palatal shell with a milky-white semitranslucent composite. (H) Dentin layer. (I) Translucent enamel (opalescent effect). (J) Body (chromatic) enamel. (K) White effect enamel. (L) Value (achromatic) enamel. (M and N) Follow-up after rehydration.

polishability, nanofilled and especially microfilled composites must be used. Nanohybrids with a predominance of nano and microparticles are also indicated. These materials must contain chromatic characteristics that will act synergistically with the opacity of the dentin. Thus, VITA-based resins of higher opacity designated by the manufacturer as "body" or natural translucency enamels will be essential allies in masking transition lines, especially in Class III and IV restorations.

Layer 5: This final layer aims to emphasize or modulate the effects obtained in the underlying layers. It must present high polishability and wear resistance like the previous layer. In addition, this resin must have a noticeable opalescent effect that increases significantly with thickness. Frequently, there is a decrease in luminosity compatible with the naturalness of the incisal third. In young teeth, the opposite may occur due to histological changes in the enamel. The same category of materials should be preferred as the previous layer (nanofills, microfills, or small particle nanohybrids) to avoid "islands" with different degrees of polishing in the final buccal layer. However, concerning translucency, they must be achromatic (non-VITA based) to only generate chromatic expressions by effect and not by pigments.

For the longevity of the restoration, the right choice of material in each of these five regions is paramount. To that effect, an analysis of the mechanical properties of the composite resins must be carried out to ensure a long-lasting functional behavior. Below is the indication of each brand according to the current literature and the authors' research and clinical experience regarding the characteristics of each material available on the market (Table 1).

The polychromatic technique predictably restores the anterior dentition seamlessly, provided the composite resins are selected according to their optimal mechanical and optical properties, and a methodical restorative protocol is followed. However, choosing the optimal shades for each layer from among the available brands may be challenging, especially when the clinician needs to gain hands-on familiarity with the vast array of commercial possibilities. Therefore, the authors recommend keeping a select combination of shades that clinicians can repeatedly master in their day-to-day challenges. Once the fundamental concepts of bioinspired protocols are fully mastered, combining different brands in a single case will no longer be a challenge and thus can provide esthetic results of high magnitude (Figure 19A–N).

8 | CONCLUSION

After the bio-inspired analysis, using nature as a model to be understood and followed, it is possible to note how the polychromatic technique remains current and viable in mimicking nature, providing esthetic and natural results in the layering of composite resins.

DISCLOSURE

The authors declare that they do not have any financial interest in the companies whose materials are included in this article.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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