Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

DIRECT COMPOSITE RESIN COLOR CHANGE IN ANTERIOR TEETH

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ABSTRACT

Introduction: Color defects in anterior teeth can be a constraint for most of the patients, the origin can be different and multiple, but the impact is mainly related to the aesthetic aspect of the patient which can impede the psychological and social life of the patient, leading in many cases to a decrease in self-confidence.
Direct composite resin is a widely spread technique currently use, in order to fix some small or important defects affecting the original tooth color. Direct composite resin is commonly used for anterior teeth because it is a minimally invasive and effective way to improve the appearance of the teeth. **Objectives**: The purpose of this literature review was to study how can direct composite influence the original color of anterior teeth.
Materials and methods: Several investigations were carried out by analyzing over 30 articles sourced from Medline the CRAI library and PubMed. **Results:** The most important thing to mimic the original tooth color in anterior teeth with direct composite resin is proper color management, which involves selecting the proper materials, the appropriate shade and using a layering technique to apply the resin.
Conclusion: Direct composite resin is a popular material in dentistry that can mimic the natural color of the teeth. The material is available in various shades and can be customized to match the specific color of the patient's natural teeth. Dentists can use a layering technique to apply the composite resin in a way that blends seamlessly with the surrounding teeth. This creates a natural-looking appearance that enhances the patient's smile. With proper color management and attention to detail, direct composite resin can provide excellent results that mimic the original tooth color.

KEYWORDS: Dentistry; color change; anterior teeth; direct composite resin; natural tooth color.

RESUMEN

Introducción: Los defectos de color en los dientes anteriores pueden ser un impedimento para los pacientes, el origen puede ser diferente y múltiple, pero el impacto está principalmente relacionado con el aspecto estético del paciente, lo que puede dificultar la vida psicológica y social del paciente. La resina compuesta directa es una técnica ampliamente utilizada actualmente para corregir algunos defectos pequeños o importantes que afectan el color original del diente. La resina compuesta directa se utiliza comúnmente en los dientes anteriores porque es una forma mínimamente invasiva y efectiva de mejorar la apariencia de los dientes. **Objetivos:** El propósito de esta revisión de literatura fue estudiar cómo la resina compuesta directa puede influir el color original de los dientes anteriores. **Materiales y métodos:** Se llevaron a cabo varias investigaciones analizando 30 artículos obtenidos de Medline, la biblioteca CRAI y PubMed. **Resultados:** La cosa más importante para imitar el color original del diente en los dientes anteriores con resina compuesta directa es una adecuada gestión del color, que implica seleccionar la sombra adecuada y utilizar una técnica de capas para aplicar la resina. **Conclusión**: La resina compuesta directa es un material popular que puede imitar el color natural de los dientes. El material está disponible en varias tonalidades y se puede personalizar para que coincida con el color específico de los dientes naturales. Los dentistas pueden usar una técnica de capas para aplicar la resina compuesta de manera que se mezcla perfectamente con los dientes circundantes, lo que crea una apariencia natural que mejora la sonrisa del paciente. Con una adecuada gestión del color y atención al detalle, la resina compuesta directa puede proporcionar excelentes resultados que imitan el color original del diente.

PALABRAS CLAVE: Odontología; cambio de color; dientes anteriores; resina compuesta directa; color natural del diente.

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1. INTRODUCTION

Nowadays, aesthetic becomes one of the most important criteria in some patients who are seeking being at the height of this new aesthetic word (1).

The era of 1900 (1960), marked the beginning of anterior teeth restoration using composite resin in dentistry (2). The first resin composite was released by Bowen on 1962, this material is used to fill or restore teeth when prepared after caries and composed of three different parts, the organic matrix, the inorganic filler part which will reinforce the mechanical property of the composite resin, and the silane being the link between the first two parts (3). Modifications to improve this material have been made all along those years until now. At this time, new composite resins still continue to be improved, in order to provide longevity and quality of restorations, and try making this technique the most effective way to achieve the best outcome possible in order to reproduce the natural tooth color.(2)

Direct composite resin is one of the main and most used technique in dentistry in terms of restoration in order to repair some tooth malformations due to traumas, fluorosis or hypo-mineralization (MIH) (4). In terms of aesthetics, direct composite resin can have the capacity to achieve a natural result of the original tooth color without being too invasive with the natural dentition of the patient (5). On the other hand, more difficult cases can be treated with more abrasive techniques (6).

Direct composite resin (DCR) can be used in case of defects, or some alterations that need to be improved, such as color, shape (such as diastemas), position (inclination or rotation of the tooth) and functions (mastication or grinding) (3). As health professionals, it is more than necessary to be updated about new materials, their use, and the tooth structure as a whole in order to give the patient an adapted and individualized treatment (7).

Some factors must be considered to know which technique will be the most appropriate one to restore a tooth, such as the quantity of tooth remaining, and the possible capacity of retention. Some situations can’t be treated, such as a lack of structure or bad oral hygiene followed by an incorrect diet will counteract the treatment. Direct restorations (DR) are the most common restorative procedures because natural teeth have a high

adhesion capacity to biomaterials (3). The choice of choosing direct restoration is also due to the good adhesion that the tooth structure can have to the materials creating a good retention and strengthening at the same time the tooth (3). DR are at the chairside made in clinic and usually require less amount of time to attain the desired result. However, indirect restorations (IR) are usually recommended in case of severe stains or color changes of teeth, and when direct restoration will not be enough to solve the problem. Furthermore, in case of parafunctional habits, the indirect technique will allow a higher mechanical strength, with less wear of the antagonist teeth (8). The direct technique is known as the standard one for reproducing natural tooth color and a way for the dentist to work easier without intervention of the laboratory minimizing the stress, without the need of taking any analogical nor digital impression or doing any cementation of the indirect restoration with the possibility to see instant results at the chairside (6). Nevertheless, when the patient will make the decision some characteristics have to be taken into account such as cost, treatment length, longevity and teeth color (9).

A review about direct composite resin color change in anterior teeth is useful because anterior teeth are the teeth in the front of the mouth, and they play a significant role in our appearance and self-confidence. Direct composite resin is a popular material employed in cosmetic dentistry to improve the appearance of anterior teeth, and understanding how this material changes color over time is important for both dentists and patients. This review can help dentists make informed treatment decisions, improves patient satisfaction by improving treatment outcomes, advances material technology, and drive further research and development in this area.

1.1 Properties of natural teeth

1.1.1 Optical properties of natural teeth

Micro-aesthetic of the tooth and factors such as light, anatomy and hydration of the tooth, in relation with the dentin and enamel properties are responsible for the natural tooth color (3).

A natural tooth is an entire structure with its own color, shades and properties that are difficult to reproduce it. The main features of the optical properties include the shape, and the surface texture of the tooth. Education in terms of knowledge regarding the different properties of a tooth color are required (6). The micro-aesthetic of the tooth such as the shape and the dimensions, the texture of the tooth and the color, are important details that we need to consider. The shape of the tooth can be different and can give a different aspect of the tooth perception, it can be square, oval, or even triangular. Line angles are also part of the micro esthetic of the tooth, and according to their relation between them, they give a more flat or round surface. If we separate them, the surface of our tooth will look flat and smooth, giving an aspect of a wider tooth surface, because it reflects lighter. While, in the opposite way having irregular and round surface will reflect less the light and will give a narrower aspect to the tooth.

The texture is a significant tooth factor that is age related and which is directly linked to the light and how will be perceived the outcome of the tooth aspect. Young people will have more surface texture, which will reflect lighter and will appear brighter than old one. Two different elements exist and must be considered in term of surface texture.

- The horizontal (developmental lines, Striae of Retzius called perikymatas that decrease towards incisal) and vertical grooves or ridges (defined by the developmental lobes), and line angles.
- Small irregularities present at the surface that are related to change of enamel during the tooth formation such as the Retzius incremental lines (10).

Less luminosity will be present in the case of having a smooth surface, because of a specular reflection (11).

1.1.2 Color perception of natural teeth

Regarding the color, it is a subjective phenomenon. The way we can perceive this color is due to different factors such as the type of light received, the amount of light absorption or reflection by the tooth and the capacity of the eye to see properly those changes (12). The light photoreceptor cells of the human eyes can detect light between the wavelength range of 390 to 770nm. Each color has her own wavelength. When only one wavelength is emitted, it is characterized as monochromatic. When an object is

crossed by light, two phenomena are observable, the absorption and the reflection. The color perception is mainly due to the reflected light. On the other hand, the light absorbed by an object will give a darker color (3). The final tooth color is the relation between the underlying dentin and the scattered and reflected light by the enamel (13). Dentin is responsible to affect more the tooth color than the enamel being more chromatic. The other way around, the translucency is given by the enamel layer, which alters the dentin apparency and therefore the final aesthetic outcome (14). The superposition of both the enamel and dentin gives a polychromatic aspect of the natural tooth. The thickness of those both layers is directly related to the translucency (3).

But how to evaluate the exact color of the tooth in an efficient and objective language? Three parameters are necessary to evaluate the color, from them we have the tone, the value and the chroma, from the most relative and important to the less.

- The value or the brightness: it is the amount of light returned from an object, it determines the amount of black and white that we have in an object, according to different shades of grey. In order words, it is an interpretation of luminance that is subjective. The more value, the whiter will appear the tooth color. The value defines the tooth vitality and is directly related to the opacity and the translucency of the tooth. There is different brightness in a tooth, the incisal part has the lower value, followed by the cervical part, and the middle 1/3 which has the highest one.

  The value of a tooth is also related to the texture of the tooth.

  The brightness can be increased reducing the chroma or raising the reflectivity of the surface (15).
- The chroma or saturation: it is characterized by the color saturation degree; it is the intensity of a color. When the enamel is thinner the chroma is more visible (15). The chroma of the dentin is decreasing from the cervical part to the incisal one (3).
- The hue : is the property that is determining the color perception, it is defined as different families of true color in terms of green, blue, red and yellow present in the color (15).

1.1.3 Characterization of the tooth color

The tooth is separated in three mains part on its buccal side: the incisal, the middle part and the cervical part. Every third of the tooth structure plays an important role for the tooth contour (11). The opaque property of the cervical part of the tooth is due to the dentin and its thicker thickness in comparison with the enamel layer which is thinner. The middle third of the tooth appear less brightened due to the equal thickness of both the enamel and the dentin. And at the incisal level, the enamel layer is well above the dentin one, which creates the aspect of translucency (3).The brightness of a tooth is mainly due to the light reflection that is present at the most superficial aspect of the tooth : the enamel (11).

Tooth properties may change throughout time, there is a reduction of the pulp volume and an increase of the dentin due to the secondary dentin deposition, resulting in a darker aspect of the tooth induced by the chromatic saturation level that increase, and a decrease of the opacity levels. On the other side, the mineralization due to the absorption of ions coming from foods or even saliva, makes the enamel thinner and smoother with less surface texture. Thus, enamel become more translucent (16). The characterization of the tooth color can be made using three different parameters.

- Translucency: the capacity of a material to transmit light is connected to translucency and opacity. It is the capacity of an object to let pass light through it. It is mainly related to the enamel. The more translucency, the more dentin will be visible, so the lower will be the value (12). The incisal part of the tooth is translucent. In older people, the wear of enamel will increase the translucency, which will reflect less luminosity.
- Opacity: the opalescence gives the tooth a bluish color aspect in reflected color and an orange color for the color transmitted, mainly present at the incisal level. It is the main parameter that gives the tooth the vital aspect (17).
- Fluorescence: Is defined as the capacity to absorb short wavelengths and emit light energy within the spectrum visible. The light emitted is a white bluish light, that makes the tooth look brighter (3). Enamel and dentin are both able to have this property but due to its organic content, the dentin is more fluorescent (12).

The enamel is mainly characterized by the translucency and opalescence, whereas the dentin more opaque will express the inner structure of the tooth (18).

1.2 Color determination of the natural tooth

There is two different way to distinct tooth color, the objective way through the use of instruments and the subjective one by means of our eyes (13). Conventional methods can help us to differentiate colors such as a guide using shades, but it is often a subjective way to determine colors as the light conditions can be inadequate (19). Dental shade guides are used comparing dental materials or dental structures with shades already present in the guide. Most famous guides are Ivoclar vivadent, Dentsply Esthet-X, Blue line, but commonly the shade guide used for 60 years from now one is the Vita classical where are including 16 different shades samples and 3 shades bleached. Another guide from the same Vita family commonly used is Vita System 3D Master which is composed of 26 shades and 3 bleached shades, this guide is more used in term of tooth bleaching treatments. The main inconvenient is that those shade guides are only representing the central part of the tooth, which requires a certain attention from the dentist (12). As it is not possible for the human eye to see less than 1,5 for the color change values, the use of spectrophotometer and colorimeters is recommended. It has been recognized as a good and evolved technology tool, as also the camera (20). Through the contact means and using the light that a sample reflect both colorimeters and spectrophotometers can calculate the color surface (13). The spectrophotometer help to decrease the risk of errors, and in order to quantify the colors a system called CIELAB is used, using a certain formula (21) . CIELAB use three different parameters (explained in the following figure, figure 2),in order to measure the tooth color (13).

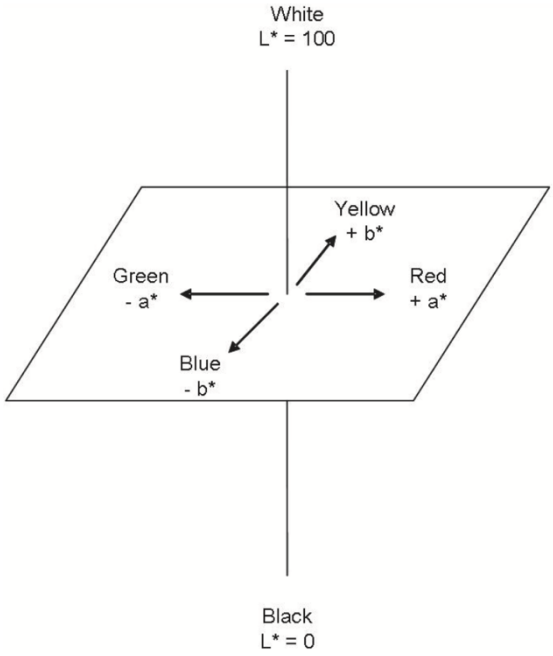


Figure 2 CIELAB three different parameters are the lightness transcribed as a L*, the position on a red-green scale a*, and the position on a yellow-blue scale inscribed b* (13).

1.3 Color change of natural tooth

From the childhood and throughout the whole life, a lot of changes can happen regarding the tooth color general aspect. Tooth discoloration is a common concern for many patients seeking dental treatment. The color of our dental structures has a crucial function in our general outlook and self-assurance, and changes in tooth color can be caused by a variety of factors. In fact, the volume of the pulp in young patients is way more important than in the adult one. The thick layers of enamel are covering the dentin which leads to a thicker and whiter tooth aspect. The enamel of an adult become more translucent with the time with a bluish-orange aspect. At the same time, as a result of a pulp volume reduction, the dentin gets thicker dentin and therefore less opaque (16).

Teeth can be stained due to extrinsic or intrinsic stains. Extrinsic discoloration, or discoloration that occurs on the outer layer of tooth enamel, is often caused by consuming certain foods and drinks, tobacco use, and poor oral hygiene. These factors can cause the outer layer of tooth enamel to become stained or discolored over time.

Extrinsic stains can usually be removed with professional teeth cleaning or teeth whitening treatments. They can be easily removed doing a prophylaxis and applying an abrasive paste. There are several treatment options available for patients who are concerned about the color of their teeth. The specialized treatment recommended will be based on the underlying cause of the discoloration and the patient's individual needs and preferences.

For extrinsic discoloration, professional teeth cleaning is often the first step in treatment. This can involve removing surface stains with a polishing paste or performing a deeper cleaning to remove plaque and tartar buildup. Whitening treatments can be effective in removing stains caused by food and drink, tobacco use, and poor oral hygiene.

Conversely, intrinsic discoloration, or discoloration that occurs within the tooth, is often caused by aging, genetics, trauma, or medications. Intrinsic discoloration can be more difficult to treat than extrinsic discoloration, as it involves addressing the underlying cause of the discoloration. For example, if a patient's teeth have become discolored due to taking tetracycline antibiotics during childhood, their dentist may recommend cosmetic treatments. Intrinsic stains can be present on a single or multiple teeth and are more difficult to remove, they can be due to dentin age which is related to pulp calcification (22). Intrinsic stains can be congenital (such as amelogenesis imperfecta, dentinogenesis imperfecta, tetracyclines stains, fluorosis) or can come after eruption such as a trauma (13). For adults, fractures are the most common cause of trauma in the anterior part and the main reason is usually due to some extremes sport and physical contacts that they can have with anterior teeth (23). In those cases, internal bleaching can be tried but some more aggressive treatments will be needed in order to remove staining (3).

Teeth can also be stained due to the current intake of medicines such as chlorhexidine, for some cases patient’s medication can’t be interrupt, this must be taking into consideration during the diagnosis, in order to find the best treatment plan. If the defect is simple and localized, external bleaching can be made before doing the restoration, in order to achieve a similar result with the adjacent teeth (3).

Moreover, resin composite restorations are frequently susceptible to pigments from food and beverages in the common diet, leading to staining. Incomplete polymerization

is among the factors that can influence the extent of composite staining, as indicated by earlier research (24).

It is important to understand that not all the teeth are restorable. In the case of being constantly exposed to a high risk of injuries, the solution will have to be reviewed (6).

The society requires a certain perfection in terms of aesthetic that everyone tries to achieve. As we said before aesthetic has taken a huge place in this new generation and therefore in some patient's life, having some defects of the anterior teeth can be an obstacle to their social life, and affect the psychological side. Indeed, this difference can lower the self-esteem, making individuals withdraw in a selfish way into themselves(4).

1.4 Indications and contraindications of direct composite resin

The decision of using the DCR may be complex and consider more than one factor, this option of treatment can be used to improve the general aspect of the tooth color after a trauma or an alteration, but it has some limitations in order to have a restoration that last throughout the time. Regarding the indications, it is more than recommended to do those restorations on patients motivated and who comes often to the clinic are more susceptible of having a good outcome after the minimally invasive way of treatment. On the other hand, patients with some inabilities to attempt long chair side treatments will be favored to this type of treatment. It would be advisable patients with low-risk caries to have to preserve a maximum the restorations.

Added to that, DCR are indicated in terms of color, shape or form change. They can also be operated in case of diastema closure or small defects (conoid tooth, tooth with a lot of dentin that modify the whole tooth color) and in order to enhance esthetic restorations (in the case of previous bleaching without the success of the tooth color expected) (25). Obviously, a good oral hygiene must be present for the patient to receive this type of treatment, if not the matrix of the composite can be more easily stained and damaged due to the presence of bacteria. Patient needs to know about the possible risk of fracture in case of parafunctional habits, for instance bruxism or clenching. The material can experience fatigue over the time and depending on the load, which can lead to fractures (3).

1.5 Advantages and disadvantages of the direct composite resin

The principal advantage of the composite resin is its capacity to adhere the tooth surface in order to have more retention and to strengthen the existent tooth structure. Moreover, the use of DCR allow the dentist to perform a minimally invasive restoration, and one session is enough. Among the disadvantages, the correct adhesion of the resin composite to the tooth require a proper isolation to avoid the preparation's contamination (3). The matrix of the composite can be more susceptible to be stained due to the organic matrix that absorbs the moisture, which means that they may have to be changed in the future. DCR will allow preserve antagonist tooth from excessive wear (24).

It is apparent that there are certain drawbacks associated with composites, such as their reduced ability to retain gloss over time and their heightened susceptibility to staining (26). Color stability is an important factor when considering direct composite resin for anterior teeth. The color change can be influenced by several factors such as water absorption, light exposure, and oral environment. The type of composite resin used, the curing process, and the bonding agent also play a role in determining the level of color stability (3).

1.6 Diagnosis and treatment plan

1.6.1 Diagnosis.

The correct diagnosis of the problem and the understanding of the patient expectations are essential to carry out a good treatment.

Diagnosis is defined as the study of any change such as loss of function, signs, symptoms of the patient but also regarding aesthetic problems. It will help us to define

a correct and individual treatment plan of the patient considering his demands at first sight. For this aim, a correct anamnesis and exploration must be made beforehand. Following this, an analysis of the patient's general aspect, medical situation with allergies and medications is important, being also careful to account of the patient's chief complaint. Some photography and extra tools can be useful for the analysis of the case, such as radiographies and impression with their plaster models (3). Occlusion and radiographies are also necessary to better target its treatment (18). The age, the gender, the stress related to the occlusion are factors that we need to take into account, as the susceptibility of having anterior teeth caries, which can be a cause of DCR failure (8). In order to provide the patient, the best aesthetic outcome occlusion of the patient and also properties such as tooth size, shape, and position are important (6).

1.6.2 Treatment plan

Dentists must weigh the risks and factors to ensure accurate treatment planning for each patient. The plan should be tailored to the individual's needs, considering factors such as cost, aesthetic desires, access to healthcare, and prioritizing patient safety. Dentists should have adequate knowledge and be transparent with patients, presenting clear and concise treatment options. The patient may require prior treatments and informed consent must be obtained before any procedure. The informed consent should be kept for at least 3 years after treatment. (3).

1.7 Direct composite resin restoration

1.7.1 Composition of composite resin

Composite resin is a material made of different part. Among them three main components.

- The organic part which is the resin matrix mainly made of monomers such as Bis-GMA (bisphenol – Aglycidyldimethacrylate), which is mixed with short chain monomers such as TEGMA due to its high viscosity. The bigger is the concentration of TEGMA and the lower of Bis-GMA, the rate of polymerization shrinkage is higher. The higher is the molecular weight, the higher will be the viscosity and the harder will be to incorporate inorganic filler. But the lower will be the molecular weight, the higher the risk will be to experience shrinkage during the polymerization.
- The inorganic part is the filler. It is responsible of the composite resin final characteristics such as mechanical properties (strength, resistance of wear), the roughness of the surface, the optical properties and the shrinkage. A high percentage of filler will allow better mechanical properties of the resin composite and will decrease the polymerization shrinkage. The shape of the filler will define the filler composition. Small particles in a high filler content will enhance the surface roughness and the polishing of the restoration.
- Agents of coupling to improve the adherence between the filler and the organic part.
- Systems that initiate the polymerization such heat inducer (benzoyl peroxide), photochemical (Camphoroquinone and amine tertiary) and chemical (benzoyl peroxide and amine aromatic).
- Additives such as optical modifiers, fillers radiopaque, dyes. Tints can be used for the final aesthetic of the tooth, they are composed of colorants, and they will help us to reproduce some chromatic or morphological characteristics of our patient such as white spots, lines and cracks. Their use must be controlled (12).

1.7.2 Optical properties of the composite resin.

Composites are present in different forms in order for them to reproduce the natural tooth color (3).

Three properties can be distinguished:

1. Translucency
    - Incisal part will require a very clear or almost transparent composite.
    - The enamel will require a translucent composite.
    - The body of the dentin will require a composite with medium opacity.
    - The dentin will require an opaque composite.
    - And opaquers will be required in order to hide some defects.

2. The optical effect, which is define by how we see the tooth by working on the fluorescence or the opalescence.
3. Use of the stratification technique with the main purpose of reproducing a natural tooth.

Several compositions of composite resin are available in order to achieve the result attempted. Some properties such as the handling, the shrinkage or the way of curing can be adjusted. And each of those properties, carry a certain function to the composite used (6).

Classification of composite resin is done based on the amount of inorganic filler. Three categories are noticeable the conventional, the hybrids (which is an association of microfill particles and glass ground) and microfilled one (27).

- Macrofilled composite are rarely used in dentistry due to their big filler particles, they have a bad polishing capacity (6).
- In order to achieve an esthetic result, microfilled composite are known to be the most appropriate ones, they allow a better polishing than macrofilled one, which lead to a better anterior esthetic result. However, they prevent the insertion of a high number of filler, which impede on the fracture resistance by making them weaker (2). Microfilled composites are highly used for anterior restoration, as they can mimic the enamel and offer the appearance of vitality to the tooth (28).
- Nanohybrid composite resin is the association of microfilled and macrofilled composites generate a new form of composite resin with an improved resistance, higher durability and superior esthetic (2). They provide resistance, simple handling and good aesthetic (opaque

properties). They are qualified as universal composite resin for posterior as anterior restorations, but can be harmful over the time for the gingival tissues (6).

The small particles present in the hybrid composite are good for esthetic restorations, but the polishing doesn't last enough over the time due to their irregular shape and their distribution. Their also have less color stability and less resistance of fractures. In order to correct this, microparticles composite resin have been created. They have a better texture, which increase the resistance (25).

The selection of the composite resin must fulfill some conditions, such as the strength, the fracture resistance, the longevity, the shrinkage polymerization, the capacity of absorbing the water that are part of practical characteristics. And the comfort and the safety of the patient without any signs of pain or sensibility for the biological ones. Evidently aesthetic characteristics such as color and stability over the time must be considered (27).

To know which one will be the best composite to fit our needs, it is important to focus ourselves on the location of the cavity and the rest of teeth color, to be able to add some additives tints or other materials to hide defects (19).

1.7.3 Technique of stratification.

Different techniques can be used, but in order to achieve an aesthetic aspect of the restoration, the stratified one is the best one (25).

Different techniques exist for the direct restoration to be done, such as the bulk technique, the incremental techniques or the esthetic one, named stratification technique (29).

After the election of the color using a shade guide matching system, the record and the analysis of the occlusion, the restoration will be done using the "esthetic composite resin" technique which is the stratified one. The stress that suffers the restoration during the polymerization is one of the main causes of failure. The insertion of different layers at different levels and with a certain thickness will enhance the final resistance. The stratification technique is a technique that use different layers with a proper

physiomechanical properties, thickness and optical properties in order to recreate the aesthetic tooth. Different composites are used in a precise order, among them:

- Dentin composite (nanohybrids) that will provide fluorescence of the restoration, in the upper two third of the tooth.
- Enamel composites (microfilled), that will provide the translucency of the restoration. Composite enamel should not exceed half of the thickness of the initial tooth enamel structure (5).
- Composite effects such as high translucent composite for the incisal part to increase the brightness of the tooth, the opalescent one at the level of the incisal third and between the mamelons areas.
- Opaquer to hide defects applied with a thin brush and in thin layers.
- Tints

The stratification technique gives the tooth a natural tooth color and aspect. The following figure shows the application of the technique at the incisal level (Figure 3).

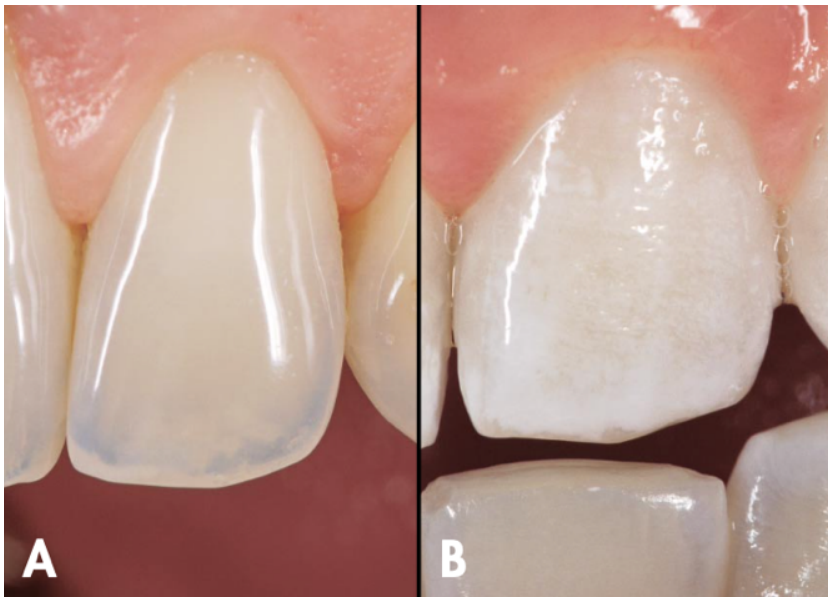


Figure 3 Example of natural tooth translucency and opacity (18).

- A Translucent layer with gray blue shades for the incisal and proximal parts
- B Presence of opalescence at the incisal and proximal ends.

Layers should not exceed a thickness of more than 2mm (3). A proper technique can improve the durability of the treatment over the time, while struggling against the polymerization shrinkage (30). As the composite can offer a monochromatic, it is important for the dentist to play with the different additives with the aim to create the polychromatic natural tooth color (Figure 4) (18).

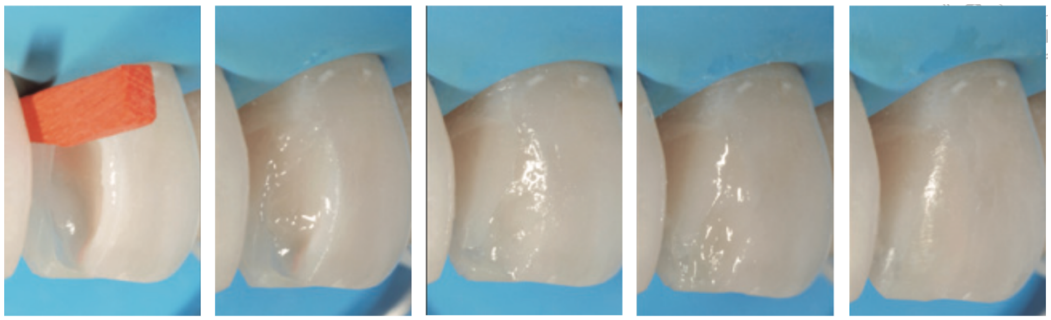


Figure 4 Direct composite restoration using the stratification technique (5).

1.8 Operative procedure

Before start with the treatment, the color shade has to be choose and a correct isolation is fundamental to avoid any forms of contamination from the saliva, the blood and to allow a correct procedure of adhesion between the sound tooth structure and the restoration (18).

The tooth needs to be prepared before any treatment, caries and old restorations has to be eliminated (5).

The type and depth of the tooth preparation depend on the outcome that we want to achieve. Three main types of preparation are achievable.

- The partial preparation is made for localized defect, a bevel is done around the area to enhance the aesthetic.
- The total preparation is whenever a huge color change, position or shape must be corrected. In this case, the incisal and palatal functions are maintaining and protected from occlusal stress.

- The total and incisal preparation, in the case of defect at the incisal level, or when the tooth needs to be enlarged.

Regarding the depth of the preparation, it can involve only the enamel, enamel and dentin, or nothing at all.

A bevel can be performed to avoid a visible demarcation between the tooth structure and the restoration, to avoid fracture at the level of the margin (1).

In order to reproduce the palatal layer of the original tooth, a silicon mold can be used. This mold can be procured using the previous old restoration or from a wax-up, in the case of diastema closure it is more than recommended to use it (Figure 5)

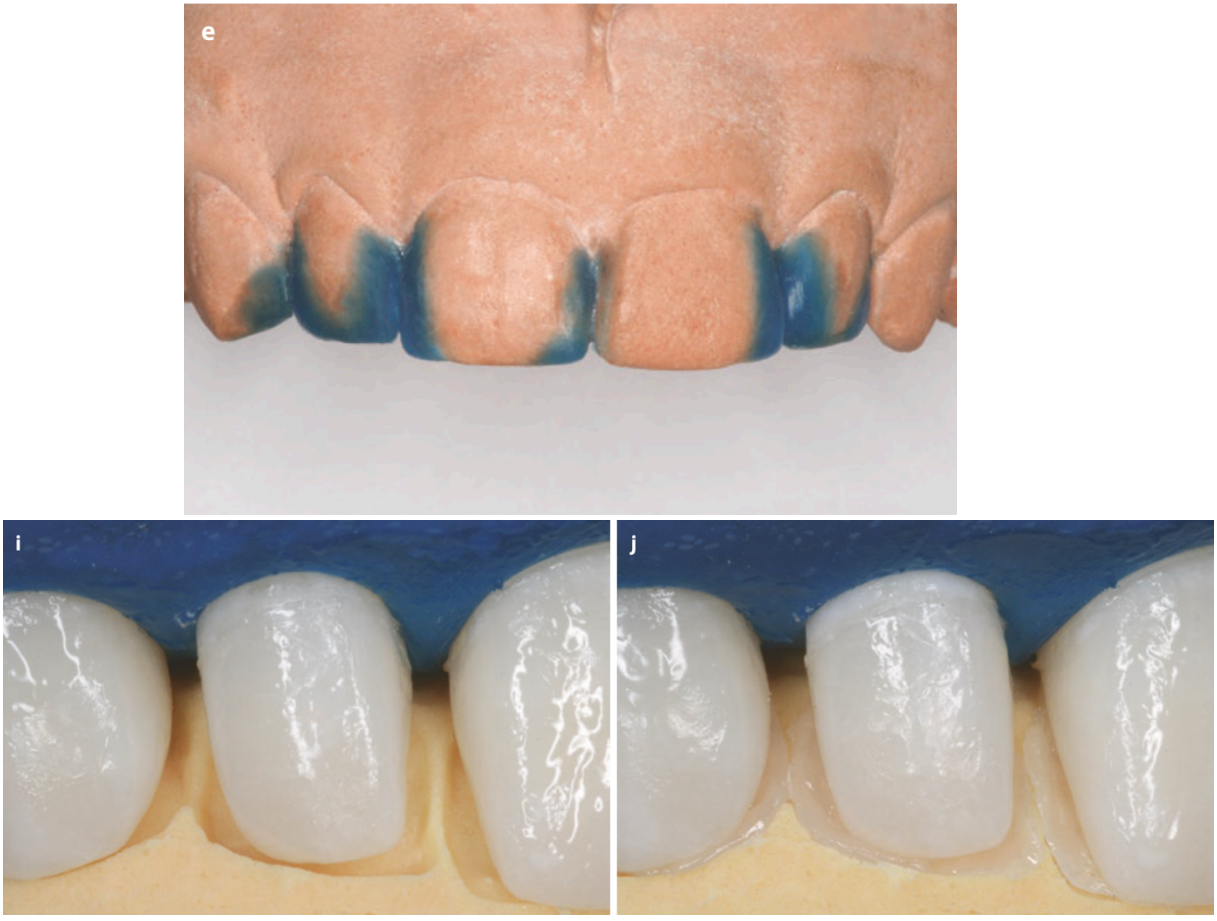


Figure 5 Wax up and silicon key in order to close a diastema of upper anterior teeth (5).

Some factors can impede the result, such as the polymerization technique and material used. The curing time must be respected for each composite, according to the directives of the manufacturer. With the intention of reducing the problem of

polymerization, a glycerin gel can be used and positioned on top of the restoration, it will remove the oxygen responsible of polymerization failure and will give a shiny aspect to the tooth after the last polymerization (3).

1.9 Post operative procedure

The restoration needs to be sustainable over the time, the last step of polishing and finishing is more than crucial. But before this, the occlusion must be controlled to prevent future tooth fractures, checking both centric and eccentric movements (3). This final step will also allow the tooth to have its final natural aspect (18). The micro and macro morphology must be replicated to imitate the original tooth color, considering that young teeth will have more marked details than adult ones that tend to have a surface with less roughness. Five steps need to be respected.

1: The contour perimeter needs to be defined by remove excess that can damage gums, for this we use fine grit diamond burs, polishing discs and strips.

2: Texture, with the application of the macroscopic morphology (angles lines and developmental lobes) using burs.

3: Continue with the fine grit polishing discs and low speed.

4: Definition of the microscopic morphology with inverted cone burs, with an inclination of 45 degrees at the buccal surface area.

5: Last polish with rounded and felt brushes and diamond paste

Microscopic as macroscopic morphology is important, and it can be replicate using diamond burs of fine grain (Figure 6).

Figure 6 Importance of the natural teeth external structure for the shine and the tooth color aspects (18).

Materials used for the final part of polishing needs to be used knowing for each of them their principal functions (Figure 7).

Instruments and materials*	Use in morphology	Use in texturing	Features	Speed (RPM)	Manufacturer
Flat-end taper 848 diamond bur (L 10.0) 	Labial interproximal contouring	NA	Diamond bur, 110 to 120 µm	30,000 max	Edenta
Fine-grit 120 ceramic bur (L 6.0) 	Creation of labial longitudinal and/or vertical grooves	Smoothing of the surface lobes	Ceramic abrasive in green silicon carbide	20,000 to 30,000	Edenta
CeraPro 040 ceramic/ diamond bur (L 11) 	Rounding off of transition ridges	NA	Ceramic abrasive grinder with CeraTex diamond bonding	15,000	Edenta
Round diamond bur (Ø 2.3) 	Shaping of incisal border and concave areas	NA	Diamond bur, green ring, 135 µm	30,000 max	Edenta
Exa Cerapol silicon/ diamond disk (L 3.0, Ø 17) 	Smoothing of incisal borders	Final polishing, elimination of scratches, and smoothing of surfaces	White abrasive disk for ceramics	20,000	Edenta
Separating disk (L 0.6, Ø 25) 	Create worn areas at the incisal borders	NA	Synthetic resin bond with medium grit	10,000 to 12,000	Edenta
Texturemarker gold powder 	General appraisal of morphology	Verification of surface status	Gold powder	NA	Benzer Dental
Meister Cone, small/ fine abrasive paper 	NA	Creation of specific surface texture, first polishing	Abrasive paper	10,000	Noritake Dental
Meister Cone, large/ medium abrasive paper 	NA	Polishing and border finishing	Abrasive paper	10,000	Noritake Dental
Four-sided TC850.4 ultrafine ceramic carbide finishing bur (L 2.5, Ø 2.5) 	Fix chips or small enamel defects	Enamel fissures	Ceramic carbide finishing bur	150,000 to 200,000	Edenta

*Length (L) and diameter (Ø) of the instruments' working areas are shown in millimeters.
RPM = revolutions per minute.

Figure 7 Final restoration step materials and their special use (11).

Polishing is also a way to smoothens the surface avoiding the entrance of bacteria, and protect all the surroundings such as the jaws, the tongue from rough restorations (5).

But obtaining the exact natural characteristics using composite resin involve good knowledge and a proper use of different techniques. Studies shows that dentists still need to update and improve their knowledge about the colors characteristics (12).
Composite resins continue to evolve, each time becoming a better version in attempting to solve some disadvantages. Even if, they allow the reproducibility of the natural tooth color aspect in an easier and non-time consuming technique, being minimally invasive, but they cannot last forever because of their lack of color stability (8). Recommendations are given to the patient, in order for the restoration to last over the time (3).

1.10 Recommendations post treatment

The patient needs to maintain a good oral hygiene over the years, using dental floss at least once a day at night and mouthwashes, regular checkup must be done every six months. As health professionals we need to educate our patients about the eventual risks. In the case of DCR, the intake of stained beverages such as coffee, tea many times during the day can stain the tooth over the time. The diet is also important, to keep the outcome attempted. Occlusal stress and parafunctional habits such as bruxism, can cause the failure of the treatment which will need to be redone another time(3). Occlusal splints can be suggested to the patient in case of excessive bruxism (8).

Stratification technique was created to solve dental problems and enhance natural tooth color in restorations. Proper steps and post-treatment recommendations must be followed to achieve and maintain the desired result. This review is made with the aim to analyze the efficacy of direct composite resin to restore anterior teeth in relation with color. In this study will be carry out also, the study about the different and multiple teeth color change. Interrogating ourselves about their properties and how they can mimic the original tooth color using different techniques, such as the stratification technique.

2. OBJECTIVES

a. Main objective

The main purpose of this literature review was to study how direct composite can mimic the original tooth color.

b. Secondary objectives

- To study different reasons of natural tooth color change
- To investigate that use of stratification as a technique to achieve the natural tooth aspect.

3. METHODOLOGY

Inclusions criteria were studies or review articles search on different data bases such as articles took from CRAI Dulce Chacon library of the University Europea of Madrid, books and websites such as PubMed, Medline.

All gender were accepted in this study, and over the age of 18 years, people with permanent and restorable teeth were included. Articles were selected in Spanish and English.

Inclusions criteria are presented in table 1.

Inclusion criteria

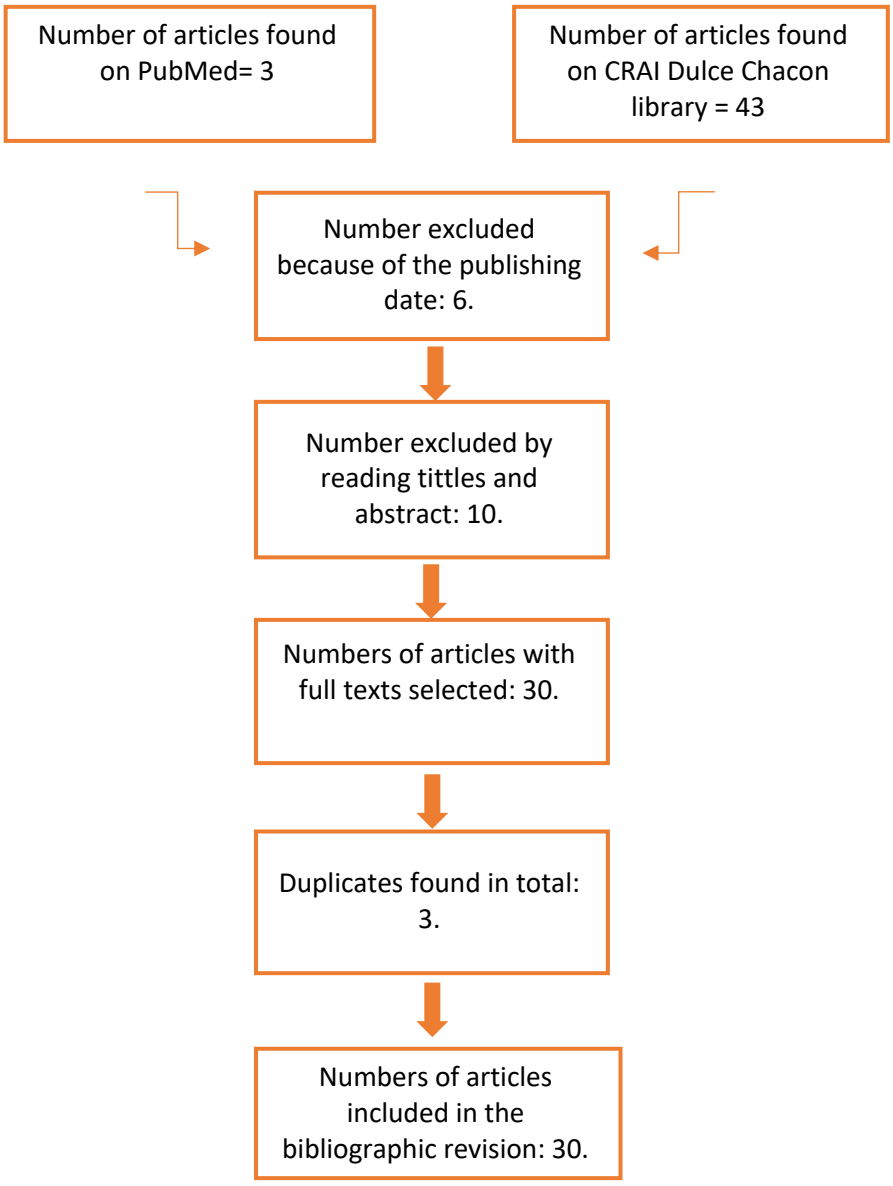
Langue	English and Spanish
Date of publication	2012-2022
Gender	All gender
Age	Over 18 years old
Types of bases	Books from CRAI Dulce Chacon library, Medline, PubMed
Species	Human

Patients of less than 18 years old, with non-restorable teeth and articles out of a range of 10 years from 2012 to 2023 were excluded of the review.

KEYWORDS: **"**Dentistry", "composite resin", "direct", "anterior teeth", "color change", "values", "tooth color", "dentin", "surface texture", "organic matrix".

4. RESULTS

Flow chart:



Results tables:

- Main objective:

Article	Author	Methodology	Results	Conclusion
Opalescence of human teeth and dental esthetic restorative materials (2016)	Yong-Keun LEE	A literature search found 29 articles about tooth opalescence and esthetic dental materials.	Results revealed that the masking effect can be impacted by translucency, and opalescence and affect it when translucency was similar. This confirms opalescence's role in the masking effect.	Direct resin composites have higher OP-RT values than unfilled resin. OP-RT values of composites and ceramics are inferior with enamel, so to mimic natural teeth, the composition of filler and matrix phase should be adjusted.
Should my composite restorations last forever? Why are they failing? (2017)	Flávio Fernando DEMARCO, Kauê COLLARES, Marcos Britto CORREA, Maximiliano Sergio CENCI,	Scientific study that investigates the impact of different surface treatments and the strength between	The findings indicated that the combination of acid etching and air abrasion resulted in the highest bond	The combination of acid etching and air abrasion is an effective surface treatment for enhancing the

	Rafael Ratto de MORAES,Niek Johannes OPDAM	composite resin and primary tooth dentin.	strength, followed by Er:YAG laser, air abrasion, and acid etching.	bond strength between composite resin and primary tooth dentin.
Modern operative dentistry (2013)	Carlos Rocha Gomes Torres	Book made through the collaboration of professors, and experts from the Institute of Science and Technology at Sao Paulo State University and dental schools.	The application of the layering technique is critical for standard composites. The finishing and polishing methods play a crucial role.	Proper techniques, including tooth preparation and layering, are crucial for success. The use of bulk-fill materials offers a quicker option. Finishing and polishing also impact the restoration's quality and longevity.
Color and appearance in dentistry (2020)	Alvaro Della Bona	This publication is a product of international collaboration and presents scientific findings with	A science quiz for Dentistry with instant feedback and a final answer review is made to assess any	Dental students demonstrate a significant improvement in their overall shade-

		evidence-based information and demonstrated through clinical procedures.	improvement in their ability to determine tooth color.	matching scores in the latter session.
Dental composite materials for direct restorations (2018)	Vesna Miletic	This publication explores both the scientific fundamentals and clinically relevant aspects of using dental composites for direct restorations.	Despite numerous studies on the shrinkage stress of bulk-fill composites, the findings remain conflicting and indecisive.	Bulk-fill composites have varying mechanical properties but are usually comparable to conventional composites. More testing is needed for general conclusions
Table 1. The main purpose of this literature review was to study how direct composite can mimic the original tooth color.				

- <u>Secondary objectives:</u>

Article	Author	Methodology	Results	Conclusion
Esthetic direct restoration in endodontically	Gaetano Paolone, Monaldo Saracinelli,	The study evaluates 4 different clinical cases with the use	When dealing with root-treated	Successful restorations require proper

treated anterior teeth (2013)	Walter Devoto, Angelo Putignano	of direct resin composite after a root canal treatment in anterior teeth.	teeth, direct restorations should be viewed as a viable and efficient option for restoration.	planning based on impressions and wax up and understanding material properties for a natural and predictable result.
Molar incisor hypomineralization: an aesthetic conservative restorative approach (2016)	Manoelito Ferreira SILVA-JUNIOR,Rahyza Inácio Freire de ASSIS, Flávia Bittencourt PAZINATTO	This study presents a case of conservative aesthetic restoration with molar incisor hypomineralization. The diagnosis had negative effects on her aesthetics and emotional well-being.	The proposed course of treatment prioritized a minimally invasive approach that aimed to preserve as much healthy tooth structure as possible.	Utilizing a conservative approach to aesthetic enhancement, a satisfactory solution was achieved through direct restoration using composite resin.

Table 2. To study different reasons of natural tooth color change.

Article	Author	Methodology	Results	Conclusion
Incremental techniques in direct composite restorations (2017)	Veeramachaneni Chandrasekhar, Laharika Rudrapati, Vijetha Badami, Muralidhar Tummala	In order to restore lost tooth structure in a manner that mimics the natural morphology, composites with varying levels of translucency are employed.	For most of the patients, the stratified layering technique that involves the use of enamel and dentin shade composites can yield exceptional outcomes.	An effective strategy for achieving an optimal shade and translucency match is to employ a stratified layering technique that mimics the original tooth structure, utilizing enamel and dentin shade composite layers.
Techniques in direct composite restorations (2019)	Karthik D Yadav, Shesha Prasad, Harika Chaganti, Mohammed Saleem and Anuradha Pai	The study has listed different methods of composite restoration to enhance comprehension and achieve a desirable treatment result.	The best techniques to overcome these issues are the three-site and oblique layering techniques.	Composite restorations are popular among dentists for their adaptability, variety of shades, and longevity.

				However, they can be technique-sensitive, prone to shrinkage, and require sufficient light curing.

Table 3. To investigate that use of stratification as a technique to achieve the natural tooth aspect.

5. DISCUSSION

Direct composite resin is a popular dental material used for restoring damaged or decayed teeth, as well as for improving the appearance of teeth. One of the advantages of composite resin is that it can match the original color of patient's natural teeth, providing an unnoticeable and authentic restoration appearance. The main objective of this literature review is to study how direct composite can mimic the original tooth color.

Regarding the authors Carlos Rocha Gomes Torres and Flavio Fernando Demarco the execution of a proper diagnosis and a good treatment plan helps in providing an optimal and seamless treatment. This results by performing a correct anamnesis, a good medical, dental history of the patient and considering the economic and esthetic aspect. It will also ensure the long-term success of a restoration project (3, 8). The author Flavio Fernando Demarco insists on the fact that an unbiased clinical assessment (indications of tooth wear) as well as a personal self-reported evaluation of parafunctional habits via a survey is necessary to avoid any restorations failures. It is crucial to emphasize that the viewpoint of patients must always be considered in the planning of treatment. In order to avoid any problems, informed consent must be provided to the patient before any restoration treatment. While it is essential to achieve a pleasing smile (mini aesthetics), it should be done in conjunction with a balanced facial appearance (macro aesthetics) to generate a positive sense of self-worth (hyper aesthetics) (8).

Carlos Rocha Gomez Torres demonstrate that to achieve optimal function and aesthetics, it is important that the restoration closely imitate the unique anatomical shape of the original tooth structure (3).

Both the authors Vesna Miletic and Flavio Fernando Demarco are agreeing to emphasize the fact that the election of the composite is fundamental for the final tooth color as there is some differences among them. Macrofilled present a poor dental appearance, with an increase of tooth damage and color degradation, due to the presence of a high composition of filler and the difficulty of polishing the restoration, leaving a rough tooth aspect. At this point, microfilled composites were created in order to solve those points such as roughness, and esthetic. The composition of filler was less important, leading to

less polishing issues and stains problems. (2, 8). Regarding the abrasion with the antagonist tooth, the author Carlos Rocha Gomez Torres accentuate the fact that microfilled composites exhibit wear comparable to enamel, whereas hybrid composites generate more wear contrasted to enamel (3).

All the authors mentioned previously affirmed that the isolation of the operative field is required in order to manage moisture and prevent any contamination. It is also significant the correct use of adequate instruments, materials and polymerization can mainly influence the final esthetic outcome and help to obtain and mimic the natural tooth color (3, 2, 8, 18, 28).

With regards to the author Yong-Keun LEE, a good analysis of the optical characteristics of natural teeth allows the operator to avoid complications, the different light phenomena are crucial to consider in aesthetic restorations. Assessing and documenting the optical characteristics of natural teeth and materials used for the restoration are important because their interplay forms the foundation for achieving a visual harmony between the restoration and the adjoining or tooth remnants (17).
For both, Carlos Rocha Gomez Torres and Yong-Keun LEE the dynamic nature of natural teeth color is influenced by various factors such as incident light, tooth structure topography, hydration levels, and individual optical properties of the enamel and dentin. It is not only necessary to understand the concept of the three-color dimensions but also how they react with translucency, opalescence, counter-opalescence, fluorescence, and surface enamel texture (3, 18).

The author Yong-Keun LEE demonstrate that opalescence is stated as a participant of the tooth vitality and the most important characteristics in order to reproduce and mimic the original tooth color (17), while Alvaro Della Bona is based on the fact that dental professionals should take into account that fluorescence release is a synonym of a fruitful aesthetic makeover. In order to help for the final outcome, tools can be useful such as visual shade guides (VITA classical), colorimeters and spectrophotometers (12).
In teeth, the enamel is more translucent compared to the almost opaque dentin. To restore teeth effectively, it is favorable to employ composites that have translucency levels like natural dental tissues and with a proper thickness because the final esthetic

outcome of a restoration is largely influenced by the thickness of the enamel and dentin shade layers.

The composite translucency is as important as its color, as it significantly impacts the outcome of the dental rehabilitation (3).

All authors considers that the final stages of a composite restoration, namely finishing and polishing, are critical to achieving optimal results. Finishing involves the removal of excess restorative material, improving contour, adjusting occlusion, and producing a smooth surface. Conversely, polishing entails the delicate removal of restorative material, in order to have a smooth and shiny surface, mimicking the texture of natural teeth and promoting patient well-being. Above all, medical professionals must possess extensive knowledge of the latest evidence pertaining to the advantages and drawbacks of the treatments being provided. Overall, direct composite resin color change is a common issue in anterior teeth restorations, but with the right strategies and techniques, it can be managed effectively to achieve optimal aesthetic outcomes for patients.

(3, 2, 8, 18, 28).

Secondary objectives:

Over time, the color of composite resin can change due to a variety of factors. The objective is to explain and study the different reasons of natural tooth color change. Both authors Carlos Rocha Gomez Torres and Manoelito Ferreira SILVA-JUNIOR mentioned that this can result in a noticeable difference between the color of the natural teeth and the composite resin restoration, which can affect the aesthetic outcome (13, 3). As stated by the authors throughout a person's lifespan, significant alterations arise in the enamel, dentin, and pulp of their teeth.

For the author Carlos Rocha Gomez Torres, two types of discolorations can appear, the intrinsic and the extrinsic ones. And certain individuals possess teeth that are inherently darker in shade than others. Intrinsic alterations in tooth coloration may arise due to anomalies during the development of teeth. The phenomenon of intrinsic discoloration transpires when chromophores become assimilated into the dental hard tissues during

the growth of teeth, or due to circumstances that are attained subsequently in life, for instance, endodontic therapy, dental injury, or decay.

The ingestion of an excessive amount of fluoride which can lead to hypomineralization while the enamel is being formed, resulting in white patches on the enamel surface and possibly causing porous or pitted areas in more severe cases. The author author Manoelito Ferreira SILVA-JUNIOR talks about the dental qualitative defect named as Molar incisor hypomineralization that results in dental opalescence , he insists on the fact that dental stains in this case in addition to the low self-value that the patient suffer can also cause the patient to experience a great deal of sensitivity and raise the probability of having decays due to the roughen tooth surface (4).

Dental fluorosis is also mentioned as a side effect of chronic fluoride overexposure during tooth development. Amelogenesis and dentinogenesis imperfecta, which originate from different causes, can also cause significant cosmetic issues and may necessitate extensive dental treatment. Tetracycline, an antibiotic that was widely used in the past, can create a horizontal striped pattern when taken during odontogenesis and subsequently deposited in the dental structure (3, 13).

On the other way, food and beverages are often the culprits behind extrinsic staining, as chromogenic elements attach themselves to the surface of the enamel. This type of staining is commonly seen in individuals who regularly consume coffee or tea, smoke tobacco, ingest iron-containing vitamins, or harbor chromogenic bacteria in their dental biofilm. Some of these substances, which can lead to extrinsic discoloration, can penetrate the tooth to some extent, causing it to appear predominantly yellowish in color (3).

The author Gaetano Paolone present also a different cause of tooth stain due to pulp necrosis, from an aesthetic perspective, dental professionals typically view non-vital anterior teeth as a major challenge, but direct restorations can really help to cover those types of tooth color defects (5).

To address this issue, there are several strategies that can be employed to manage composite resin color change after the treatment done. One approach is to use

composite resin materials that are more resistant to discoloration, such as materials with a higher translucency or with added opacifiers. Another approach is to provide patients with guidance on how to maintain their restorations, such as avoiding certain foods and beverages that may cause staining and practicing good oral hygiene habits (13, 3, 5).

Stratification technique is a popular approach for creating natural-looking restorations, particularly in direct composite restorations of anterior teeth. This technique involves layering different shades and opacities of composite resin to mimic the complex anatomy of the natural tooth.

Both authors Veeramachaneni Chandrasekhar and Karthik D Yadav rely on the fact that the technique with stratified layers is using the different properties of each composite material is effective in order to achieve an esthetic outcome.

The primary drawback of composites is polymerization shrinkage, which ultimately results in a reduction of cohesion and adhesion between the material and the tooth surface.

The shrinkage that occurs during polymerization can be significantly decreased through the stratification technique (32, 33).

The author Veeramachaneni Chandrasekhar includes the point of using a minimum volume of composite, a decrease amount of the configuration factor and the less interaction with the contrary walls of the cavity while polymerizing. The author also adds that the stratification ideas must be clear, uniform, and duplicable in order to avoid too opaque or translucent restorations (30).

This is the general overview of the stratification technique for direct composite restorations regarding both authors, Veeramachaneni Chandrasekhar and Karthik D Yadav: the initial layer is the first layer of composite resin that is placed on the tooth surface. This layer is usually a translucent or opaque shade that matches the overall color of the tooth.

The middle layer is added to create the anatomy of the tooth. This layer should be slightly darker or opaquer than the initial layer to create depth and contrast. And to complete, the surface layer which is added to create the final shape and texture of the tooth. This layer should be the lightest or most translucent shade to create a natural-looking appearance.

Once the composite resin is fully cured, it is shaped and polished to match the natural teeth. This step is critical in creating a seamless blend between the restoration and the surrounding teeth. Nonetheless, there are numerous drawbacks such as being prone to a sensitive approach insufficiently dry working area leading to problems and Insufficient light exposure (lack of duration or deepness) (32, 33).

It is important to choose composite resins with high resistance to water absorption and color stability, and to properly cure the resin to ensure maximum color stability. Additionally, using proper bonding techniques, avoiding excessive light exposure during the curing process, and using proper oral hygiene practices can also help reduce the risk of color change once the restoration done.

The key to a successful stratification technique is careful layering and blending of the composite resin. The dentist must have a good understanding of tooth anatomy, color, and light reflection to achieve a natural-looking restoration (3).

6. CONCLUSION

The direct composite resin color change in anterior teeth is an effective and minimally invasive method to achieve the natural tooth color.

- Execution of a proper diagnosis and a good treatment plan helps in providing an optimal and seamless treatment.
- Dentists must have a good understanding of tooth anatomy, color, and light reflection to achieve a natural-looking restoration.
- Stratification technique is an approach for creating natural-looking restorations, particularly in direct composite restorations of anterior teeth.
- Careful selection of materials, proper knowledge of the tooth structure, with the appropriate shade, and using a layering technique (Macrofilled composites present a poor dental appearance due to the presence of a high composition of filler and the difficulty of polishing the restoration).
- Finishing and polishing are critical to achieving optimal results.
- Stratification technique is highly useful to cover intrinsic defects such hypomineralization and fluorosis.
- Composite polymerization shrinkage can be significantly decreased through the stratification technique.
- In stratification technique, the first layer of composite should be a translucent or opaque shade that matches the overall tooth color. The middle layer will create the anatomy of the tooth. This layer should be slightly darker or opaquer than the initial layer to create depth and contrast. And to complete, the surface layer to create the final shape and texture of the tooth. This layer should be the lightest or most translucent shade to create a natural-looking appearance.
- To avoid composite color changes, it is important to choose materials with high resistance to water absorption and proper bonding techniques.
- Patient's proper oral hygiene can help reduce the risk of color change.

Further research is needed to establish long-term durability and effectiveness, the current evidence suggests that this approach is a viable alternative to more invasive and costly options.

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