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COMPARATIVE EVALUATION OF SHADE MATCHING USING A DIGITAL SPECTROPHOTOMETER IN MONOCHROMATIC VERSUS POLYCHROMATIC LAYERING TECHNIQUES FOR RESTORING FRACTURED INCISAL ANGLES OF MAXILLARY INCISORS: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Aim of the Study: Contemporary dentistry faces an ongoing challenge in achieving natural-looking anterior restorations. This investigation sought to determine the effectiveness of three distinct approaches to shade matching when restoring fractured incisal angles in maxillary incisors: traditional polychromatic layering, contemporary monochromatic single shade, and universal body shade techniques.

Materials and Methods: Researchers recruited 48 individuals presenting with fractured incisal angles in vital maxillary permanent incisors for this randomized clinical trial. Through random allocation, participants received one of three restoration methods using Charisma® Diamond composite: layered polychromatic technique, single-shade monochromatic approach, or universal body shade restoration. A VITA Easyshade® V spectrophotometer enabled precise color measurements before and following restoration, with researchers examining variations in luminosity (ΔL), red-green balance (Δa), blue-yellow spectrum (Δb), and overall color deviation (ΔE).

Results: Analysis revealed that traditional polychromatic layering achieved remarkably natural results, demonstrating the smallest color deviation (ΔE = 3.88±1.43). Universal body shade technique showed comparable effectiveness (ΔE = 5.47±2.41), while the monochromatic approach resulted in notably higher color disparity (ΔE = 10.70±5.82, p<0.001). Interestingly, brightness values (ΔL) remained consistent across all techniques (p=0.121), though red-green and blue-yellow parameters showed meaningful variations between the monochromatic method and its counterparts.
Conclusion: These findings suggest that while both layering and universal body shade techniques can deliver aesthetically pleasing outcomes, the monochromatic approach may present limitations in achieving optimal color harmony.

Clinical Recommendation: Dental practitioners should weigh various factors including clinical presentation, desired aesthetic outcomes, and technical expertise when selecting between layering and universal body shade approaches.

KEYWORDS: aesthetic dentistry, monochromatic approach, color matching, composite layering, spectrophotometric analysis

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INTRODUCTION

In dentistry, resin-based composites have attained considerable acclaim over the past decade [1]. The trajectory of development for these materials is significant, with numerous manufacturers actively striving to improve their properties by mitigating structural deficiencies that pose various clinical challenges, including structural integrity, optical congruity, and the seamless integration of composite restorations with both natural tooth structures and neighboring teeth [2].

The growing aesthetic sensibilities of patients and dental professionals have increased patient inquiries regarding aesthetic enhancements [1]. Patients predominantly desire restorative materials that are visually appealing and biocompatible and exhibit durability while maintaining their color and functional properties over time [3].

To achieve restorations that are indistinguishable from natural dentition, restorative materials must accurately emulate the color, translucency, and luster characteristic of healthy teeth (Sikri, 2010). A precise color match between the tooth substrate and the resin composite is imperative for fulfilling aesthetic expectations and ensuring effective treatment outcomes in restorative dentistry [4]. The meticulous selection of the appropriate composite shade is essential for accurately replicating dental tissues. Presently, a notable lack of shade uniformity exists across various commercial product lines [5]. Furthermore, the shade-selection process often prolongs clinical chair time and is subject to individual variability, complicating the experience for both practitioners and patients [6]. Resin composites are available in multiple opacities, generally classified as dentin, opaque or body, and enamel, to simulate the optical characteristics of natural dentin and enamel [7]. Nonetheless, identifying the optimal combination of materials that aligns with the optical properties of teeth in aesthetic regions continues to be a formidable challenge. Various shade guides employ value-based or chroma-based systems (Chavan et al., 2023), often resulting in extensive time requirements for patients and clinicians [1,2].

Moreover, natural teeth display a diverse color spectrum and possess attributes such as translucency, opalescence, and fluorescence, which resin composite materials must authentically replicate during restoration procedures to achieve optimal aesthetic results. Incorporating nano-composite fillers in anterior composites has been introduced to enhance surface smoothness and polishability [8].

Color characterization encompasses three dimensions: hue, chroma, and value, which are employed to delineate the shades of commercially available resin composites [9]. Additional visual parameters—including opacity, translucency, and surface gloss—should also be carefully considered in the formulation of resin-based composites [10].

The intricacies of color and appearance in a tooth are influenced by many factors, including color stability, blending effects, color induction, and the color assimilation phenomenon of resin composites, collectively called the “chameleon effect.” This effect permits resin composites to achieve shades that closely resemble those of adjacent tooth structures. Through light scattering between enamel and dentin, resin composites promote internal diffusion, facilitating their integration with the surrounding environment. The modulation of color corresponds directly to the absorption of light, making the composite virtually indistinguishable when integrated with natural tooth structures [11,12].

Numerous methodologies have been implemented for placing resin composites within prepared cavities to attain optimal shade matching, including universal composite body shades, layered composites, and single-shade universal composites [13]. Universal shade resin composite restorations—alluding to their color alteration, mixing, shifting, and assimilation capabilities—are recognized as embodying the “chameleon effect” in aesthetic dentistry[8]. These innovations are designed to replace multiple shades while ensuring compatibility across a spectrum of dental hues [9,14,15].

The polychromatic layering approach is the gold standard for anterior tooth restoration, adeptly replicating the natural appearance and optical properties observed in healthy dentition [16]. However, this technique is acknowledged for its sensitivity to procedural nuances, which may lead to increased chairside time and cost, necessitating advanced technical skills and prolonged clinical engagement [8,17].

The monochromatic layering technique utilizing solely body shade has been implemented to substitute enamel and dentin; it exhibits reduced technique sensitivity compared to polychromatic layering and possesses an opacity that is intermediate between enamel and dentin [18].

Restoring fractured anterior teeth is clinically complex since it must satisfy multiple criteria, including shape, function, phonetics, aesthetics, and replicating the surviving tooth structure and adjacent teeth. In class IV cavities, each third of the tooth exhibits a distinct chromatic look owing to its structure's differing thicknesses of enamel and dentin [8].

There is a lack of evidence concerning the efficacy of ONE shade composite in restoring fractured incisal angles. Therefore, the study aims to clinically evaluate the shade matching of polychromatic versus monochromatic composite layering techniques in fractured class IV maxillary central incisors. The null hypothesis examined was that there is no difference in shade matching between the monochromatic and polychromatic techniques in restoring fractured incisal angles.

Methodology

Ethical Approval and Trial Registration

This randomized clinical trial was conducted at the Faculty of Dentistry, Badr University in Cairo (BUC), Egypt. The protocol for this study was pre-registered in the ClinicalTrials.gov database (NCT06827847). All procedures followed the ethical standards set forth by the Research Ethics Committee (REC) of the Faculty of Dentistry at BUC (BUC-IACUC-250119-127).

Sample Size Calculation

The sample size calculation was based on a previous study [19]. The sample size was calculated using a one-way ANOVA test comparing mean color difference (ΔE) among three different groups, an effect size of 0.938, a standard deviation of 0.58, a 5% level of statistical significance, and 80% power. The sample size calculated for each group was 15, which was then increased to 16 per group for non-parametric compensation. The total sample size was 48 patients.

Patient Selection

Inclusion and exclusion criteria were established for patient selection in this study. Eligible patients had fractured incisal angles in vital maxillary permanent incisors, aged 16 to 35, and exhibited good oral hygiene. Patients signed an informed consent form before participating in the study. Exclusion criteria included individuals with nonvital or endodontically treated teeth, active periodontal disease, significant medical complications, malocclusion, or parafunctional habits [8]. Of the 55 patients screened at the Faculty of Dentistry, BUC, 48 fulfilled the eligibility criteria and provided informed consent to participate in the study.

Randomization and Sample Distribution

Randomization was executed by generating random numbers from 1 to 48 using an online randomization tool (www.randomization.com), which allocated participants to intervention or comparison groups. Fractured incisal angles were restored using Charisma® Diamond (Kulzer GmbH, Hanau, Germany), a nano-hybrid filler resin composite characterized by universal opacity and a "chameleon effect," providing an aesthetically natural appearance. All resin composites were utilized in conjunction with Gluma universal adhesive in selective enamel etching mode [5], employing either universal body shade, monochromatic layering technique (ONE), or polychromatic layering technique. The polychromatic layering technique (G1) was assigned to restore teeth numbered 1 to 16, the monochromatic ONE shade layering approach (G2) was utilized for teeth numbered 17 to 32, and the Universal body shade (G3) was applied to restore teeth numbered 33 to 48.

Clinical Procedures

Pre-Operative Procedures Before treatment, all patients received oral hygiene instructions, and the vitality of their teeth was assessed (Figure 1A). The teeth were polished, and shade assessment was performed using a spectrophotometer (VITA Easyshade® V, VITA Zahnfabrik, Bad Sackingen, Germany) to determine the color of each tooth and the surrounding tooth structure before cavity preparation (Figure 1B). Two readings were recorded, and the average of the L*, a*, and b* color parameters were calculated by positioning the Easyshade device perpendicular to the tooth surface in the middle third [20] (Figure 1C).

Cavity Preparation Procedures Before cavity preparation, a palatal shell was created using a silicone rubber index technique, employing a composite shade different from that obtained by VITA Easyshade® V to restore fractured Incisal angle cavities. A silicone impression was taken, and the palatal shell was fabricated before removing the composite. Pre-wedging was performed to achieve interdental separation and apical depression of the papilla for optimal rubber dam inversion, followed by multiple isolation techniques using a rubber dam (Figure 1D). Beveling of the cavo-surface margin was completed using a yellow-coded diamond bur at a 75° angle (Figure 1E), and finishing was conducted with TOR VM discs [21] (Figure 1F).

Bonding Procedures Selective enamel etching was done using universal Etchant by applying the gel for 30 seconds on enamel only, followed by rinsing for 20 seconds (Figure 1G). Drying of the etched enamel surface was done using a way syringe of the dental unit; dry etched enamel should have a white, chalky appearance. The bonding agent was applied by placing one coat of Gluma universal, followed by agitation for 20 seconds (Figure 1H). Air thinning was done afterward to remove excess adhesive and

TABLE (1) Materials Used in this Study

Material	Type	Shade	Manufacturer	Composition
Charisma® Diamond	Resin composite	Body	Kulzer GmbH, Hanau, Germany	UDMS, TC-DI-HEA, TEGDMA, Ba– Al– B– F– Si glass, PPF, SiO2 Particle size - 5nm - 20μm wt./vol. 81/ 64
		ONE		
		OM (Opaque Medium)		
GLUMA® Bond universal	Adhesive	-	Kulzer GmbH, Hanau, Germany	Acetone, 4-META, 7,7,9(or 7,9,9)-trimethyl-4,13-dioxo-3,14-dioxa-5,12-diazahexadecane-1, 16-diyl bismethacrylate
Meta Etchant	Etchant	-	METABIOMED CO., LTD., Korea	37% Phosphoric Acid, Xanthan gum, Blue pigment

UDMS: urethane dimethacrylate silane; TCD-DI-HEA: Bis (acryloyloxymethyl) tricyclo [5.2.1.02,6] decane; TEGDMA: Triethylene glycol dimethacrylate; 4-META: 4-Methacryloxyethyl trimellitic anhydride

allow homogenous distribution. Finally, light curing was done for 20 seconds using an LED light curing unit of intensity $1000 mW/cm^2$.

Composite Application Resin composites were applied according to manufacturer instructions. For the monochromatic layering technique, a palatal shell was constructed using a blocker or opaquer to achieve an optimal thickness of approximately 1 mm against the silicone index, extending to the incisal edge and curing for 20 seconds. The silicone index was removed and replaced with an anterior spoon proximal matrix (TOR VM, Moscow, Russia) to establish the proximal wall. The remaining cavity was restored using incremental monochromatic ONE shade resin composite packing, with light curing performed for 20 seconds after each increment.

In the case of the polychromatic layering technique, the silicone index was employed to form the palatal shell with a thickness of 0.5 mm using body shade to allow adequate space for subsequent layers of opaque and body shades, followed by curing for 20 seconds. After removing the silicone index, the anterior spoon proximal matrix was placed, and the proximal wall was constructed using body shade to a thickness of 0.5 mm, which was also light-cured for 20 seconds. An opaque shade was then placed to fill most of the prepared cavity, leaving approximately 0.5 mm labially, proximally, and 1.5 mm incisally for the final body shade layer. A final layer of body shade was applied to restore the remaining cavity to the desired shape and contour, followed by light curing for 20 seconds. For the Universal body shade composite, the palatal shell was built to a thickness of 0.5 mm (Figure 1I), and subsequent layers were added using body shade.

Finishing and Polishing Procedures Gross finishing was initially conducted using yellow-coded diamond finishing stones. Primary anatomy corrections were made with TOR VM finishing discs, starting with incisal edge length and thickness adjustments. Line angles on the central incisor were drawn using a pencil to determine the proper width of the restoration concerning the contralateral tooth, followed by contouring those line angles with discs. Secondary and tertiary anatomical features were reproduced according to their presence in the contralateral tooth (Figure 1J). Occlusion was carefully evaluated for any premature contacts or interferences, and polishing was performed using rubber cups and polishing tips (Kenda, Vaduz, Liechtenstein) (Figure 1K).

Post-Operative Procedures and Color Assessment The restorative procedures were carried out by two skilled clinicians, one responsible for cavity preparations and the other for all restorative tasks. Color assessment was performed using the VITA Easyshade® V spectrophotometer, which measures color parameters where L* denotes lightness, a* indicates red-green value, and b* represents yellow-blue value. Dental restorations were evaluated for shade matching two hours after placement to ensure rehydration of the teeth. The color assessment involved calculating the ΔE value to assess color changes before and after restoration using the following equation:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\wedge}(1/2)$$

Statistical Analysis

Statistical analyses were conducted using SPSS Version 20 (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA). Numerical data were summarized with descriptive statistics, including median, mean, standard deviation, confidence intervals, and range. The normality of the data distribution was assessed using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Comparisons among groups were performed with the Kruskal-Wallis test, followed by Bonferroni's post hoc analysis for inter-group assessments due to the non-parametric distribution of most of the data. All p-values were two-sided, with a threshold for statistical significance set at $p \leq 0.05$.

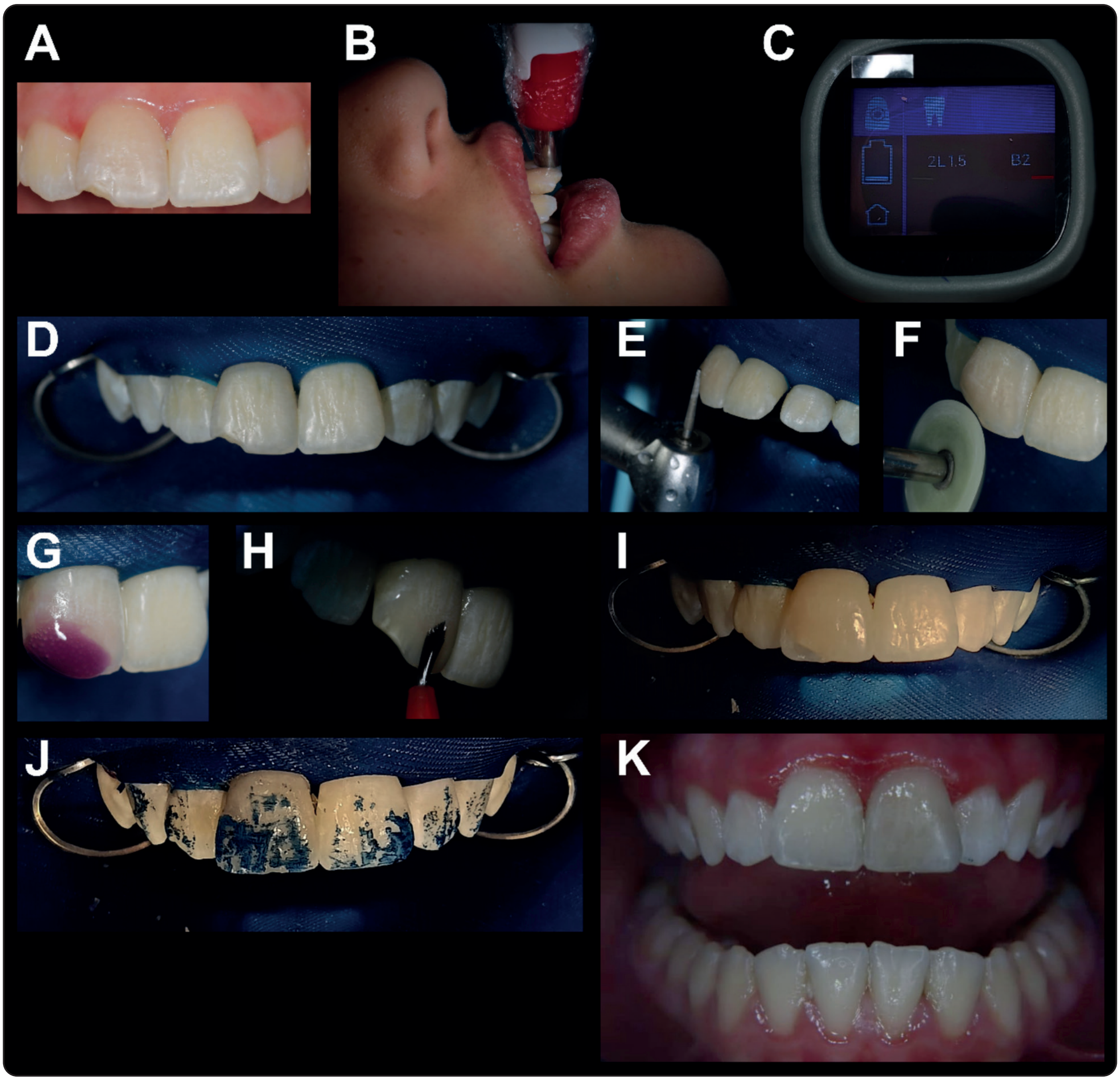

Fig. (1) Clinical procedures photos during shade matching and restoration using Universal body shade composite.

A. Preoperative fractured class IV in left central incisor. B. Shade determination by placement of the tip of the Easyshade device in the middle third of the adjacent tooth in a direction perpendicular to the tooth surface labially. C. Easyshade device display of shade detection. D. Multiple isolations using rubber dam E. Beveling of cavo-surface margin using diamond bur in a 75° direction. F. Finishing using TOR VM discs. G. Selective enamel etching was done using Universal Etchant. H. Application of Gluma Universal bonding agent. I. Building of the palatel shell. J. During finishing and polishing procedures. K. Postoperative.

RESULTS

ΔL: Group 1 (Layering shades composite) recorded (-0.44±2.3, median 0.05), in comparison to Group 2 (single shade composite technique) (-4.06±5.89, median -3.50), while Group 3 (universal shade composite technique) recorded (-1.33±4.58; median -2.4). The difference between groups was not statistically significant ($p=0.121$)

ΔA: Group 1 (Layering shades composite) recorded (1.39±1.12, median 1.4), followed by Group 3 (universal shade composite technique) (0.47±1.35; median 0.95). The value recorded in these two groups was significantly greater than Group 2 (single shade composite technique) (-0.96±1.21, median -1.05) ($p=0.000$). The post hoc test revealed no significant difference between groups 1 and 3.

ΔB: Group 1 (Layering shades composite) recorded (-0.24±3.05, median -0.10), followed by Group 3 (universal shade composite technique) (-1.69±3.13; median -1.05). The value recorded in these two groups was significantly greater than Group 2 (single shade composite technique) (-8.01±5.73, median -8.10) ($p=0.000$). The post hoc test revealed no significant difference between groups 1 and 3.

ΔE: The highest value was recorded in Group 2 (monochromatic single shade composite technique) (10.70±5.82, median 9.76) Figure 2. This value was significantly greater than Group 3 (universal shade composite technique) (5.47±2.41; median 5.5) Figure 4, and Group 1 (Layering shades composite) (3.88±1.43, median 4.15) ($p=0.000$) Figure 3. The post hoc test revealed no significant difference between groups 1 and 3.

Fig. (2) Monochromatic composite layering technique before and after

Fig. (3) Polychromatic composite layering technique before and after

Fig. (4) Universal body shade composite before and after

TABLE (1) Descriptive statistics and comparison of ΔL, ΔA, ΔB, and ΔE between groups (Kruskal Wallis test)

		Mean	Std. Dev	Median	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max	test value	P value
ΔL	Group1 (Layering shades composite)	-.44[a]	2.30	.05	-1.66	.79	-4.90	2.80	4.22	.121 ns
	Group 2 (Single shade composite)	-4.06[a]	5.89	-3.50	-7.20	-.93	-19.90	4.40		
	Group 3 (Universal shade composite)	-1.33[a]	4.58	-2.40	-3.77	1.11	-8.60	6.40		
ΔA	Group1 (Layering shades composite)	1.39[a]	1.12	1.40	.79	1.99	-1.00	2.90	19.64	.000*
	Group 2 (Single shade composite)	-.96[b]	1.21	-1.05	-1.60	-.31	-3.60	1.20		
	Group 3 (Universal shade composite)	.47[a]	1.35	.95	-.25	1.19	-2.60	2.30		
ΔB	Group1 (Layering shades composite)	-.24[a]	3.05	-.10	-1.87	1.38	-5.40	4.30	16.55	.000*
	Group 2 (Single shade composite)	-8.01[b]	5.73	-8.10	-11.07	-4.96	-19.20	.90		
	Group 3 (Universal shade composite)	-1.69[a]	3.13	-1.05	-3.36	-.02	-8.80	2.90		
ΔE	Group 1 (Layering shades composite)	3.88[b]	1.43	4.15	3.12	4.65	1.62	5.66	17.37	.000*
	Group 2 (Single shade composite)	10.70[a]	5.82	9.76	7.60	13.80	3.81	24.05		
	Group 3 (Universal shade composite)	5.47[b]	2.41	5.50	4.19	6.76	1.08	9.44		

Significance level p≤0.05, *significant, ns=non-significant
Post hoc test: within the same comparison, which means sharing the same superscript letter is not significantly different.

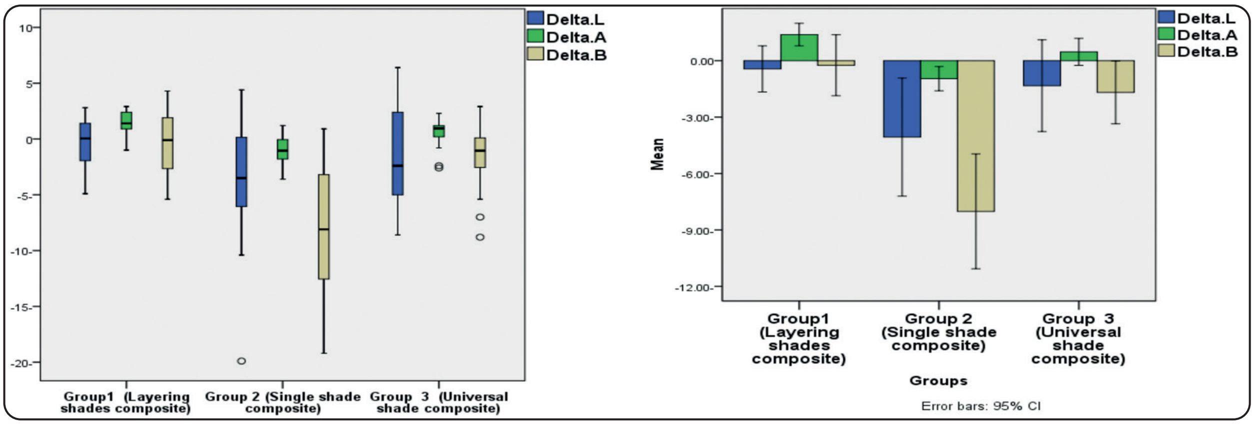

Fig. (5) (a) Bar chart illustrating the mean value of ΔL, ΔA, and ΔB in different groups (b) Box plot illustrating the median value of ΔL, ΔA, and ΔB in different groups

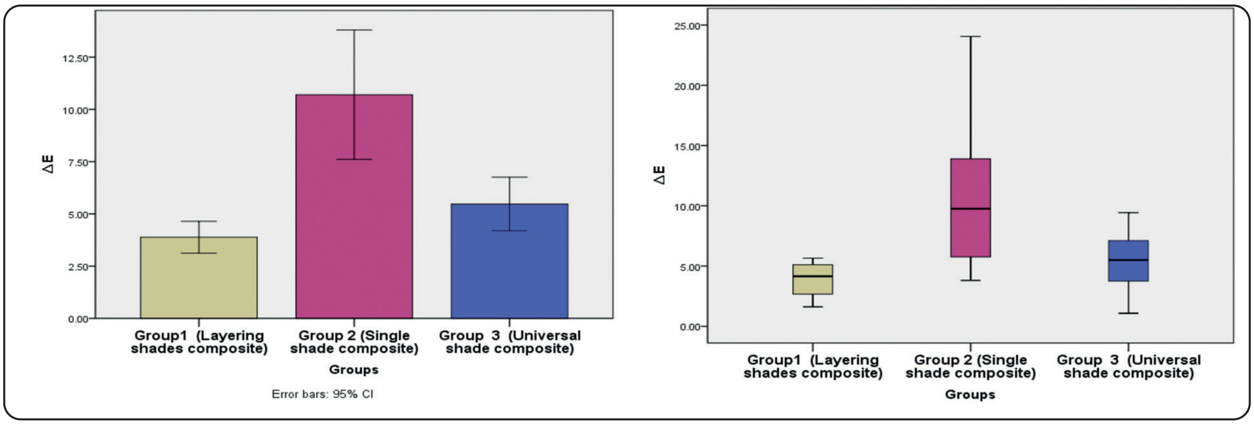

Fig. (6) (a) Bar chart illustrating the mean value of ΔE in different groups (b) Box plot illustrating the median value of ΔE in different groups

DISCUSSION

Achieving an accurate match for the hue and chromaticity of natural teeth is a significant challenge in restorative dentistry. This task requires a detailed understanding of color science and an acknowledgment of the limitations of traditional shade guides and the quirks of human perception. Color perception is not just a simple visual phenomenon; it involves a complex interaction of cognitive, physiological, and contextual factors that are often overlooked in clinical settings. Variations in individual color perception, shaped by different cognitive biases and physiological differences, play a significant role in the discrepancies in shade-matching results [22].

Traditionally, shade guides like the VITA Classical system have been the standard in clinical shade assessment. While these guides focus on hue and chroma, their limited color range often fails to adequately represent the diverse shades in natural teeth. Introducing more advanced systems, such as the VITA 3D-Master, signifies a significant shift in shade-matching techniques. This system systematically prioritizes the value of color perception, thereby improving shade selection accuracy. These developments highlight a growing awareness in the field about the need for practical tools that enable precise shade matching, which is essential for enhancing the aesthetic results of restorative treatments [22].

Contrary to subjective visual assessments, which various external factors can influence, spectrophotometers are pivotal in achieving objective and precise shade determination. These advanced instruments measure the spectral reflectance of dental tissues, yielding meticulous colorimetric data that augments a clinician's capacity to achieve optimal shade matches. The inherent objectivity of spectrophotometric measurements effectively diminishes the variability traditionally associated with human judgment, thus potentially elevating the success rates of aesthetic restorations [22,23].

The introduction of single-shade resin composites, such as Omnichroma, heralds a new paradigm in the shade selection process, presenting materials specifically designed for adaptability to a broad spectrum of natural tooth colors. While the promise of these composites includes significant workflow efficiencies, it is imperative that ongoing research rigorously evaluates their clinical performance and color adaptation capabilities under diverse conditions pertinent to dental practice. Key areas for further investigation include the dimensional characteristics of cavities, the nuances of layering techniques, and the interaction of these advanced materials with existing tooth structures [23–25].

Charisma composite materials, meticulously engineered by Kulzer, have gained recognition for their exceptional performance and aesthetic quality within anterior restorations. Charisma composites are designed to meet the discerning aesthetic demands of clinicians and patients. They encompass three pivotal categories relevant to anterior restorations: body shade, single shade, and polychromatic composites. Body shade composites are adeptly formulated to emulate the optical properties of dentin, rendering them suitable for foundational layers in anterior restorations. Their composition ensures strength and durability and facilitates a lifelike replication of the hue and translucency characteristic of natural teeth [26].

Single-shade composites mark a significant breakthrough in selecting shades that adapt to different tooth colors. They facilitate an efficient restorative process through "smart chromatic technology," allowing products like Omnichroma to adjust to the surrounding tooth color dynamically. This innovation minimizes the time needed for shade matching while delivering excellent aesthetic outcomes. Additionally, polychromatic composites are skillfully crafted to mimic the complex color variations found in natural teeth. These materials combine multiple shades in restoration and utilize advanced layering techniques, enabling clinicians to realistically replicate the transitional effects between dentin and enamel, resulting in superior aesthetics for anterior restorations. [27].

The wide range of Charisma composites available for front restorations allows dentists to customize their methods according to the specific needs of each restoration case, ensuring they achieve the best aesthetic outcomes that meet both functional and cosmetic goals. Numerous factors greatly affect the effectiveness of shade-matching techniques in restorative dentistry. Recent studies indicate that larger cavity sizes may negatively affect the precision of color matching when using single-shade composites, making the amount of restorative material an essential element in achieving a seamless blend efficacy [23]. Moreover, monochromatic layering techniques involving single-shade composites have exhibited satisfactory shade-matching potential, notwithstanding the potential for initial color discrepancies that may necessitate further application technique refinement [8].

Although single-shade composites commonly demonstrate commendable clinical performance, there are pertinent concerns regarding their long-term color stability, particularly when subjected to the deleterious effects of staining agents such as coffee. Understanding how these materials endure such extrinsic factors is vital for predicting their clinical longevity [19,25,28]. Indeed, the durability of these materials against staining necessitates a comprehensive evaluation encompassing their inherent properties and the environmental conditions to which they are exposed over time.

The subjective nature of color perception further complicates the landscape of shade matching, as it can lead to significant variability in shade assessments, even among trained dental professionals. Studies have illuminated the existing disparities, highlighting that laypersons are typically less discerning of subtle color discrepancies than their trained counterparts. This underscores the pressing need for objective measurement tools and methodologies in clinical practice to enhance consistency and reliability in shade-matching outcomes [29]. Furthermore, the role of dentin in contributing to overall tooth aesthetics cannot be overstated. In restorations with minimal enamel thickness, such as Class V cavities, an astute evaluation of the shade-matching capabilities of resin composites becomes paramount. The interaction between dentin shade and composite materials often dictates the ultimate aesthetic success of the restoration, thus warranting detailed investigation [19].

A critical synthesis of the existing literature indicates that a multifaceted approach to shade matching, integrating both traditional and contemporary techniques, may hold the key to enhancing the accuracy and predictability of aesthetic restorations in dentistry. Integrating advanced digital technologies such as spectrophotometry with innovative material development, like single-shade and polychromatic composites, fosters a more nuanced comprehension of the complexities of achieving optimal shade replication. As restorative dentistry continues to evolve, it will be imperative for clinicians to remain abreast of advances in color science and material technology, ensuring that they are equipped with the knowledge and tools necessary to meet the aesthetic demands of today's patients [6].

This study was performed to assess and compare the color change of three different groups using three different restorative techniques: polychromatic layering technique (G1), Monochromatic single Shade technique (G2), and Universal Body shade technique (G3) before and immediately after resin composite restoration of fractured incisal angles in vital maxillary permanent incisors.

In restorative dentistry, randomized clinical trials (RCTs) are used to evaluate a new or modified dental material or restorative technique and recommend its validity for its specific indication of intraoral use, such as restoring function, improving/maintaining aesthetics, and not causing any harm to adjacent biological tissues, as well as to determine whether the proposed material/ technique can be applied by the majority of dental healthcare professionals who will perform a similar procedure [8].

The current study evaluated the color change with an easy shade device using L, a, and b parameters for color and a digital camera for precise assessment. In contrast to visual subjective evaluations, spectrophotometers are pivotal in achieving objective and accurate shade determination. These sophisticated devices measure the spectral reflectance of dental tissues, providing precise colorimetric data that enhances the clinician's ability to achieve optimal shade matches. The objective nature of spectrophotometric measurements reduces variability associated with human judgment, thereby potentially increasing the success rate of aesthetic restorations [22,23].

In clinical trials and studies related to tooth color shade matching, ΔL, Δa, Δb, and ΔE are parameters derived from the CIELAB color space, which is commonly used to quantify and describe color. Here's what each parameter represents: L (Lightness), where ΔL refers to the difference in lightness between samples; in the current study, the results of ΔL showed that the difference between groups was not statistically significant ($p=0.121$). A value represents the position on the red-green axis, and Δa refers to the difference in the red-green axis between samples. In the current study, the value recorded in the layering and universal groups (G1 and G3) was significantly greater than that of the single shade technique (G2). The b value represents the position on the yellow-blue axis, where Δb refers to the difference in the yellow-blue axis between samples. The value recorded in layering and universal groups (G1 and G3) was significantly more significant than the single shade composite technique (G2) [19,25,30].

ΔE is a single value that represents the overall color difference between samples, calculated using the ΔL, Δa, and Δb values. The color, translucency, and whiteness agreements in dentistry are described by the visual thresholds of perceptibility and acceptability. These thresholds serve as crucial guides for the selection of restorative materials, the assessment of clinical performance, and the standardization of restorative dentistry. On the allowable degree of hue difference, however, there was no agreement [31].

The best color matching was recorded using the multi-shaded layering resin composite technique (G1), indicating the best color matching with natural teeth. Which was not statistically significant with the universal shading technique (G3), While the least was recorded for the single shade group (G2), which was significantly greater than those recorded for the other two groups (G1 and G3); therefore, the null hypothesis was rejected. (Table 1 and Figure 6)

The incisal third's unique characteristics influence whether a single shade could be used with one opacity or a blend of tones with two or more opacities is required. Based on these criteria, some patients will have minimal intrinsic effects, suggesting that a monochromatic approach will suffice. Other patients, on the other hand, will have a combination of translucency, white spots, and a halo effect, necessitating additional clinical attention [8].

Polychromatic composites are designed to replicate the complex color variations in natural teeth, incorporating multiple shades within the restoration. These materials utilize a layering technique that allows clinicians to effectively mimic dentin and enamel transitions, enhancing the overall aesthetic outcome in anterior restorations. The ability to manipulate color through various opacities and shades provides a high degree of customization for each case, catering to individual patient needs and expectations**.** Due to their composition and thickness, Enamel and dentin possess different translucency and opacity. Finding the optimal translucency and opacity of the material, crucial to reaching the optical behavior of enamel and dentin, is a significant issue for manufacturers when producing resin composite. Filler content and distribution have previously been observed to be directly connected to translucency and opacity[10,13,32].

Body Shade Composites is also designed to provide a natural appearance that closely mimics the optical properties of dentin, making them suitable for foundational layers in anterior restorations. Body shade composites are characterized by their ability to replicate the hue and translucency of natural dentition, offering clinicians the flexibility to create aesthetically pleasing restorations that blend seamlessly with surrounding teeth. Their formulation ensures strength and durability while maintaining a lifelike appearance, and single-shade composites represent an innovative advancement to simplify shade selection processes. This composite type is engineered to adapt to various tooth shades, making it a versatile option for anterior restorations[22].

The present study demonstrated that the color-matching results of the shades and universal groups are comparable with no statistically significant difference between them, meanwhile showing more acceptable color matching in anterior class IV restorations and overperformed the single-shade resin composite with the darker tooth shade shifted toward the greenish blueish axis. Nevertheless, all showed a noticeable color change.(Figures 5a,5b)

One significant factor contributing to color matching is the material composition, which can, in turn, affect the degree of conversion, polishability, and light transmittance of the restorative material. Filler particle size, type, volume, and morphology also affect the aesthetic properties of resin composites. Spherical-shaped symmetric nano-fillers with a diameter smaller than the visible wavelength light can improve the color-matching capacity of the resin composite by producing structural color without the need for pigment addition [33].

The results of the current study were in agreement with one study [34]; the clinical significance of the results from their study points out that the layering strategy and substrate color influence the masking ability. The layering strategy was the only combination capable of achieving an excellent match ($\Delta E_{00} \leq 0.8$). These results may be linked with the translucency parameter of the dentin shade. Also, this was consistent with another study [35], who concluded, based on visual color assessments, that multi-shade composites (A1-A3) achieved superior color matching compared to single-shade composites in class III restorations. The former study [35] stated that the universal composites tested in anterior restorations showed different color-matching values. In contrast, multishade universal composites presented higher color matching than single-shade universal composites. However, in comparison a study[36] found that a single-shade system utilizing body shade performed better than multiple-shade systems in optical integration. When employing more complex techniques, single shading is preferable over dual shading, which requires more time. Universal composites with improved color matching might make anterior restorations easier to perform and reduce clinical errors.

In agreement with our results, another study [33] found out that the single shade resin composite showed the least acceptable color matching with noticeable circular depressions on the SEM images of Charisma composite with all Finishing and polishing techniques. After finishing and polishing, resin composites with smaller particle sizes have lower surface roughness and higher gloss. The surface roughness of the composite material is improved by filler size reduction, which lessens particle projection at the surface. The Barium Aluminum Boro Fluor Silicate found in Charisma has bigger particles, ranging in size from 5 nm to 20 µm. Furthermore, because of their weak link with the polymer matrix, the pre-polymerized fillers may be gouged out, producing noticeable surface flaws that could have led to the color discrepancy [5]. In his research, he identified the cause of the Charisma Diamond One's color shift despite the presence of tricyclodecane, which offers a high level of discoloration resistance. However, the high color change can be caused by the nanoclusters and decreased filler quantities. Furthermore, in comparison to comparable resin composite restorations like Omnichroma, a recent study found that Charisma Diamond One had noticeably less surface smoothness.

Furthermore, pigment is present in Charisma Diamond One. This could be the reason for the greatest color change in this material. It is possible that the filler particles, which can result in weak cross-linking between the filler and the polymer matrix, are the cause of the high color change of Charisma Diamond One among the studied materials. Since the color resistance of resins is influenced by their resin matrices, filler types, sizes, and concentrations, pigment types, initiator types and concentrations, inhibitor types and activators, and unreacted carbon bonds, the bis-acryloyloxymethyl tricyclododecane monomer in the Charisma Diamond One may be the cause of the low color stability. It has been reported that this monomer has a significant affinity for the low polarity beverage coffee [37].

This was in contrast to a study [38], which stated that single-shade composite Charisma Diamond One with either composite A1 or A3 yielded a slight reduction in color discrepancy for the single specimens constructed using these chromatic composites. Charisma Diamond One composite exhibited the ability to adapt its color to match its surroundings. Also, the monoshade universal composites were claimed to have a more significant blending effect, which works for the clinician by reducing color mismatches.

Another aspect that contributes to color blending is the impact of cavity dimensions on the blending effect. Better color matching with the tooth is achieved with restorations that are smaller. Furthermore, research on the effect of cavity depth has shown that thicker restorations and deeper cavities mix better. By establishing a gradual transition between the restoration and the tooth surface, the beveling of the enamel margins also improves blending. Flatter surfaces, such as the buccal, tend to reflect light in a specular manner, resulting in a lighter and more luminous appearance, whereas irregular surfaces, such as the occlusal, tend to scatter light, creating a more favorable environment for shade-matching [5]**.** Also, the background cavity color can affect the final shade of the restoration, depending on the translucency of the resin-based material used [27]. Nanofiller composites in lighter cavities showed better color adjustment, whereas multishade composites in darker cavities showed better color matching.

Finding the ideal material's translucency, a crucial characteristic to approach the optical behavior of dentin and enamel, is a major issue for producers creating universal composites. The filler content is one element that has been shown to be directly related to translucency; larger filler amounts may have an impact on the composite's optical scattering, which in turn may affect translucency. According to earlier research, composites with these filler materials had higher translucency values than lower ones, and the blending effect increased with translucency. This explains the current study's findings, which demonstrated that the groups' differences were not statistically significant ($p=0.121$) with acceptable translucency values, as indicated by ΔL.

It has been discovered that the degree of hydration of dental tissue significantly impacts enamel translucency. In the present study, there was a statistically significant difference in shade matching with the remaining tooth structure at baseline between monochromatic and polychromatic layering techniques (Figure 6). This could be attributed to the dehydration phenomenon produced by rubber dam isolation, which may have altered the chameleon effect of the monochromatic composite. Monochromatic resin composite systems with only body shade have been utilized to replace enamel and dentin and have an opacity midway between enamel and dentin due to their filler content [8] In the current study, Charisma has barium aluminum boro-fluor-silicate with a large particle size of 5 nm-20 µm. In addition, the prepolymerized fillers can be gouged out where these particles may be attributed to the opacity, which explains the acceptable shade-matching potential and the presence of nanoclusters that could be accountable for the translucency and light transmission.

The limitations of the present clinical trial were the relatively small sample size and short-term baseline assessment. A larger sample size is recommended to provide more accurate results, detect differences between layering techniques, and enhance generalizability to the population. Moreover, the immediate short-term follow-up period might be insufficient to assess the color stability.

Future Research Directions

Continued research should prioritize investigations into the long-term color stability of single-shade resin composites, exploring their performance across diverse clinical situations and under varying exposure conditions. Additionally, establishing standardized protocols for shade matching that effectively incorporate visual assessment and instrumental techniques is essential. Future studies should also focus on developing innovative resin composite formulations that enhance color blending and stability and maintain desired mechanical properties, thus ensuring an optimal balance between aesthetic outcomes and material performance.

CONCLUSION

Multi-shade composite with the layering technique showed the best shade-matching ability with the lowest color difference from the tooth, followed by the universal composite. However, the one-shade composite exhibited a higher color difference than the tooth shade. The choice between them should consider clinical situations, aesthetic goals, and clinician expertise. Both are valuable in restorative dentistry, balancing convenience, effectiveness, and aesthetic quality. Ongoing innovation in shade-matching technologies and materials is essential for improving aesthetic dental outcomes.

CLINICAL RECOMMENDATION

Dental practitioners should weigh various factors including clinical presentation, desired aesthetic outcomes, and technical expertise when selecting between layering and universal body shade approaches, as both demonstrated clinically acceptable results in anterior restorations.

REFERENCES

1. Jouhar R, Ahmed MA, Khurshid Z. An Overview of Shade Selection in Clinical Dentistry. Applied Sciences 2022, Vol 12, Page 6841. 2022 Jul 6;12(14):6841.
2. German MJ. Developments in resin-based composites. British Dental Journal 2022 232:9. 2022 May 13;232(9):638–43.
3. Leal CDFC;, Miranda SB, Neto A, Freitas ELD;, De Sousa K;, Lins WV;, et al. Color Stability of Single-Shade Resin Composites in Direct Restorations: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Polymers 2024, Vol 16, Page 2172. 2024 Jul 30;16(15):2172.
4. Batista GR, Borges AB, Zanatta RF, Pucci CR, Torres CRG. Esthetical Properties of Single-Shade and Multishade Composites in Posterior Teeth. Int J Dent.; 2023:7783321.
5. Uctasli M, Garoushi S, Uctasli M, Vallittu P, Lassila L. A comparative assessment of color stability among various commercial resin composites. BMC Oral Health. 2023 Dec 1;23(1):1–11.
6. Nayak VM, Sulaya K, Venkatesh SB. Current trends in digital shade matching – A scoping review. Japanese Dental Science Review. 2024 Dec 1;60:211–9.
7. Vargas M, Saisho H, Maharishi A, Margeas R. A practical, predictable, and reliable method to select shades for direct resin composite restorations. J Esthet Restor Dent. 2023 Jan 1;35(1):19–25.
8. Hashem B, Khairy M, Shaalan O. Evaluation of shade matching of monochromatic versus polychromatic layering techniques in restoration of fractured incisal angle of maxillary incisors: A randomized controlled trial. Journal of International Oral Health. 2023 Jan 1;15(1):43–51.
9. Malekipour MR, Sharafi A, Kazemi S, Khazaei S, Shirani F. Comparison of color stability of a composite resin in different color media. Dent Res J (Isfahan). 2012 Jul;9(4):441.
10. Mikhail SS, Schricker SR, Azer SS, Brantley WA, Johnston WM. Optical characteristics of contemporary dental composite resin materials. J Dent. 2013 Sep 1;41(9):771–8.
11. Lassila L, Keulemans F, Vallittu P, Garoushi S. Optimising chameleon effect for dental composite. Dental Materials. 2023 Jan 1;39:e84.
12. Pecho OE, Ghinea R, Amaral EAN Do, Cardona JC, Della Bona A, Pérez MM. Relevant optical properties for direct restorative materials. Dent Mater. 2016 May 1; 32(5):e105–12.
13. Hardan L, Bourgi R, Cuevas-Suárez CE, Lukomska-Szymanska M, Monjarás-ávila AJ, Zarow M, et al. Novel Trends in Dental Color Match Using Different Shade Selection Methods: A Systematic Review and Meta-Analysis. Materials (Basel). 2022 Jan 1;15(2).
14. Abdelraouf RM, Habib NA. Color-Matching and Blending-Effect of Universal Shade Bulk-Fill-Resin-Composite in Resin-Composite-Models and Natural Teeth. Biomed Res Int. 2016;2016.
15. Lee JH, Kim HK. A comparative study of shade-matching performance using intraoral scanner, spectrophotometer, and visual assessment. Scientific Reports 2024 14:1. 2024 Oct 9;14(1):1–7.
16. Fahl N. A polychromatic composite layering approach for solving a complex Class IV/direct veneer/diastema combination: Part II. Pract Proced Aesthet Dent. 2007;19(1):17–22.
17. Chandrasekhar V, Rudrapati L, Badami V, Tummala M. Incremental techniques in direct composite restoration. J Conserv Dent. 2017 Nov 1;20(6):386.
18. Kaushal R, Gupta I, Gupta U. Recent advances in dental composites. Int J Health Sci (Qassim). 2021 Jul 31;5(S1):36–44.
19. Habib MS, Fahmy OI, Abo Elezz AF. Evaluation of Shade Matching Ability of Three Resin Composites with Three Different Teeth Shades (An In-Vivo Study). Dental Science Updates. 2022 Sep 1;3(2):237–45.
20. Lehmann K, Devigus A, Wentaschek S, Igiel C, Scheller H, Paravina R. Comparison of visual shade matching and electronic color measurement device. Int J Esthet Dent. 2017;12(3):396–404.
21. Daudt E, Lopes GC, Vieira LC. Does operatory field isolation influence the performance of direct adhesive restorations? J Adhes Dent. 2013 Feb;15(1):27–32.
22. Mohammed AO, Mohammed GS, Mathew M, Alzarea B, Bandela V. Shade Selection in Esthetic Dentistry: A Review. Cureus. 2022 Mar 20;14(3).
23. Antony JK, George L, Mathew J. Assessment of shade matching using visual and instrumental methods. The Saint's International Dental Journal. 2021 Jul;5(2):37–41.
24. Erçin Ö, Kopuz D, Erçin Ö, Kopuz D. The visual and instrumental analyses of different single-shade resin composites. Odovtos International Journal of Dental Sciences. 2024;26(1):54–64.
25. Duzyol M, Duzyol E, Çarıkçıoğlu B. Assessing one-shade composite resin color stability in response to everyday drinks. BMC Oral Health. 2024 Dec 1;24(1):1–8.

26. Gurgan S, Koc Vural U, Miletic I. Comparison of mechanical and optical properties of a newly marketed universal composite resin with contemporary universal composite resins: An in vitro study. Microsc Res Tech. 2022 Mar 1;85(3):1171–9.

27. Iyer RS, Babani VR, Yaman P, Dennison J. Color match using instrumental and visual methods for single, group, and multi-shade composite resins. Journal of Esthetic and Restorative Dentistry. 2021 Mar 1;33(2):394–400.

28. Shaalan O, El-Rashidy A. Color matching of single-shade composite compared to multi-shade composite after aging and bleaching: An In Vitro Study. Egypt Dent J. 2023 Jul 1;69(3):2481–93.

29. Çapa N, Malkondu Ö, Kazazoğlu E, Çalikkocaoğlu S. Evaluating factors that affect the shade-matching ability of dentists, dental staff members and laypeople. J Am Dent Assoc. 2010;141(1):71–6.

30. morsy ahmad safwat, Gamal WM, Riad M. Color Matching of a Single Shade Structurally Colored Universal Resin Composite with the Surrounding Hard Dental Tissues. Egypt Dent J. 2020 Oct 1;66(4):2721–7.

31. Khashayar G, Bain PA, Salari S, Dozic A, Kleverlaan CJ, Feilzer AJ. Perceptibility and acceptability thresholds for colour differences in dentistry. J Dent. 2014 Jun;42(6):637–44.

32. Rashid F, Farook TH, Dudley J. Digital Shade Matching in Dentistry: A Systematic Review. Dent J (Basel). 2023 Nov 1;11(11):250.

33. Ghadeer AE, Mohamed Amr K. Color Stability of Nanofilled and Suprananofilled Resin Composites with Different Polishing Techniques after Immersion in Coffee Solution. Egypt Dent J. 2023 Jan 1;69(1):827–36.

34. Perez BG, Gaidarji B, Palm BG, Ruiz-López J, Pérez MM, Durand LB. Masking ability of resin composites: Effect of the layering strategy and substrate color. J Esthet Restor Dent. 2022 Dec 1;34(8):1206–12.

35. de Abreu JLB, Sampaio CS, Benalcázar Jalkh EB, Hirata R. Analysis of the color matching of universal resin composites in anterior restorations. J Esthet Restor Dent. 2021 Mar 1;33(2):269–76.

36. Magne P, So WS. Optical integration of incisoproximal restorations using the natural layering concept. Quintessence Int. 2008 Sep;39(8):633–43.

37. Fidan M, Yağci Ö. Do universal adhesive systems affect color coordinates and color change of single-shade resin composites compared with a multi-shade composite? Dent Mater J. 2023;42(6):886–93.

38. Santana MLC, de Jess Santos Livi G, Santana TR, Silva PFD, de Matos CLLB, Maciel CM, et al. Surrounding and background shades effect on color adjustment of single-shade composites. Braz Dent J. 2024;35.