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A Biomimetic Look on Nature: Direct Anterior Restorations - Systematic Review

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A Biomimetic Look on Nature: Direct Anterior Restorations - Systematic Review

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RESUMO

Introdução: Atualmente, devido à forte influência dos media e das redes sociais, o sorriso tem vindo a desempenhar um papel fundamental nos padrões de beleza, levando assim a uma crescente valorização da estética e harmonia deste, assim como a procura de formas de o melhorar. Mediante estas novas tendências, a Medicina Dentária contemporânea tem procurado otimizar as características e desempenho dos materiais restauradores existentes. É nesse contexto que surge então a Biomimética, derivada da palavra *bios*, que significa vida, e da palavra *mimesis*, que significa imitação. É a mimetização da natureza e a cópia de todas as suas propriedades óticas e mecânicas. Deste modo, com a realização de um tratamento que respeite os princípios biomiméticos, pretende-se devolver a biomecânica perdida (através do restabelecimento da estrutura), a função e a estética a um dente. Nesse sentido, a Biomimética começa com o estudo e a compreensão dos tecidos duros do dente, assim como das suas características óticas. Através da associação do esmalte e da dentina (unidos pela Junção Amelodentinária), o dente natural é a referência e apresenta uma união perfeita e inigualável de força, resiliência e rigidez. Nenhum material apresenta propriedades exatamente iguais ao dente, pelo que é importante estudar e perceber quais são os materiais disponíveis que têm uma maior semelhança em termos de comportamento biomecânico e ótico.

Objetivos: O presente estudo terá como objetivo esclarecer, como base no estado da arte atual, que procedimentos e materiais serão os mais indicados para realizar uma restauração estética e natural no setor anterior, usando uma técnica direta, seguindo os conceitos biomiméticos. Este trabalho pretende ainda esclarecer quais dos materiais existentes atualmente são mais semelhantes às características do dente natural.

Materiais e Métodos: A pesquisa bibliográfica foi realizada nas bases de dados *Medline* (via Pubmed), SCOPUS e *Web of Science*; usando como estratégia de pesquisa o PICO. O espaço temporal empregue foram os últimos 10 anos. Para além disso, como critério de inclusão, foram selecionados artigos disponíveis de forma integra, fundamentados e realizados em humanos, assim como escritos em português, inglês e espanhol.

Resultados: Foram incorporados 30 artigos nesta revisão sistemática. O campo de resultados foi dividido em 4 grupos principais: seleção da cor, propriedades dos matérias, técnicas de estratificação e, por último, espessura das camadas.

Desenvolvimento: Ao utilizar resinas compostas numa abordagem direta, é possível obter um tratamento conservador, preservando a estrutura dentária ao máximo. O operador deve ter conhecimento e experiência sobre as propriedades intrínsecas dos materiais restauradores, de modo a obter o máximo deles. A

seleção da cor deve ser feita em dentes limpos, antes haja desidratação, uma vez que este processo aparenta os dentes mais brancos. Na estratificação com a configuração EDDE, a camada vestibular de esmalte não deve ser superior a 0.5 mm, caso contrário, a restauração ganhará um aspeto acinzentado.

Conclusões: Este trabalho pode servir como ponto de partida para compreender as inúmeras técnicas e produtos existentes no mercado e quais os indicados uma restauração biomimética anterior direta. Pode, também, ser utilizado como base para a criação de um protocolo atualizado sobre este procedimento.

Palavras-Chave: *Biomimética*; *Estética Dentária; Restaurações Biomiméticas; Restaurações Anteriores; Técnica de Estratificação; Restaurações Diretas; Restaurações Mão Livre* e *Resinas Compostas.*

ABSTRACT

Introduction: Nowadays, due to the strong influence of the media and social media, the smile has a significant impact on beauty patterns. For this reason, there has been a growing appreciation of harmonious and aesthetic smiles, making people look for ways to improve them. Along with these new tendencies, contemporary dentistry has sought to optimize the characteristics and performance of the existing restorative materials. This is where the term "Biomimetics" emerges, which comes from the word *bios*, which means life, and from the word *mimesis*, meaning imitation. It is centered around the science of mimicking biology and the copy of all its optical and mechanical properties. Therefore, a treatment that respects the biomimetic principles is intended to restore the lost biomechanics (by recovering the structure), function, and aesthetics of a tooth. In this way, biomimetics starts with comprehending the tooth's hard-tissue structures and associated optical characteristics. By combining enamel and dentin, united by the Dentinoenamel Junction, the natural tooth is the reference and presents a perfect and unmatchable combination of rigidity, resilience, and strength. In Dentistry, no material has the same exact properties as the tooth structure, so studying and understanding the available restorative materials with the most tooth-like features is important.

Purpose: The present research aims to obtain an answer, based on the current state of the art, to the question regarding which procedures and materials will be the most suitable to achieve an esthetic and natural restoration in the anterior sector, using a direct technique, following the biomimetic concepts. This work also intends to clarify which ones are the closest to the natural tooth within the current existing material options.

Materials and Methods: The bibliographic research was carried out on the databases *Medline* (via Pubmed), SCOPUS, and *Web of Science*, using the PICO search strategy. As inclusion criteria, only fully accessible, based on human articles, and whose language was Portuguese, English, or Spanish, were selected.

Results: This systematic review incorporated 30 articles. The results were divided into the following 4 approaches: color selection, material properties, layering technique, and layer thickness.

Discussion: Using composite resins in a direct approach makes it possible to have a conservative treatment, preserving the tooth structure as much as possible. The operator should have maximum knowledge and understanding of the intrinsic properties of the restorative materials to get the maximum out of them. The color selection must be made on clean teeth before dehydration occurs, since this process makes the teeth look whiter. In the stratification with

the EDDE configuration the vestibular enamel layer should not be over 0.5 mm, otherwise, the restoration will gain a grayish aspect.

Conclusions: This work can serve as a starting point to understanding the numerous techniques and products existing in the market and which one is the best to obtain a biomimetic anterior direct restoration. It can be used as a baseline for the conception of a new and updated protocol for this procedure.

Keywords: *Biomimetics*; *Dental Esthetic; Biomimetic Restorations; Anterior Restorations; Layering Technique; Direct Restorations; Free-hand Restorations* and *Composite Resins.*

INDEX OF ABBREVIATIONS

DEJ	Dentinoenamel Junction
ΔE	Color Difference
PD	Polishing Discs
R_a	Roughness
PP	Polishing Procedure
SiC	Silicon Carbide
C*	Chroma
h	Hue
L*	Value
a*	Red/Green Chromaticity Index
b*	Yellow/Blue Chromaticity Index
µTBS	Microtensile Bond Strength
AOBD	Aluminum Oxide-Bonded Discs
LPM	Liquid Polishing Material
I	Transmitted Light
TP	Translucency
RFU	Relative Fluorescence Units
OP	Opalescence
E	Enamel
D	Dentin
HRi	High Refractive Index Composite
HFO	Traditional Refractive Index Composite
UV	Ultraviolet

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INTRODUCTION

I. INTRODUCTION

Nowadays, due to the strong influence of the media and social media, the smile has a significant impact on beauty patterns. For this reason, there has been a growing appreciation of harmonious and aesthetic smiles, making people look for ways to improve them [1].

Along with these new tendencies, contemporary dentistry has sought to optimize the characteristics and performance of the existing restorative materials. For that reason, there has been an evolution of these, which allows for the emulation of the nature of the tooth, mimicking the biomechanical and optical characteristics, leading to the goal of functional and esthetic excellence [2].

1.1 What Is Biomimetics?

This is where the term “Biomimetics” emerges, which comes from the word *bios*, which means life, and from the word *mimesis*, meaning imitation. Biomimetics is observing and learning with nature and using that knowledge to imitate the natural structures and solve human problems. It is defined as the study of the structure, function, and formation of biologically produced materials to synthesize similar products by artificial mechanisms. It is centered around the science of mimicking biology and the copy of all its optical and mechanical properties [3].

From a restorative dentistry perspective, the primary goal of the biomimetic concept is for restorative materials to achieve similarity with the natural tissues and mechanisms of the oral environment. The secondary goal is to design and reproduce a copy of a model, that is, a reference. That reference is, without a doubt, in the natural and intact tooth [4].

Therefore, a treatment that respects the biomimetic principles is intended to restore the lost biomechanics (by recovering the structure), function, and aesthetics of a tooth. In this way, biomimetics starts with comprehending the tooth's hard-tissue structures and associated optical characteristics [4].

1.2 Enamel-Dentin Complex

Enamel is a highly mineralized crystalline structure, making it a very dense and rigid structure. It is formed by hydroxyapatite, crystalline calcium phosphate, representing 96%-97% of the volume. The other remaining constituents include water (2%-3%) and organic matrix proteins (1%), such as amelogenins and enamelines. Microscopically, it is composed of enamel rods (prisms), compacted masses of hydroxyapatite. During the variation of structural formation and mineralization of the enamel, the striae of Retzius, is created, which is known as growth rings [5].

Dentin is composed of inorganic (70%) and organic material (18%), 90% of which is type 1 collagen, and water (12%). It is formed by odontoblastic processes that create the dentinal tubules, where the dentinal fluid is. The movement of this fluid conducts all the chemical, physical, thermal, bacterial, and traumatic stimulation that the tooth is submitted to. The dentinal tubules extend from the Dentinoenamel Junction (DEJ) into the crown area or Dentinocemental Junction in the root area; to the outer wall of the pulp [6].

The appearance and color of the tooth are a phenomenon generated by various factors, such as human perception, lighting conditions, light scattering, and gloss, among others. The dentin determines the tooth color; however, the thickness and translucency of the overlaying enamel determine how much chromatic influence the dentin has. According to the Munsell Color Order system, color is determined by three dimensions: hue, chroma, and value (lightness) [7].

Hue is defined as the quality that distinguishes one family color from another: green from blue, yellow from red. *Chroma* is considered the saturation or intensity of the hue, expressing how vivid or dull the color is. Therefore, chroma only exists when there is hue present. In addition, *value* describes the quantity of light an object reflects compared to a black absorber (0% reflection) and to a pure white diffuser (100% reflection). It can also be called lightness, brightness, or luminance [8, 9].

Additionally, there are secondary optical properties that can strongly affect the overall tooth appearance [7].

Translucency is considered to be the gradient between transparency and opacification. This indicates the ability of a layer to show through the underlying background [9].

Opalescence is an optical property of enamel caused by the light scattering of shorter wavelengths of the visible light spectrum, which gives the material a bluish appearance under reflected light and an orange/brown appearance due to the longer wavelengths that go through the tooth. On the incisal third, the tooth is not supported by dentin, only by enamel. On the incisal edge, there is a change in the direction of the enamel prisms, making it opaque. As the light is scattered throughout each enamel rod, it creates an optical effect due to the refraction of bluish-white light, called the incisal halo [10].

Lastly, *fluorescence* is an optical property of dentin and DEJ. It is the absorption of light by a substance and its emission at the same time in a longer wavelength. Both enamel and dentin possess this asset; however, dentin exhibits it three times more intensely than enamel [7].

By combining enamel and dentin, united by the DEJ, the natural tooth is the reference and presents a perfect and unmatchable combination of rigidity, resilience, and strength. In Dentistry, no material has the same exact properties as the tooth structure, so studying and understanding the available restorative materials with the most tooth-like features is important. Otherwise, the structural

integrity of teeth can easily be violated and damage the balance that the enamel-dentin complex offers, leading to unesthetic restorations [4].

1.3 Resin Composites

In order to simulate the previously described tooth characteristics, resin composites suffered a considerable evolution throughout time. A resin composite comprises inorganic filler-like silica and a resin-based matrix such as bisphenol A-glycidyl methacrylate. The filler improves the composite's mechanical properties, wear resistance, and translucency. Microfilled composites contain filler particles with sizes in the micron scale, while, on the other hand, nanofilled composites contain them with sizes in the nanometric scale. The most popular are the nanohybrid resin composites, which combine nanoparticles with submicron particles to optimize the distribution of fillers in the matrix. This results in superior mechanical, chemical, and optical features [11].

Both nanohybrid and nanofilled composites are clinically effective and widely used. Their superior qualities result in clinical wear resistance, diminishment staining and plaque accumulation, with excellent esthetic outcomes. The nanoparticle fillers enhance the polishability and ability to provide a smooth and shiny surface [12].

Currently, composites with different opacities exist to simulate the natural optical features. Therefore, the dentin shade mimics the natural dentin; the enamel shade copies the natural enamel; the body shade is an in-between of the dentin and enamel shade; and lastly, the different effect shades are used to achieve the small individual details [13].

1.4 Purpose

The present research aims to obtain an answer, based on the current state of the art, to which procedures and materials will be the most suitable to achieve an esthetic and natural restoration in the anterior sector, using a direct technique with composite resins following the biomimetic concepts.

This work also intends to clarify, within the current material options, which ones are the closest to the natural tooth. That way, it will be possible to mimic its optical properties and recover the tooth's full function and structure as conservatively and biomimetically as possible. The final goal is to obtain a natural, esthetic result without compromising oral health.

MATERIALS AND METHODS

II. MATERIALS AND METHODS

The present research was conducted following the guidelines of the review article *"Stages for Undertaking a Systematic Review"* [14].

2.1 Focused Question

The PICO model was used to define the investigation question, as shown in *Table I*.

Table I. *PICO Search Strategy*

P *(Problem)*	Permanent anterior teeth in need of restoration
I *(Intervention)*	Direct restoration with composite
C *(Comparison)*	Different types of materials and methods to a Biomimetic approach with a conservative perspective using composite resins
O *(Outcome)*	Mimic the natural properties and the optical view of intact teeth

2.2 Search Strategy and Information Sources

To assemble this review, three search engines of the scientific database were consulted to find relevant articles that met the goal of this study. The electronic search was also complemented with a manual search covering all the references of the included articles.

The search methods were personalized according to the different electronic sources and are described in *Table II*. These databases were consulted up to the 3rd of December of 2021.

Table II. *Database Search Strategy*

Database	Search Strategy
MEDLINE (via Pubmed)	("esthetic rehabilitation" OR "composite restoration" OR "free-hand restorations" OR "anterior restorations" OR "layering technique" OR "color") AND ("Esthetics, Dental*[MESH]" OR "Composite Resins/chemistry [MESH]" OR "Dental enamel [MeSH]" "Biomimetics*[MESH]" "Dentin / anatomy & histology [MESH]")
Web of Science (Clarivate Analytics)	TS = ("layering technique" OR "chromatic" OR "biomimetic" OR "direct restorations" OR "composite restorations") AND ("anterior restoration" OR "esthetic" OR "dentistry")

Scopus (Elsevier)	(“layering technique” OR "composite restorations" OR "esthetic") AND ("anterior restorations" OR "biomimetics" OR “composite”)

2.3 Eligible Criteria

Only articles carried on humans and written in Portuguese, English, and Spanish were selected during the screening. In addition, only fully accessible articles written in the past ten years were considered.

Within this table, it is possible to check the detailed criteria used for the paper’s triage.

Table III. *Criteria Selection*

Inclusion Criteria	Permanent Dentition
	Anterior Restorations
	Direct Restorations
	Composite Fillings
	Resin Fillings
Exclusion Criteria	Deciduous Dentition
	Indirect Restorations
	Class I, II, and V Cavities
	Amalgam Fillings
	CAD/CAM
	Ceramics

2.4 Data Management

Once collected, all the data that met the criteria was managed and stored by the program *EndNote* 20.1 (*Clarivate Analytics*, Pennsylvania, United States of America).

The final extraction of the articles’ data was summarized on *Microsoft Office Word 365* version 2204 (*Microsoft Corporation*, Washington, United States of America), using the following protocol: the author categorized similar information into groups according to the proposed approach. Therefore, for each article, the acquired information was organized according to the following parameters: author, year, results, and relevant comments.

RESULTS

III. RESULTS

The initial electronic search outcome was comprised of 1220 articles: 807 in *PubMed*, 191 in *Web of Science,* and 222 in *Scopus*. After removing 239 duplicate studies, another 635 studies were declined because the title did not meet the requirements. After screening the abstract, 256 studies were also rejected.

The remaining 90 papers were exhaustively analyzed. Subsequently to the full-text analysis, only 55 articles that met the inclusion criteria were retrieved. To this number, 6 additional articles [4, 5, 8, 17, 33, 53] were added after a manual search through the list of references of the selected articles.

In the end, in this systematic review, 61 articles were included. The selection process is laid out in the following *Figure*.

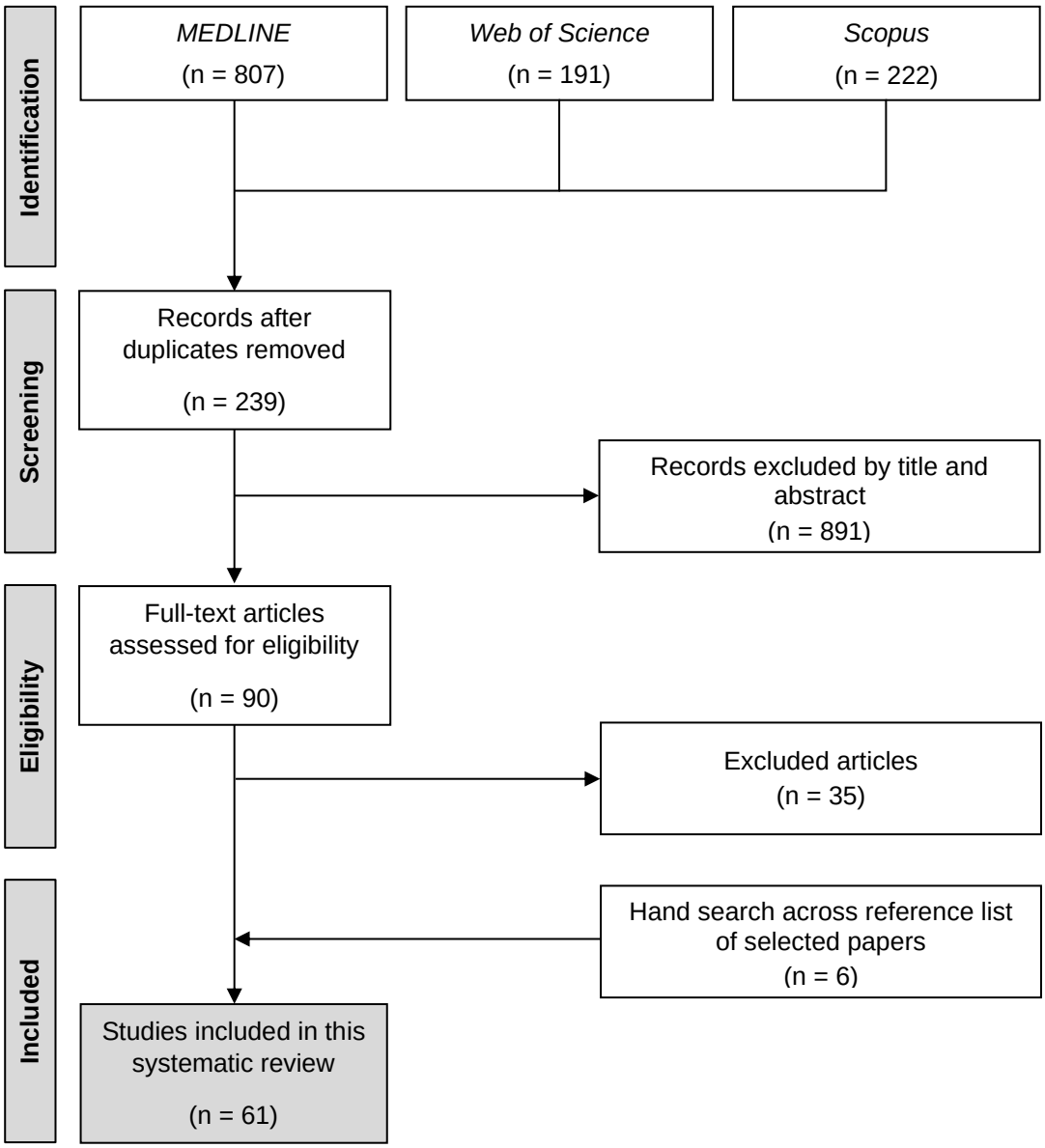

Figure I. *Flowchart of literature search and study selection*

In the subsequent tables (*Tables IV, V, VI* and *VII*), only the results of the most relevant investigation articles are present, not including systematic reviews and case reports.

Considering the extension and number of articles, only 30 of the 61 are mentioned in those tables. In these, the authors of those same articles, the publishing year, the control and test groups, the results, and, lastly, some comments are included. The remaining articles can be found in *Supplemental Table I* in the Appendix to facilitate the understanding of their conclusions.

The different approaches to a conservative direct restoration, following the biomimetic concept, were divided into the following 4 pertinent groups:

- Color Selection
- Material Properties
- Layering Technique
- Layer Thickness

Table IV. *Color Selection*

Author, Year	Groups	Results	Comments
Abreu *et al*, 2021 [15]	C: Tooth Color T1: Single-shade Universal Composite T2: Multishade Universal Composite	Δ*E* in T1 is above the level of acceptability Δ*E* in T2 did not show a statistical difference, and it's in the acceptability level	T1 showed different color matching values in anterior restorations. T2 presented higher color matching than T1.
Chong-Gamero *et al*, 2016 [16]	C: Nanohybrid Composite Probes T1: PD (Polishing Discs) T2: PD + Wetting Resin T3: Diamond Polishers T4: Diamond Polishers + Wetting Resin	*R*a (Roughness): T1 = T2; T3 = T4	The *R*a of the composite is not affected by the use of a wetting resin during its adaptation.
Ghinea *et al*, 2011 [17]	C: Microfilled, Microhybrid Composite T1: PP (Polishing Procedure) with 500-grit SiC paper T2: PP with 500- and 1200-grit SiC papers T3: PP with 500-, 1200-, and 2000-grit SiC papers T4: PP with 500-, 1200-, 2000-, and 4000-grit SiC papers	> *ΔE* (Color Difference) was between T1 and T2 T1 presented significant differences in chroma (*C**), hue (*h*), and value (*L**) when compared to T2, T3 and T4 *L** ↑ T1, T2, and T3; *L** ↓ T4 The differences in the *Ra* among the different groups of composites were not significant	Since the differences among the different composites were not significant, the *Ra* after PP is not influenced by filler size or distribution. *L** ↓ in T4 was caused by overpolishing. The *R*a after the different PP influenced the color of the resin composites.
Gómez-Polo *et al*, 2014 [18]	C: Natural Teeth T1: Subjective method (human eye) T2: Objective method (spectrophotometer)	T1: reproducibility of 65% T2: reproducibility of 80% % of agreement between T1 and T2: *L** > *C** > *h*	Spectrophotometers can detect variations of color at the midpoint, which the human eye is incapable of doing.

Table IV. *Cont.*

Gueli *et al*, 2017 [19]	C: VITA shade guide T1: A2/B2 shade of a commercial composite T2: A2 shade of another commercial composite	*L**, *a**, *b**, *C*,* and *h* of C ≠ *L**, *a**, *b**, *C*,* and *h* of T1 and T2	The actual color of both composites does not match the VITA shade guide values declared by the manufacturers.
Hatırlı *et al*, 2021 [20]	C: Original teeth color T1: Teeth dehydration during 30 min T2: Teeth rehydration after 30 min T3: Teeth rehydration after 24 hours	Significant color change in T1: 85% of the teeth were above the acceptability threshold *ΔE*: T2 > T3 *L**: ↑ in T1, ↓ in T2, and T3 *a** and *b**: ↓ in T1, ↑ in T2, and T3	During dehydration, the teeth become lighter, and the TP (Translucency) of the enamel decreases. After 30 min of rehydration, the tooth color did not return to the baseline color. After 24 hours, the tooth color was closer but still not the same.
Kutuk *et al*, 2020 [21]	C: No modeling agent T1: Top surface regularized with modeling liquid T2: Top surface regularized with universal adhesive T3: Top surface regularized with the primer of a 2-step self-adhesive	After staining procedures: *R*a and *ΔE*: T1 < C < T2 < T3	Using a hydrophobic modeling liquid (T1) keeps the color of the composite stable over time. *R*a is less influenced in T1 due to the similar composition between the modeling liquid and the nano-hybrid resin matrix. The low pH of T2 and T3 can deteriorate the composite surface.
Ritter *et al*, 2016 [22]	C: A2 and AO2 shade (opaque A2) of a nanohybrid resin composite T1: 2 etch-and-rinse adhesive T2: 2 self-etch system T3: universal adhesive system	In the A2 shade: • *ΔE*: T3 > T1 > T2 • *Δa**: T3 > T1 = T2, in the green spectrum (-) • *Δb**: T3 > T1 > T2, in the yellow spectrum (+) In the AO2 shade: • No significant color changes were observed	Due to the opacifiers, no color alteration was significant in the AO2 shade. In the A2 shade, more translucent, T3 compromised the final color, bringing darkness and yellowness to the restoration. However, these results were still clinically acceptable.

Table IV. *Cont.*

Sedrez-Porto *et al*, 2016 [23]	C: Increment composite specimens without modeling liquid in between T: Increment composite specimens with modeling liquid in between the layers (Half of each: PP with PD and diamond paste; other half: no PP)	After staining procedures: No PP: ↓ *L**, ↑ *a*,* and *b** *ΔE* and *R*a: C > T *ΔE* and *R*a*:* no PP > with PP	Compared to the specimens made without modeling liquid and without PP, specimens prepared with modeling liquid and PP showed minor overall color change.
Topcu *et al*, 2017 [24]	C: Enamel non-bleached T1: Enamel immediately after bleaching T2: Enamel bleached after 1 week T3: Enamel bleached after 2 weeks	After the restoration process: µTBS: T1 > T2 > T3 = C	The µTBS only goes back to its average values after 2 weeks of the end of the bleaching treatment. Therefore, the adhesive will fail during that period, leading to unsuccessful restorations.
Yildiz *et al*, 2015 [25]	C: Composite specimen with no PP T1: AOBD and pastes as PP T2: PD for 15 s as PP T3: LPM as PP	After staining procedures: *ΔE*: C > T2 > T3 > T1 *L** ↓ in all groups *a** and *b** ↑ in all groups *R*a values were clinically undetectable	The *ΔE* between the T groups is not significant. Even though the composite has high color stability, after the staining procedures, all samples became darker. Finishing and PP influence color stability. No relationship between color stability and *R*a was found in this study.

C: Control Group; T: Test Group.

Table V. *Material Properties*

Author, Year	Groups	Results	Comments
Azhar *et al*, 2019 [26]	C: Composite with no pigments T1: Composites with only red pigments T2: Composites with only yellow pigments T3: Composites with red and yellow pigments	TP ↓ with ↑ pigments concentration T1: *L** ↑, *a** ↑, *b** ↑ T2: *L** ↓, *a** ↓, *b** ↑ T3: slight variation in *L**, ↑ TP when there is more red pigment than yellow pigment	Because the pigment particles behave as scattering centers, the TP of resin composites decreases. The *ΔE* was clinically perceptible.
Lee *et al*, 2016 [27]	C: Nanofilled Resin Composite T1: Enamel Shade T2: Translucent Shade	TP after curing: ↑ T1 and ↓ T2 TP after aging 8 weeks: ↓ T1 and T2	The TP changes are shade and product-dependent. Degradation of resin composites was mainly composite product dependent; the enzymatic effects of saliva did not adversely alter the TP of resin composites.
Meller *et al*, 2012 [28]	C: Natural Teeth T: Different Shades and Brands of Composite Probes	RFU (Relative Fluorescence Units): C > T Lighter shades have bigger RFU RFU was significantly different between the same shades of different brands and between different shades of the same brand.	Brand and shade influence the RFU. Restorations with adequate fluorescence are problematic to achieve because it is necessary to apply several portions of different shades.
Meller *et al*, 2015 [29]	C: Natural Teeth T1: Enamel Shades T2: Dentin Shades T3: Special Shades	RFU: T2 < T1 < T3 T1, T2, and T2 reached their maximum fluorescence at about the same excitation and equal emission wavelengths.	All shades are from the same composite brand. The current reality of fluorescence disparities between composite shades demonstrates the necessity for new, superior materials, even if only for aesthetic reasons.

Table V. *Cont.*

Mourouzis *et al*, 2015 [30]	C: Natural Teeth T1: Microhybrid composite T2: Microfilled composite T3: Nanofilled compsoite	*ΔL**: positive in T1, T2, and T3 → shift to a lighter shade *Δa**: positive in T1 and T2 → shift to red negative in T3 → shift to green *Δb**: positive in T1, T2, and T3 → shift to yellow *ΔE* is significantly higher in T3	The variations in the color parameters can be explained because of the different matrix compositions of the different groups. The *ΔE* increases with an increase in the amount of fillers. However, this difference was not distinguishable by observation.
Naeimi *et al*, 2012 [31]	C: Composite Probes T1: Regular Body T2: Opaque Dentin T3: Translucent Enamel	TP: T2 < T1 < T3 TP decreases significantly from A shades towards C and D shades.	The TP is influenced by the difference in the refractive indices between the resin matrix and the filler. Composite resins that are more translucent have a smaller filler size.
Ning *et al*, 2021 [32]	C: Restorations after the final adjustments T1: Restoration with a microhybrid composite T2: Restoration with a nanocomposite (Measurements of the tooth height were made after 1, 3, and 5 years)	The tooth height was measured after 1, 3, and 5 years → with the increase of time, more height loss was observed Restoration's wear: T2 > T1	The larger filler particles of the microhybrid composite remain embedded in the matrix after minor fillers get removed due to the limited bonding to the matrix. This results in higher wear resistance when compared to the nanocomposites.
Rocha Maia *et al*, 2018 [11]	C: Natural Dental Tissues T1: Nanofilled composite T2: Microfilled composite T3: Microhybrid composite T4: Supra-nanofilled composite	Mean of *I* (Transmitted Light) values: C < T4 < T3 < T1 < T2	As the filler content increases, *I* reduces. In the supra-nanofilled composites, the silica particles do not tend to agglomerate; therefore, T4 had the most similar *I* pattern compared to C.

Table V. *Cont.*

Schmeling *et al*, 2010 [33]	C: Entire build-up of dentin composite T1: Build-up with dentin composite and high-value composite T2: Build-up with dentin composite and medium value composite T3: Build-up with dentin composite and low-value composite	*L**: C > T1 > T2 > T3 Δ*E*: T1 < T2 < T3, in which the majority of the values were clinically unacceptable 1.0 mm T1 = 0.8 mm T2 = 0.6 mm T3, on a chromatic influence level	The low *L** values occurred because of the light dispersion. The layering of an enamel composite over a dentin composite increases this effect. Regardless of the type of value resin composite utilized, a similar chromatic perception can be achieved.
Schmeling *et al*, 2012 [34]	C: Composite Specimens T1: High-value resin composite T2: Medium-valu resin composite T3: Low-value resin composite	TP: T1 > T2 > T3	High-, medium-, and low-value resin composites are utilized to replicate the enamel qualities. TP decreases with the value.
Tabatabaei *et al*, 2019 [35]	C: Composite Discs T1: Composite disc build-up with enamel shade T2: Composite disc build-up with body shade	RFU: T1 > T2 OP: T2 > T1	The opaque the material, the lower the RFU will be since the probability of the light reaching the fluorescent particles diminishes.

C: Control Group; T: Test Group.

Table VI. *Layering Techinque*

Author, Year	Groups	Results	Comments
Betrisey *et al*, 2016 [36]	C: EDDE, the gold standard T1: DDEE T2: EEDD T3: EDDD	*ΔE* T1 is not clinically acceptable *ΔE* T2 is acceptable but perceptible *ΔE* T3 is clinically acceptable	In T3, the substitution of the buccal layer from E to D, within 4 mm of the total thickness, did not affect the result. The sequence in which the layers are placed is more relevant than the quantity of material.
Elzayat *et al*, 2020 [2]	C: Polychromatic layering T: Dual-shade layering	Surface Luster: C > T Color match and TP: C = T	After one year, T's clinical performance is essentially identical to C's. The surface luster variation is explained by applying a thin buccal layer of a translucent resin on C.
Gueli *et al*, 2017 [19]	C: EDDE T1: EEDD T2: EDED T3: EEEE T4: DDDD	*L** of T1 and T2 is similar to *L* of* C In T3 and T4, the values were not clinically acceptable.	Better results when the buccal surface is restored by E. This suggests that the cover material significantly influences the color impression when layering than the underlying material.
Khashayar *et al*, 2014 [37]	C: Dentin and Translucent Composite T1: Classic layering concept T2: Modern 2-layered concept	TP: T1 < T2 ↑ thickness: *ΔE* T2 > *ΔE* T1	T1 follows the natural layering technique, whereas T2 combines an opaque dentin shade with highly translucent enamel, justifying the results. T1 is less affected by layer thickness, resulting in a more predictable outcome.

C: Control Group; T: Test Group.

Table VII. *Layer Thickness*

Author, Year	Groups	Results	Comments
Ardu *et al*, 2019 [38]	C: Resin composite material at 0.5 mm T1: 1.0 mm T2: 1.5 mm	*ΔE*: T1 < T2 TP: T1 > T2	The *L*a*b** and TP of composite samples are significantly affected by their thickness. A layer of excessively transparent enamel thicker than recommended can give the restoration an undesirable grey appearance.
Ferraris *et al*, 2014 [7]	C: Nanohybrid (HRi) and Microhybrid Composite (HFO) T1: 0.3 mm T2: 0.5 mm T3: 1 mm T4: 1.5 mm T5: 2 mm	HRi: > T → ↓ *C** and TP, ↑ *L** HFO: > T → ↓ *C**, *L**, and TP *ΔE* between HRi and HFO: • T1: no *ΔE* • From T2: ↑ and the results were clinically perceptible	HRi behaves similarly to natural enamel in that its *L** rises with increasing thickness, whereas this is not the case with HFO. When there is dentin underlying, the enamel layer's increase causes the dentin color to desaturate, therefore reducing the *C** and *L**. This makes the restoration appear darker.
Gueli *et al*, 2017 [19]	C: A2 and B2 shades T1: 1.0 mm T2: 2.0 mm T3: 3.0 mm T4: 4.0 mm	Higher *C** - T2, Lower *C** - T4 Higher *h* – T4, Lower *h* - T1	Variations in dentin and enamel thicknesses influence widely clinical results.
Hajira *et al*, 2015 [39]	C: Entire build-up of dentin composite T1: Dentin with 0.5 mm of enamel T2: Dentin with 0.7 mm of enamel T3: Dentin with 1 mm of enamel	*C**: C < T1 < T3 < T2 *L**: C > T1 > T2 > T3	*C** only has a positive correlation with thickness until T2. After that, it starts to diminish. Thickness at 0.5 mm and 0.7 mm produces similar effects to the natural enamel.

Table VII. *Cont.*

Khashayar *et al*, 2014 [37]	C: Dentin and Translucent Composite Restoration T1: 0 - 0.4 mm translucent layer T2: 0.4 – 0.8 mm translucent layer T3: 0.8 – 1.2 mm translucent layer	*ΔE*: T1-T2 < T2-T3 < T1-T3 ↓ TP with ↑ thickness	The variation in thickness of the highly translucent enamel substitute strongly influences the *L** of the restoration, making the restoration look too gray.
Manauta *et al*, 2014 [40]	C: Enamel Shell Polymerized T1: Cervical measurements (0.2 mm) T2: Middle measurements (0.5 mm) T3: Incisal measurements (0.7 mm)	*L**: T1 > T2 > T3 T1: Modifies the underlying layer minimally T2: *L** decrease is not crucial T3: *L** is too lower	In T1, there is too much display of dentin, making the restoration too opaque. 0.5mm of enamel is the right thickness for an optimal opacity-translucency appearance.
Paolone *et al*, 2014 [41]	C: 16 different enamel composites T1: Cervical measurements (0.2 mm) T2: Middle measurements (0.5 mm) T3: Incisal measurements (0.7mm)	In all 16 specimens (C): T1, T2, and T3 were constant	Using a custom-made shade guide has advantages: The enamel shell has a consistent thickness. The thickness of the specimen is unaffected by the material used.
Rocha Maia *et al*, 2018 [11]	C: Natural Dental Tissues T1: 0.3 mm layer T2: 0.5 mm layer T3: 1.2 mm layer	Mean *I* values: T1 > T2 > T3 *I* values closer to C: T3 followed by T2 followed by T1	There is a more significant light absorption and reflection with a thicker layer and an increase of light scattering throughout the superficial composite, which decreases the *I* value.

Table VII. *Cont.*

Schmeling *et al*, 2010 [33]	C: Dentin composite - 2.0 mm T1: 0.4 mm T2: 0.6 mm T3: 0.8 mm T4: 1.0 mm (T was a build-up of value composite over C)	*L**: T1 > T2 > T3 > T4 T2, T3, and T4 had clinically unacceptable chromatic changes	The resin composite will have a lower *L** with the layer thickness increase.
Schmeling *et al*, 2012 [34]	C: Composite Specimens T1: 0.5 mm T2: 1.0 mm T3: 1.5 mm T4: 2.0 mm T5: 3.0 mm T6: 4.0 mm	TP: T6 < T5 < T4 < T3 < T2 < T1	TP decreased as the thickness increased.
Tabatabaei *et al*, 2019 [35]	C: Composite Discs T1: 0.5 mm T2: 1.0 mm	RFU: T1 > T2 OP: T2 > T1	TP and OP have a negative correlation; therefore, with an increase in the thickness, TP decreases, and OP increases. With the OP increased, there will be more light scattering, decreasing the RFU.

C: Control Group; T: Test Group.

3.1 Color Selection

In this group, 11 articles were compiled. Even though some articles could be included in other sub-groups, they were incorporated here for organizational purposes since their content had the most to do with color selection [15-19, 22-25].

The surroundings, the operator, and the color guide reference, among others, significantly influence the color selection process of the restorative materials that will be used. Thus, it is important to understand and know all aspects related to it [18, 19]. The color selection process should be the first step to be done, with the teeth still hydrated [20]. A spectrophotometer can be a helpful asset in this process since it detects color variation that the human eye cannot [18]. When choosing the color, it is essential to know that the classic VITA shade guides, most of the time, do not have an accurate match with the color of the actual composite [19].

Several variables significantly affect the color of the final restoration. For example, the type of adhesive, the material's roughness after polishing procedures, the shade selection, and the finishing and polishing procedures [15-17, 22, 25]. Modeling liquids enhance color stability through time [21, 23]. If a bleaching treatment is conducted, it is crucial to wait 2 weeks before the end of the treatment so that the surface microhardness can be restored and the adhesive system does not fail [24]. The results are summarized in *Table IV*.

3.2 Material Properties

This group collected 11 articles that investigate the different material properties and how they affect the whole restoration [11, 26-35].

Knowing the natural teeth's optical properties is crucial to use them as a reference when selecting the most aesthetic restorative material. As a matter of fact, the optical property that is the hardest to imitate is fluorescence, which is very noticeable under Ultraviolet (UV) illumination. To overcome this, rare earth oxides are beginning to be added to the restorative materials [28, 29]. These pigments scatter a small amount of light, causing a translucent appearance [35]. However, the addition of red and yellow oxide pigments significantly reduces translucency [26]. The use of different shades of composite leads to a more natural restoration, in which the translucency is mimicked. Using an opaque shade, less translucent, such as dentin, brings opacity and yellowness to the restoration. In contrast, the enamel shade, more translucent, creates a depth from within the restorations, consequently reducing the color coming from the opaque shade [31, 33]. Using a value resin composite makes it possible to mimic the natural enamel characteristics [34].

It is essential to consider instabilities, such as the fact that after curing, aging, and treatment, there are differences in the translucency of the direct materials [27]. In addition, knowing how the amount of fillers affect the final restoration is essential [30]. Using supra-nanofilled composites tends to achieve similar results

to the natural dental tissue in light transmittance. In the anterior area, microhydrid composites are known for their wear resistance [11, 32]. The results are summarized in *Table V*.

3.3 Layering Technique

Only 4 articles describing the different layering techniques were retrieved [2, 19, 36, 37].

The natural layering concept follows an EDDE pattern, from palatine to vestibular. It is considered the “gold standard” stratification since it replicates the natural stratification of the teeth [17]. This means the first layer is an enamel composite, followed by 2 layers of dentine composite that mimic the dentin anatomy. The final layer is with the same enamel composite [37]. The different opacities and colors of the composites (enamel composite is translucid and dentin composite is opaque) lead to a more natural restoration [2].

The use of a simplified stratification (EDDD) results in less time-consuming restorations and provides similar optical results to the natural stratification [36]. The results are summarized in *Table VI*.

3.4 Layer Thickness

This group gathered a total of 11 papers. The importance of a defined measure of each layer was analyzed for each type of material [7, 11, 19, 33-35, 37-41].

It is an established fact that variations in the thickness of dentin and enamel composite widely influence the clinical results [19]. This is because by increasing the thickness of the enamel layers, there is a decrease in the translucency, brightness, and chroma, which lowers the value, leading to a grayish restoration [7, 33, 34, 37-39]. There is a direct relation between thickness and opalescence and an indirect relation between thickness and light-transmittance [11, 35].

Therefore, according to the studies, a 0.5 mm enamel composite layer is the right thickness for an optimal opacity-translucency appearance, similar to that of the natural teeth [39, 40]. When choosing the material, specimens should have multiple predetermined layer thicknesses, giving an accurate perception of their behavior [41]. The results are summarized in *Table VII*.

DISCUSSION

IV. DISCUSSION

Nowadays, with the development and improvement of composite resins, their properties, longevity, and durability allow the clinician to reproduce the tooth's shape and natural optical characteristics due to the existing variety of effects and colors [42]. Therefore, it is possible to use direct esthetic restorations as a first option approach to the rehabilitation of the anterior sector [43].

In addition to these, using composite resins in a direct approach combines the principles of a minimally or noninvasive treatment philosophy. This allows for a more conservative approach, preserving more tooth structure and making it possible to reverse the treatment easily [12]. They also provide less clinical working time, at a lower cost, when compared to other options, like indirect restorations [44].

The therapy's success is highly dependent on a thorough understanding of the patient's wishes. It can be used as a multidisciplinary treatment, for example, for diastema treatment, microdontic teeth, esthetic concerns, pigmentation, tooth fracture, and dental wear; among others. Despite this, dental professionals need to keep in mind the limitations of this therapy, such as the difficulty in mimicking the color and light effects of the adjacent teeth. Additionally, composite resins tend to incorporate pigments and do not have as much color stability as ceramics do. Therefore, another condition of this therapy is the necessity of periodic repolishing, to bring back gloss and brightness to the restoration [45]. Ceramics also have better integration in the periodontal tissues [6].

4.1 Color Selection

Natural teeth are polychromatic. When looking for the most esthetic and biomimetic restoration possible, it is imperative to use multi-shades so that nature can be mimicked [15, 46]. Therefore, the first step is defining which shades and colors will be used. According to Hatırlı *et al*, this must be done right at the beginning of the appointment on clean teeth with their natural humidity and before the dehydration occurs [20]. When the water loss process takes place, the spaces on the enamel prisms, that were previously filled with water, are now filled with air. As this happens, when the light hits the enamel, it will refract differently, resulting in increased luminosity and decreased translucency, masking the dentin color and giving the optical effect that the teeth are whiter [13].

In conformity with Gómez-Polo *et al*, color selection can be made using a spectrophotometer, which is objective, quicker, and does not depend on the surroundings like visual shade matching does. The spectrophotometer can detect color variations that the human eye cannot. However, its placement must be precise in order to obtain reliable results, which can be difficult due to the convex surface of the tooth [18].

The determination of the color can also be done visually. The most used comparative method is the VITA shade guide. However, Gueli *et al*, proved that the VITA shade guide does not accurately match the color of the different company's composites [19].

To increase dental esthetics, it can be recommended that the patient does a bleaching treatment before the composite restorations. Topcu *et al*, analyzed the μTBS before and after bleaching and concluded that it is vital to wait 2 weeks after the end of the treatment so that the surface microhardness of the tissues can be fully restored [24]. Besides that, the residual release of perhydroxyl free radicals can interfere with resin polymerization and adhesion. This allows for a more conservative treatment since, to disguise darker substrates, there is the need to drill more tooth to accommodate resins and opacifiers [47].

Many other factors can affect the final color of the restoration. During the modeling of the composite, adhesion of it to the application instrument is a frequent problem. Thus, to resolve this, it is common to lubricate the instruments. In agreement with Ritter *et al*, the use of a universal adhesive can compromise the result by lowering the value and increasing the yellowness [22]. It is preferable to use a modeling liquid since it has been proven to promote long-term color stability and does not affect the material properties [16, 23]. Kutuk *et al*, showed that using a modeling liquid, which is hydrophobic, can help keep the color of the composite stable over time because hydrolysis does not occur as it does in polymer-based materials such as adhesives [21]. To prevent color alteration, it is also essential to polish the restoration [25]. However, according to Ghinea *et al*, it should not be overpolished since it will decrease the brightness, altering the outcome [17].

4.2 Material Properties

Choosing a suitable material is imperative to achieving outstanding results. To begin with, the type of composite is extremely important. Ning *et al*, tested a microhybrid and a nanocomposite under challenging clinical conditions and reported that, for the anterior area, the microhybrid composite had a higher wear resistance. This happens because the abrasion force is relatively low compared to the posterior region. As a consequence, after the minor fillers are removed from the surface layer, due to the limited bonding force; the larger particles remain in the matrix, which confers the deterioration resistance [32]. Following this reasoning, Rocha Maia *et al*, concluded that the silica particles in the nanocomposites tend to agglomerate, creating bigger particles, which reduces the transmitted light. When compared to natural teeth, supra-nanofilled composite displayed the most identical light-transmittance pattern since, in this composite, the silica particles do not cause agglomeration [11]. Mourouzis *et al*, also showed that the total color difference between the natural reference and the restored tooth increases with the increase in fillers [30].

The existing shades have varieties in their composition that also affect the materials' characteristics. Azhar *et al*, proved that with the increase of the pigment's concentration, there is a decrease in the translucency since these pigments act as light scattering centers. Pigments are added to the materials to produce distinct shades so that the clinicians can match the color of the restorations to the rest of the oral cavity [(26)]. Following this statement Naeimi *et al*, showed that translucent shades, like enamel shades, had higher translucency than opaque shades, like dentin shades. This happens because the difference in the refractive indices between resin matrix and filler influences the translucency of these materials [(31)]. It is possible to conclude that the translucency is both product and shade-dependent [(27)].

Value resin composites were created in an attempt to replicate the enamel characteristics. Unlike traditional enamel composite resins based on hue, these non-VITA composites have discrete chromatic expression and shades based on value - high, medium, and low - corresponding to light, medium, and dark chromatic expression. They are used to achieve highly aesthetic results, and Schmeling *et al*, showed that the darker the shade, the lower its translucency will be [(34)].

The fluorescent behavior of composites is not identical to the natural feature. Consequently, composite restorations may match the color of an original tooth when observed naturally, but under UV light, the mismatch becomes apparent [(29)]. Meller *et al*, compared a variety of shades and brands and concluded that both influence this property, so it can be challenging to achieve a desirable and adequate fluorescence [(28)]. To improve this ability, rare earth oxides, like cerium, and terbium, among others, are added to the restorative materials [(48)].

All things considered, as the distinct tissues combine with each other, it is important to use different resins for each of the tissues when restoring the tooth, increasing the biomimicry of the outcome [(9)].

In the following *Table VIII*, a summary of the desirable ideal characteristics for each type of resin that will form the stratification layers (enamel and dentin) is shown.

***Table VIII**. Ideal Properties of the Composite Resins*

Composite Resins for Enamel	High opalescence
	High translucency
	Balanced value for each third of the tooth
	Refraction index similar to enamel
	High hardness
	Excellent polishing

Composite Resins for Dentin	Fluorescence
	Opacifier
	Highlights of reddish-orange
	Low refraction index
	Good relationship translucency X opacity

Not all the composite resins have all of the above-listed characteristics. However, it is crucial to recognize the qualities and features of the materials that are going to be used [49]. With a good knowledge of these, it is possible to achieve a similar chromatic perception with diverse materials and thicknesses [33].

4.3 Layering Technique

Understanding how enamel and dentin respond in the presence of light and how to mimic this effect using a layering process to create exceptionally realistic restorations is critical to achieve outstanding results [50]. The multi-layer techniques allow for the reproduction of personal characteristics and can mimic natural optical effects [51]. The desired polychromatic will define the number of layers needed in the restoration. In addition, to simulate an optimal restorative integration with the surrounding tissues, a minimal amount of layers should be applied [52].

Khashayar *et al*, defended that because natural tooth color results from the interaction of the optical qualities of enamel and dentin, it seems sensible to try to replicate this layered structure using two optically distinct restorative materials [37]. Composite layering distinct materials - enamel, dentin, with varied opacities and hues, and effect resins with various shades to give the optical effect of opalescence. As a result, the layering restorative approach, also known as stratification, has been used to replicate the individual details of the tooth [2].

In 1995, Professor Didier Dietschi introduced the “Natural Layering Technique” concept based on the identification of the true enamel and dentin optical features [44]. It embraces a more accurate anatomical layering based on the natural teeth, and since then, it has been established as a reference in the field of composite restoration [53].

A traditional procedure is a buccolingual technique, which makes use of the silicone index. It follows a lingual-to-buccal layering, therefore an EDDE “gold standard” configuration, where E represents enamel and D dentin, reflecting the tooth anatomy [36]. In agreement with Gueli *et al*, when E is used as the final layer, it better influences the outcome [19]. Changes in this layer can also significantly affect the result. Khashayar *et al*, showed that using a highly translucent enamel increases the translucency of the restoration, although increasing its thickness results in a significant color difference [37].

Another widely used procedure is the dual-shade layering, suitable for small class IV and class III, which, according to Elzayat *et al*, consists of a dentine shade positioned deeply, followed by a body shade covering the whole surface [2]. Other authors have also reported this technique since it is less time-consuming and, for small cavities, can achieve esthetic results with a good color match and translucency [2, 36]. However, surface luster is lower since no translucent resin is applied vestibularly [2].

4.4 Layer Thickness

As mentioned in the last chapter, changes in the thickness of a layer can lead to undesirable results.

Since the optical characteristics of composite resins created for stratification techniques differ from the optical qualities of tooth tissues, placing the layers in the same thickness as the natural ones is not suitable [7]. According to Schmeling *et al*, unlike what happens in the dental structure, where a thicker enamel layer represents whiter teeth and greater brightness, increasing the thickness of an enamel composite layer will lower the brightness [33]. To overcome this, Ferraris *et al*, showed that by using an high refractive index composite, with the increase of the layers, the value will also increase since the high refractive index of these types of composites behaves similarly to natural enamel [7].

This final layer is very important to have the right thickness, otherwise, a thicker layer of the translucent enamel composite will give a grayish aspect to the restoration, diminishing, the translucency as well [37, 38]. Manauta *et al*, explained that this happens because internal particles exist when the thickness increases. The transmission and reflection of the light are diminished exponentially, increasing the chroma and decreasing the value [39]. Therefore, the right thickness of this layer should be 0.5mm and not go over 0.7mm, in order to obtain an optimal opacity-translucency appearance. To achieve this, a specific instrument (Misura, LM Art, Finland) that calibrates the 0.5mm and removes the excess composite should be incorporated before polymerizing [40].

For the dentin shade, the thicker the layer, the less translucent but opaquer and with a higher hue it will look [19, 34]. Tabatabaei *et al*, demonstrated that opacity is caused by light scattering. If the light is more scattered in a thicker layer, the light will not reach as much of the fluorescent particles, reducing the fluorescence [35]. In agreement with this argument, Rocha Maia *et al*, concluded that the transmitted light decreases in thicker layers [11].

As a result, there are significant clinical advantages when using a custom-made shade guide, concludes Paolone *et al*. Using the same materials that the clinician uses in their practice allows overlaying the enamel shades with the dentin shades, using different thicknesses. Consequently, it creates the possibility of testing the behavior of the composite in distinct conditions [41].

4.5 Restoration Process

4.5.1 Initial Procedure

To begin with, the first clinical step includes a careful analysis of the oral health and a balance of the periodontal tissues before proceeding with the treatment, if necessary. It is important to know the patient's oral habits and hygiene and encourage them to improve and maintain a healthy oral lifestyle.

After this, there must be a careful evaluation of the occlusion, periodontal and dental health, and, in order to do a careful study of each individual case and to come to a diagnostic, extra and intra-oral photographs should be taken as well as superior and inferior dental arch impressions and occlusal records [54].

To provide an excellent treatment, it is essential to do a wax-up (*Figure II*) to diagnose the available space and plan the occlusion scheme, indicating if there is a need to adjust the remaining dentition. Doing this gives the professional a better visualization of what they will be working with, allowing them to test and mold the restorations exact shape [54].

Figure II. *Diagnostic wax-up model mounted on the semi-adjustable articulator*

Pontons-Melo JC, Atzeri G, Collares FM, Hirata R. Cosmetic recontouring for achieving anterior esthetics. Int J Esthet Dent. 2019;14(2):134-46.". Reprinted with the author's permission.

After this process and the patient's acceptance of the new restorations, the planning is transferred to the mouth with a silicone index, created on the models, which guides the restorative process (*Figure III*). This tool helps the clinician obtain an esthetic symmetrical, and predictable outcome. To ensure that everything is correct, the buccal portion is removed, with the help of a scalpel, to create the first layer of the restoration [55].

Figure III. *Silicone index created on the diagnostic wax-up*

Paolone G, Scolavino S, Gherlone E, Spagnuolo G. Direct Esthetic Composite Restorations in Anterior Teeth: Managing Symmetry Strategies. Symmetry-Basel. 2021;13(5):14. Reprinted with the author's permission.

4.5.2 Color-Matching

The most practical alternative to selecting the color is through the “button try” technique (*Figure IV*). This consists of placing small amounts of different shades of composites on the tooth's vestibular surface, photopolymerizing them, and then comparing them to the natural tooth [56]. Determination of the color involves the analysis of the cervical, medium, and incisal third areas. The hue and saturation are better defined on the cervical third of the tooth, because the enamel layer is thinner, and the dentin color prevails, making it the best place to choose the dentin shade. The enamel layer is thicker on the middle third of the tooth; therefore, the enamel shade selection should be based there. The enamel prism changes direction at the incisal third, creating an optical effect and making the translucence and opalescence more superb. This is where a translucency composite should be chosen [57].

When taking the photographs, the flash will be, at the same time, absorbed, reflected, refracted, and transmitted on the dental structures. A cross-polarized filter should be used to compensate for this since it eliminates the unwanted reflections on the teeth. In addition, there should be a copy of the photographs in black and white for a detailed evaluation of the optical characteristics [49].

After this, it is important to rehydrate the tooth since the tooth has desiderated during this process, which can affect the color perception [20].

Figure IV. *Button try technique*

Gaião U, da Cunha LF, de Almeida Kintopp C, Garcia AV, Gonzaga CC, Moro A, et al. Clinical Steps for Restoration of Fractured Anterior Teeth: Color Protocol with Non-VITA Scale. Case Rep Dent. 2019;2019:3982082. Reprinted with the author’s permission.

4.5.3 Adult and Old Teeth

In younger patients, the enamel is thicker, since it has been less exposed to damage, increasing the value and opacity of the teeth and, therefore, decreasing the translucency [53]. Besides that, since the actual color of the tooth comes from the dentin, the enamel acts as a filter on it, making younger teeth appear whiter [39].

Furthermore, the halo effect, described previously, is characteristic of younger teeth since the incisal edge of the tooth is supported by enamel. It can, sometimes, give the perception of the dentin mamelons underneath. However, in

the long run, through wear and tear of the enamel, this optical effect is no longer noticeable [11].

Over time, there is progressive mineralization of both enamel and dentin. There is an accumulation of secondary and tertiary dentin deposition, and the dentinal tubules fill up with deposits of hydroxyapatite crystals. Additionally, the enamel thickness decreases with wear, exposure to acids in the diet, and brushing [58]. This contributes to an increase in the translucency of the enamel, bringing out the yellowish dentin color underneath [33].

4.5.4 Field Isolation

Absolute isolation must be conducted to achieve a dry operatory field free of contamination, making the use of a rubber dam a “gold standard”. The rubber dam also allows better access to the cervical area since it retracts the gingiva. This can be enhanced by utilizing a gingival retraction cord before the rubber dam [44]. Concerning the discomfort and pain, local infiltrative anesthesia can be given [59].

Only after using the rubber dam can the old restorations, if present, be removed, or the teeth can be slightly prepared to remove irregular and non-supported enamel prisms (bevel) in case of fractures [41].

4.5.5 Palatal Shell

The initial layer is composed of a high translucency enamel composite, applied directly to the silicone index and extended 1mm above the work area to have good retention in the tooth [49]. This way, it provides the palatal profile, width, and incisal edge position for the future restoration, all in one step (*Figure V*). In addition, it creates the possibility of shaping the palatal wall and the incisal edge to match the planned anatomy [53].

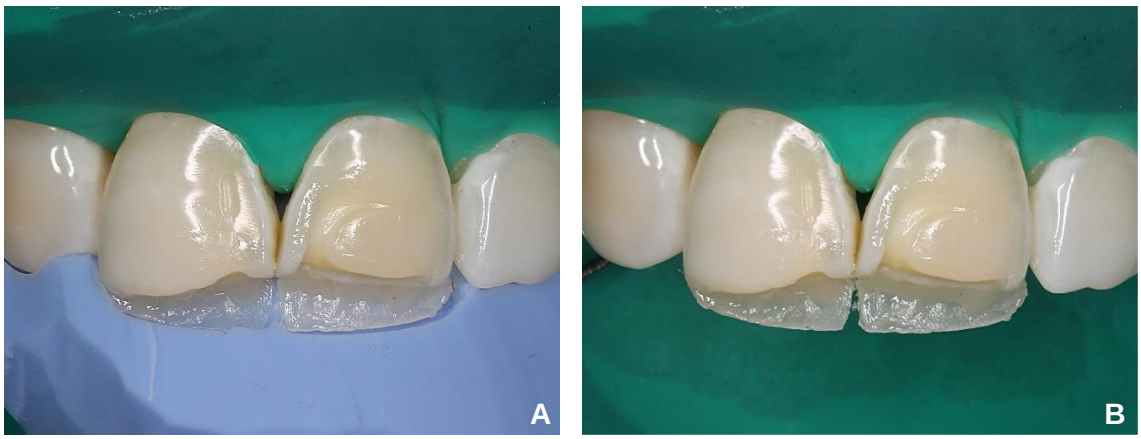

Figure V. (A) *Palatal shell built directly against the silicone index;* ***(B)*** *Enamel palatal shell.*

Original images taken by Leonor Esteves Ferreira

Before starting to layer the internal dentinal body, the interproximal walls should be created. On that account, their thickness, position, and height can be adjusted so as to not negatively affect the final result. The frame is adapted by adding or removing material with the help of burs and polishing discs [56].

4.5.6 Dentinal Body Characterization

An opaque resin must be used to make the second layer, mimicking the natural dentin. When choosing the color to use, the dentin composite should present a higher-chrome shade than the enamel composite to simulate the optical features - for example, A1 for enamel and A2 for dentin. The development of the body can be done with 2 layers; the first one to reinforce the recently constructed palatal wall and the second one to build the anatomy of the dentin [49]. Another function of the dentin layer is to blend the interface between the tooth and the restoration. Thereby, the dentin increment should be applied over half of the bevel; or at the cavosurface angle if the bevel was not conducted [42].

The primordial details of the dentin mamelons have 3 form variations: rounded, bifurcated, and serrated. To replicate their anatomy accordingly to the rest of the oral cavity, the initial photograph taken with the cross-polarization filter must be analyzed by increasing the contrast and decreasing the brightness [49]. The dentin increment should not be extended to the incisal edge since the effect colors and enamel will characterize that area. To blend it, it can be lightly feathered with a brush [42].

4.5.7 Incisal Edge Characterization

Usually, most resin systems already sufficiently mimic the halo when inserted in the proper angulation. However, when a more noticeable profiling is needed, it is possible to add some effects [49].

In this polychromatic layering technique, a thin spindle of a high-value enamel composite is put over the incisal edge to recreate the incisal halo [44]. In the space between the lobes and the incisal edge, iridescent blue and opaque white color modifiers can be added to intensify the halo effect and the decalcification spots [59].

4.5.8 Vestibular Wall Characterization

The last final layer, corresponding to enamel, must be made with translucent resins denominated as enamel colors. From the beveled region to the incisal edge, the one single increment (so there are no union lines) should be feathered to recreate a natural finishing while respecting the inclinations of the intact tooth and the proximal contour. A small excess should be left to be removed during the

polishing process. In the end, an optimal aesthetic outcome will be achieved as well as natural translucency, opalescence, and recreation of halo effects [49].

Figure VI. *Polishing with felt disk and polishing paste*

Gaião U, da Cunha LF, de Almeida Kintopp C, Garcia AV, Gonzaga CC, Moro A, et al. Clinical Steps for Restoration of Fractured Anterior Teeth: Color Protocol with Non-VITA Scale. Case Rep Dent. 2019;2019:3982082. Reprinted with the author's permission.

4.5.9 Finishing and Polishing

Finishing is the process of contouring, shaping, and smoothing restorations to restore anatomical shapes and eliminate any excess material [53]. With graphite's help, lines are drawn horizontally and vertically to define the grooves and lobes and then confectioned with diamond burs. They should not be too profound; otherwise, they appear too evident and artificial. Interproximal strips should be used to remove interproximal excess [60].

Afterwards, the polishing is performed to achieve a surface with high luster and enamel-like texture to achieve a natural appearance [61]. Subsequently to the polymerization, due to the different levels of hardness of the resin matrix and the filler particles, the composite surface exhibits diverse roughnesses. An unpolished restoration enhances the coefficient of friction, increasing the wear rate. It is therefore necessary to achieve a smooth surface to reduce surface staining, plaque accumulation (which can lead to secondary caries), and patient discomfort [17]. It is performed with decreasing grits of aluminum oxide disc, followed by polishing with a silicon carbide brush, a goat hairbrush, and a felt disc with diamond paste as well as aluminum oxide paste (*Figure VII*) [61].

In the periodic appointments, the polishing steps should be repeated to bring out the brightness and surface luster of the restoration. The patients should also be informed that eating and drinking beverages with pigmentation increase the need for follow-up appointments. Environmental factors, like smoking, are also included in these [54].

Since there is usually an increase in the Vertical Dimension of Occlusion (VDO), the patients are also recommended to use occlusal splints to reduce teeth grinding, muscle activity, myofascial discomfort and to prevent fractures and cracks in the restorations [54].

CONCLUSIONS

V. CONCLUSIONS

To sum up, according to the information obtained in this work, it is possible to conclude that:

- Direct restorations in the anterior region have a long-term prognosis and imply less chair time at a lower cost. A direct approach permits a more conservative treatment, preserving more tooth structure and makes it possible to reverse the treatment easily;
- If bleaching is done prior to the treatment, it is essential to wait 2 weeks so that the surface microhardness of the tissues can be fully restored;
- To achieve an esthetic restorative result, the clinician should determine the patient's expectations, the optical qualities of the tooth, as well as the anatomy and details that characterize the adjacent teeth;
- The VITA shade guides do not provide an accurate match with the actual color of the composite;
- The color selection must be made on clean teeth before dehydration occurs. Otherwise, the teeth will appear whiter than they actually are;
- It is necessary to improve the existing restorative materials, to achieve an acceptable fluorescence in the restorations;
- In the anterior area, microhybrid composites have greater wear resistance, and supra-nanofilled composites achieve similar light transmittance results to those of the intact tooth;
- The “gold standard” buccolingual technique follows an EDDE configuration, mimicking the natural stratification;
- The vestibular enamel layer should not be over 0.5 mm, otherwise, the restoration will gain a grayish aspect;
- To achieve aesthetic excellency, the operator should acknowledge and understand the intrinsic properties of the restorative materials to get the most out of them. The dental expert should be considerably experienced and skillful in applying the art and scientific principles when layering the material, so the result is close to the original;
- After the treatment, occlusal splints are crucial for avoiding fractures and cracks on the restorations and reducing teeth grinding and myofascial discomfort.

Within the limitations of this study, due to the lack of randomized control trials and limited evidence-based information in literature, it was found to be beneficial to evaluate the clinical performance of direct anterior restorations, to interpret the results, and learn from the mistakes that were made.

However, this work can serve as a starting point to understanding the numerous techniques and products existing in the market and which one is the best to obtain a biomimetic anterior direct restoration. It can be used as a baseline for the conception of a new and updated protocol for this procedure.

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APPENDIX

VII. APPENDIX

Supplemental Table I. *Articles used in Introduction and Discussion*

Author, Year	Article's Title	Author's Conclusions
Alajlan *et al*, 2018 [13]	Esthetic Restorative Dentistry with Composites	Artificial enamel should be made with more translucent resins to achieve natural qualities, whereas artificial dentin should be made with more opaque resins to get natural characteristics.
Amaro *et al*, 2021 [12]	Direct Restorations for Anterior Esthetic Rehabilitation and Smile Symmetry Recovery: Two Case Reports	In the anterior area, direct restorations have an excellent long-term prognosis. It is a reversible, repairable, cost-effective, minimally invasive procedure that allows for the correction of the tooth. Regular maintenance sessions are required, and all cases should be meticulously planned to provide predictable and long-term esthetic outcomes.
Basheer *et al*, 2020 [3]	Future Perspectives of Biomimetics in Restorative Dentistry	Biomimetics aims to achieve a restoration that mimics dental tissues' anatomical, biological, and functional features to duplicate and imitate the intact tooth while maintaining high durability.
Bazos *et al*, 2011 [5]	Bio-Emulation: Biomimetically Emulating Nature Utilizing a Histo-Anatomic Approach; Structural Analysis	Biomechanical forces pass freely through the surfaces, dispersing across this structurally fluid medium. The Dental-Enamel Complex is a shielding mechanism that should be conserved throughout the clinical restoration operations process wherever it is possible.
Bazos *et al*, 2014 [9]	Bio-Emulation: biomimetically emulating nature utilizing a histo-anatomic approach; visual synthesis	It must be highlighted that understanding color and shadow requires a complete comprehension of light propagation inside the coronal structures.
Dietschi *et al*, 2008 [53]	Optimising aesthetics and facilitating clinical application of free-hand bonding using the 'natural layering concept'	The centrifugal technique is the traditional method. One or two dentine layers are positioned deeply, followed by an enamel layer covering the whole surface. The buccolingual method is another frequently used technique. The first coat of enamel is applied directly to the silicone index. Then, if necessary, effect materials can be placed in a precise three-dimensional layout.

Dietschi *et al*, 2016 [52]	Shading concepts and layering techniques to master direct anterior composite restorations: an update	The desired polychromatic will define the number of layers needed in the restoration. To simulate an optimal restorative integration with surrounding tissues, the tooth's optical components should be analyzed and then apply minimal layers as possible.
Fialho *et al*, 2016 [1]	Restoring the natural smile with minimal intervention	Improved polishability has been linked to microhybrid resins. The features of these materials contribute to decreasing the staining and plaque deposition, enhancing the final aesthetic of the restoration. Pigments were used to recreate natural and unique qualities on the vestibular surface of incisors.
Gaião *et al*, 2019 [46]	Clinical Steps for Restoration of Fractured Anterior Teeth: Color Protocol with Non-VITA Scale	The dentin resins used were microhybrid. The enamel resins used were nanohybrid, resulting in a big polishability for the exterior layer.
Ismail *et al*, 2021 [43]	Color interaction between resin composite layers: An overview	The surrounding oral tissue and the position of each tooth influence the aesthetic of the teeth and their restorations. There is no quick and straightforward way to obtain a precise color match between restorations and natural teeth.
Korkut *et al*, 2016 [45]	Direct Midline Diastema Closure with Composite Layering Technique: A One-Year Follow-Up	Direct composite resin restorations do not have the color stability of glazed ceramics. Perfect finishing and polishing techniques and periodic recalls are the greatest solutions to this problem.
Lee *et al*, 2015 [58]	Translucency of human teeth and dental restorative materials and its clinical relevance	The color blending effect of dental materials refers to the relationship between these materials and the hard dental tissues. When the teeth are isolated, the color difference is more prominent than when viewed together, increasing esthetics. With a bigger translucency, the blending effect becomes more vigorous.
Lee *et al*, 2016 [10]	Opalescence of human teeth and dental esthetic restorative materials	Enamel is opalescent, making the teeth appear bluish when the light is reflected and orange/brown when transmitted. The thickness affects the opalescence of composites thicker than 1.0 mm: the translucency decreases, and the opalescence increases.
Magne *et al*, 1999 [4]	Rationalization of esthetic restorative dentistry based on biomimetics.	The new therapeutic techniques should seek to make a restoration consistent with the mechanical and biologic qualities of the underlying dental tissues rather than one made of strong materials.

Mathias *et al*, 2016 [61]	A Conservative Esthetic Approach Using Enamel Recontouring and Composite Resin Restorations	Enamel recontouring is a standard safe technique for realigning teeth, particularly in canines with rounded salience. Selective enamel recontouring is a minimally invasive therapy since only a small amount of enamel is removed, resulting in no exposure to the dentin and no postoperative sensitivity.
Milnar *et al*, 2004 [8]	Selecting Nanotechnology-Based Composites Using Colorimetric and Visual Analysis for the Restoration of Anterior Dentition: A Case Report	A nanotechnology-based direct restorative material shows promise in offering dentists a wide variety of composite shades. A colorimeter might give an objective assessment tool in determining optimal restorative shades.
Nahsan *et al*, 2012 [42]	Clinical strategies for esthetic excellence in anterior tooth restorations: understanding color and composite resin selection	The dentin increment must be gently feathered between the palatal enamel and the vestibular enamel layers to "blend" the restoration into the tooth and hide the limit or fracture line.
Paolone *et al*, 2021 [55]	Direct Esthetic Composite Restorations in Anterior Teeth: Managing Symmetry Strategies	Using an anatomic caliper and tracing an average convex shape typical of anterior teeth can overcome the limitation of the 2 appointments with a sagittal silicone index. This procedure complements it since it provides predictable symmetric restorations in an only appointment, reducing chair-time and laboratory expenses.
Paolone *et al*, 2021 [56]	The “Pre-Finishing” Approach in Direct Anterior Restorations. A Case Series	An excessively thick incisal opaque border can compromise the incisal halo effect. In terms of shade and translucency, more predictable results can be obtained with the accurate execution of the frame and its subsequent adjustment.
Paschoal *et al*, 2014 [51]	Esthetic and Function Improvement by Direct Composite Resins and Biomimetic Concept	The biomimetic layering approach can preserve a significant amount of healthy tissue while creating a harmonious esthetic smile.
Pontons-Melo *et al*, 2019 [54]	Cosmetic recontouring for achieving anterior esthetics	Patients should be informed that the material's color and texture vary over time, and periodic maintenance is required for restorations. Although occlusal splints may reduce teeth grinding, muscle activity, and myofascial discomfort, they should not be considered a long-term therapy.

Romero *et al*, 2015 [59]	Esthetic anterior composite resin restorations using a single shade: Step-by-step technique	Photographs can help with a preoperative esthetic analysis to determine the restorative approach adopted. The mesial and distal line angles can be duplicated in the first and second layers. A flat third layer of the composite should be applied between the line angles.
Romero *et al*, 2016 [60]	Restorative Technique Selection in Class IV Direct Composite Restorations: A Simplified Method	A medium 8888 diamond bur can be used to replicate the secondary anatomy in the incisal third. It has been shown that etch-and-rinse adhesive systems may be utilized safely without sacrificing bond strength.
Romero *et al*, 2017 [50]	Restoration of a large class IV fracture using direct composite resin: A clinical report	Even though there are numerous treatment options for fractured anterior teeth, the restoration's invasiveness, cost, and duration are all aspects to consider. A disadvantage is the technique's sensitivity and the artistic abilities required to get high-quality outcomes.
Rosales *et al*, 2015 [44]	Conservative Approach for the Esthetic Management of Multiple Interdental Spaces: A Systematic Approach	Fluorescence is necessary for the restoration to have "vitality". When seen under UV illumination, a non-fluorescent substance appears grey and as a "black hole”. Buccolingual layering provides a reversible therapeutic approach and an accurate transfer of anatomic forms.
Sugii *et al*, 2019 [57]	Utilizing the optical properties of composite resins to improve esthetics: a layering technique for anterior restorations	Comparing the material to the cervical third of the crown, where color and saturation are more distinct, should be the first step in choosing a composite resin shade. The enamel color is chosen on the middle third of the tooth, which has thicker enamel than the cervical third. Enamel prevails at the incisal border; this is the portion of the tooth most translucence and opalescence.
Volpato *et al*, 2018 [48]	Fluorescence of natural teeth and restorative materials, methods for analysis and quantification: A literature review	Fluorescence is an important optical feature for aesthetic rehabilitation because its presence and intensity in restorative materials allow a more realistic aesthetic outcome. Fluorescence is achieved in dental resins by incorporating materials with rare-earth luminescence centers.

Yu *et al*, 2015 [47]	Effects of bleaching agents on dental restorative materials: A review of the literature and recommendation to dental practitioners and researchers	Due to the residual emission of Perhydroxyl free radicals, it is recommended to wait at least 2 weeks following tooth bleaching before doing any adhesive technique.
Zafar *et al*, 2020 [6]	Biomimetic Aspects of Restorative Dentistry Biomaterials	The anatomical properties of structural elements in teeth, such as enamel and dentin, must be understood to use biomimetic techniques. Modern resin dental composites have a minimal toxicity level, decreasing even more after application.

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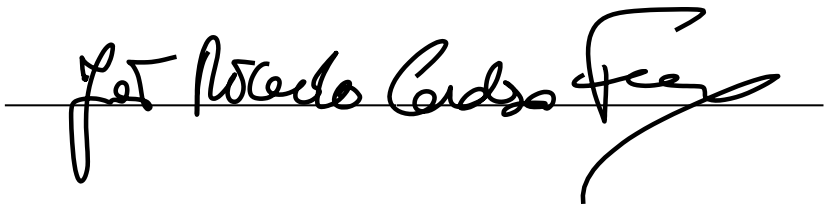

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Leonor Ferreira

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Palavras-chave: Biomimetics; Dental Esthetic; Biomimetic Restorations; Anterior Restorations; Layering Technique; Direct Restorations; Free-hand Restorations e Composite Resins.

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