Thi-Qar Medical Journal (TQMJ):Vol.(27),No.(1),2024

Web Site: https://jmed.utq.edu **Email:** utjmed@utq.edu.iq

ISSN (Print):1992-9218

Evaluation of Color Properties of Different Types of Resin Composites and Natural Tooth: in-Vitro Study

Maysarah Falih Ibraheem
(BDS) Board Candidate of Restorative Dentistry at KHCMS, Sulaymania/ Iraq (maysaraalmaarof@gmail.com)

Bassam Karem Amen
(MSc, PhD) Department of Conservative Dentistry, College of Dentistry, Hawler Medical University/ Erbil/ Iraq

Abstract

Background: Direct resin composites are often selected for anterior restorations due to their numerous advantages over indirect techniques. These benefits include the ability to be applied to tooth surfaces with minimal to no preparation, ease of repair, and excellent aesthetic properties. Additionally, they require less time in the dental chair and are more cost-effective. This study aims to characterize and compare the translucencies of two different anterior resin composite materials, Shufo resin composite (Tokyo, Japan) and Micerium resin composite (Italy), with natural dental tissues.

Method: Radiographic imaging was utilized to record the enamel and dentin thicknesses of extracted upper central incisor teeth. Ten specimens were fabricated for each group. Colorimetric measurements were conducted on dry samples using a spectrophotometer (Rayplicker spectro-diameter Micro Office device), with color space coordinates recorded.

Results: Comparative analyses of the CIE Lab color space coordinates, precisely the L* (lightness) values, were conducted for the incisal, gingival, and middle third positions. The results indicate a statistically significant difference (p-value < 0.05) between the natural tooth and Micerium and Shufo in the incisal and middle third positions. Additionally, translucency parameters, including lightness, hue, and chroma values, were calculated using a formula derived from the Commission Internationale de l'Eclairage (CIE) color space coordinates.

Conclusion: The CIE Lab colorimetric values obtained for natural enamel and dentin tissues were superior to those of all the resin composites evaluated. Furthermore, the samples' desiccation augmented the CIE Lab values for both natural enamel and dentin, indicating a significant influence of the hydration state on these tissues' color properties.

Keywords: Direct resin composites, Esthetic, Translucency

Introduction: Dental caries and other tooth imperfections must now be treated with restorations that provide excellent functional and esthetic outcomes, as patient and clinician expectations have increased the demand for highly aesthetic restorations (1). Composite resins commonly utilized in clinical practice as esthetic restorative materials are manufactured to meet these elevated standards (1). In recent years, aesthetics has emerged as a paramount consideration in dentistry, transcending the notion that a pleasing appearance is frivolous. The acceptability of any dental restoration is significantly influenced by the ability to achieve accurate color matching of the repair, which is now recognized as a fundamental clinical requirement (2).

Since their introduction in the 70s, resin composites have gained widespread acceptance due to their exceptional aesthetic properties. Despite their initial popularity, resin composites have been found to exhibit increased discoloration over time, particularly when compared to ceramics. In response, newer universal composite systems have been developed, integrating the benefits of earlier hybrid and micro-filled composites. One of the most significant advancements in recent years has been the incorporation of nanotechnology into resin composites, notably enhancing their color stability and gloss retention (3). Direct methods employing composite resins have proven effective in restoring both functional and aesthetic aspects, with the vital approach closely aligned with conservative surgical procedures. Integrating reparative techniques with a deeper understanding of the intrinsic properties of dental tissues related to light incidence enables a more innovative therapeutic strategy. Each incremental layer of resin allows for precise manipulation of light interaction, yielding highly detailed and vibrant natural restorations (4).

Commercially available composite resins have been developed in a range of enamel and dentin shades, as per the VITA Classical shade guide, with different levels of transparency and opacity. The availability of composite resins in various enamel and dentin shades, as per the VITA Classical shade guide, complicates the shade-matching process, increases inventory requirements, and raises costs and chairside time. The phenomenon where a resin can harmonize with the color of the adjacent tooth structure through reflections is referred to as the Blending-Effect (BE) or the Chameleon-Effect (5).

The filler particles present within them can influence the light transmission properties of resin composites. Additionally, the scattering and diffusing refraction of light through the resin composite can impact the restoration's blending effect (BE). To accurately predict shade matching, it is essential to assess the light transmission characteristics of resin composites with diverse filler morphologies (6). To achieve reliable and predictable aesthetic outcomes in vitro, numerous research groups have employed simulated tooth preparations instead of actual human teeth for visual and instrumental shade-matching assessments (7). Due to the inherent instability of natural sunlight, it is not suitable for precise color assessment. The Commission Internationale de l'Eclairage (CIE, International Commission on Illumination) recommended using "standard illuminants" in 1931 to address this issue. The CIE Standard Illuminant D65 was introduced as an average representation of daylight and possesses a color temperature of 6500 K (8).

The Commission Internationale de l'Eclairage (CIE) established the CIELAB color space. This standardized system converts tristimulus values into a three-dimensional coordinate system comprising L*, a*, and b* values, thereby facilitating the quantification of color. The a* and b* coordinates represent the hue and chroma of a sample, with a* denoting the red-green axis and b* representing the yellow-blue axis. The lightness of a sample, denoted by L*, is measured on a scale ranging from 0 (absolute black) to 100 (absolute white). Furthermore, the total color difference between the two specimens can be calculated using the E value (9).

Color assessment can be undertaken through two distinct approaches: visual evaluation and instrumental measurement. The latter employs a spectrophotometer, which utilizes a standardized, integrated illuminant with a correlated color temperature of 6500 K. This device quantifies the amount and spectral composition of light reflected from the object, thereby generating precise, numerical data. Notably, spectrophotometers are more accurate than colorimeters as they are immune to the effects of object metamerism, which can lead to discrepancies in color perception (10). The VITA Easyshade V intraoral spectrophotometer (VITA Zahnfabrik, Bäd Sackingen, Germany) features a 5-mm probe tip that illuminates the tooth with a standardized 6500 K light source, facilitating accurate color matching. The device generates L*, a*, and b* values, which correlate with visual shade recommendations. Notably, a Dozic et al. (11) study demonstrated that the VITA Easyshade V exhibited superior accuracy compared to four other commercially available devices, establishing its reliability and precision in color measurement.

Ethical Considerations : The study ensured ethical standards were upheld by obtaining written consent from patients to use extracted front teeth. This demonstrated respect for patient autonomy and protected the participants' rights, which are crucial ethical principles in research involving human biological materials.

Exclusion criteria : Teeth with abnormal crown morphology (fused, chipped, fractured) or those that have undergone previous restorative treatment were excluded from the study to ensure a uniform and healthy sample population.

Methods

Natural Tooth Sample Preparation : An extracted anterior maxillary upper central incisor tooth was used as a standard reference and control group for comparing natural teeth with resin composite materials. The freshly extracted tooth was cleaned and rinsed under water to remove dirt or debris. It was then fixed onto a custom acrylic holder.

Imaging Technique : Cone Beam Computed Tomography (CBCT) was utilized to capture tooth images from various angles. This imaging technique allowed precise measurements of the tooth's enamel and dentin layers.

Measurements :CBCT was employed to measure the volume of the natural tooth sample's enamel and dentin layers.

Resin Mold Specimen Preparation : Transparent resin mold specimens were fabricated using resin composite materials to simulate the dentin and enamel layers of the natural tooth. These molds were shaped to match the volume and size of the intended tooth's corresponding dentin and enamel layers. The resin molds were designed to mimic the natural tooth structure for subsequent evaluations and comparisons.

Resin Composite Materials : The study utilized two resin composite materials: Shufo, a nano-hybrid composite from Tokyo, Japan, and Micerium, a micro-hybrid composite from Italy. The lightest enamel shades of these resin composites were selected to minimize any potential shading effects that could impact the translucency differences observed between the samples.

Light-Curing Device :A third-generation polywave light-emitting diode (LED) light-curing device, ZenoLite (President, Germany), with a wavelength range of 430–490 nm and a standard polymerization mode of 900 mW/cm², was used for curing the resin composite samples.

Sample Preparation : The samples were prepared by placing the active tip of the light source as close as possible to the middle of each specimen and polymerizing them for 40 seconds. Ten consecutive polymerization procedures were performed to ensure standardization, and the curing light output was verified using an LED radiometer. Ten samples were prepared for each group, and no finishing or polishing procedures were carried out to avoid any potential changes caused by these processes. Each specimen was inspected under 10x magnification, and any samples with irregular surfaces or voids were excluded and replaced with another sample.

Color Measurements : The test specimens' color measurements were obtained after they were kept in a dry, dark container at room temperature for 48 hours. A microspectro-diameter device (Ray-picker device Medical High Technologies, USA) was used to collect the measurements, and the device was calibrated according to the manufacturer's instructions before taking the readings.

The device's angle control system was employed to position it optimally on each sample, ensuring the proper angle of incidence between the optic handpiece and the target sample. The collected spectral data were converted into CIELAB coordinates using the provided software. The CIELAB coordinates of each sample were measured against a black background (L* = 1.48, A* = 0.02, and B* = 0.03). The L* coordinate represents lightness (0 [black] - 100 [white]), the A* coordinate indicates the redness (+a) - greenness (-a) color range and the B* coordinate represents the yellowness (+b) - blueness (-b) color range. The data were recorded in Microsoft Excel, and the mean of the readings for each sample (across the three planes: gingival, middle, and incisal) was calculated. The comparative values of each sample were obtained by calculating the color difference (ΔE*ab) against the black background.

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

Statistical Analysis : The data (L, a, and b) were not normally distributed, so a non-parametric test, the Kruskal-Wallis Test, was used instead of a parametric test like two-way ANOVA. Dunn's Test for Multiple Comparisons was then employed to identify the materials with significant differences based on their plane position (gingival, middle, incisal). The statistical significance level was set at a p-value less than 0.05 for all the tests.

Results : The CIE Lab* color coordinates measured at different positions (gingival, middle, and incisal thirds) on the natural tooth (control group) and two resin composite samples (SHUFO and MICERIUM) against a black background using a spectro-photometric device are presented in Table (1). The data includes the mean values, standard deviations, minimum and maximum values, and ranges for the three factors (Factor 1, Factor 2-A, and Factor 2-B) across the three groups, providing a detailed characterization of the color properties of the natural tooth and the resin composites.

Thi-Qar Medical Journal (TQMJ):Vol.(27),No.(1),2024
Web Site: https://jmed.utq.edu Email: utjmed@utq.edu.iq
ISSN (Print):1992-9218

Table (1). Descriptive Statistics

Factor 1	Factor 2	Factor 2-Sublevel	Mean	Std. Deviation	Minimum	Maximum	Range
Natural Control Group	Gingival Third	L	69.90	0.00	69.90	69.90	0.00
	Middle Third		70.40	0.00	70.40	70.40	0.00
	Incisal Third		64.40	0.00	64.40	64.40	0.00
	Gingival Third	A	2.30	0.00	2.30	2.30	0.00
	Middle Third		0.90	0.00	0.90	0.90	0.00
	Incisal Third		1.80	0.00	1.80	1.80	0.00
	Gingival Third	B	17.40	0.00	17.40	17.40	0.00
	Middle Third		11.60	0.00	11.60	11.60	0.00
	Incisal Third		11.90	0.00	11.90	11.90	0.00
SHUFO	Gingival Third	L	70.49	1.66	68.00	73.30	5.30
	Middle Third		76.10	0.99	74.00	78.00	4.00
	Incisal Third		70.47	0.79	69.00	71.70	2.70
	Gingival Third	A	3.58	0.44	3.00	4.00	1.00
	Middle Third		3.34	0.44	2.80	4.00	1.20
	Incisal Third		4.79	0.66	2.90	5.00	2.10
	Gingival Third	B	24.29	2.29	21.60	28.10	6.50
	Middle Third		11.95	0.68	11.00	13.70	2.70
	Incisal Third		16.45	0.88	15.00	17.40	2.40
MICE RIUM	Gingival Third	L	71.05	0.91	70.00	73.00	3.00
	Middle Third		74.52	1.03	73.50	76.40	2.90
	Incisal Third		75.19	1.09	73.50	76.90	3.40
	Gingival Third	A	3.03	0.55	2.50	4.00	1.50
	Middle Third		3.03	0.72	2.10	4.00	1.90
	Incisal Third		1.23	0.13	1.00	1.30	0.30
	Gingival Third	B	23.34	1.52	21.00	25.00	4.00
	Middle Third		20.95	1.12	19.00	22.00	3.00
	Incisal Third		11.85	0.31	11.00	12.00	1.00

The distribution for the Gingival zone is skewed towards lower lightness values, indicating darker shades in this area. The Middle zone exhibits a more normal distribution, with lightness values concentrated around the mean. The Incisal zone distribution is shifted towards higher lightness values, suggesting lighter shades in this region (Figure 1).

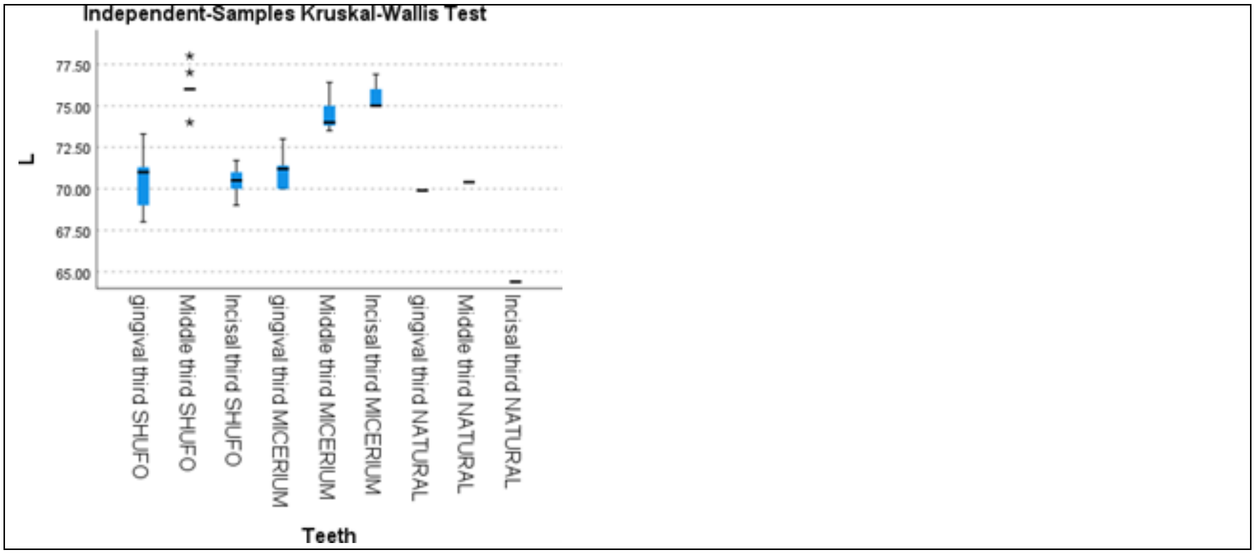

Figure (1). Distribution of lightness of teeth in Gingival, Middle, and Incisal zones

NATURAL had a significantly higher lightness in the incisal third zone than SHUFO and MICERIUM. Additionally, SHUFO had significantly higher lightness than MICERIUM in this zone. NATURAL had significantly higher lightness for the middle third zone than MICERIUM and SHUFO. However, this zone had no significant difference between MICERIUM and SHUFO (Table 2).

Table (2). Comparing the lightness factor of teeth in Gingival, Middle, and Incisal zones

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	P-Value	Adj. Sig. A
Incisal Third Natural Incisal Third Shufo	31.550	11.640	2.710	0.007	0.242
Incisal Third Natural Incisal Third Micerium	69.100	11.640	5.936	0.000	0.000
Gingival Third Natural Gingival Third Shufo	16.250	11.640	1.396	0.163	1.000
Gingival Third Natural Gingival Third Micerium	25.200	11.640	2.165	0.030	1.000
Gingival Third Shufo Gingival Third Micerium	-8.950	11.640	-0.769	0.442	1.000
Incisal Third Shufo Incisal Third Micerium	-37.550	11.640	-3.226	0.001	0.045
Middle Third Natural Middle Third Micerium	33.050	11.640	2.839	0.005	0.163
Middle Third Natural Middle Third Shufo	43.850	11.640	3.767	0.000	0.006
Middle Third Micerium Middle Third Shufo	10.800	11.640	0.928	0.353	1.000

As can be seen from Figure (2), the gingival zone exhibits the highest redness values, with a peak around 200-220 on the redness scale. The middle zone shows a broader distribution, with values ranging from 180 to 240 and a peak around 210-220. The incisal zone has the lowest redness values, concentrated primarily between 180 and 220, with a peak around 200.

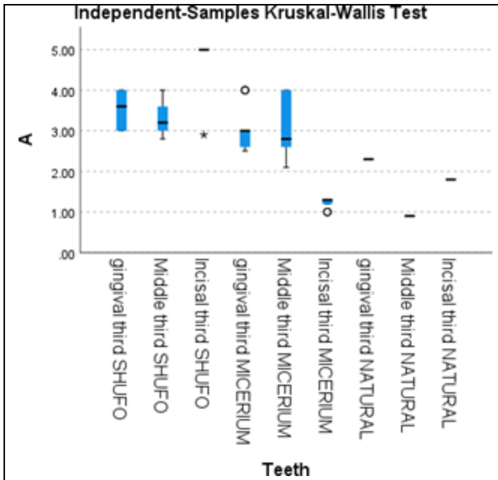

Figure (2). Distribution of redness of teeth in Gingival, Middle, and Incisal zones

Based on the data in Table (3), the middle third zone of natural teeth showed significantly higher redness than Micerium and Shufo materials. The incisal third zone of Shufo exhibited significantly higher redness than both natural teeth and Micerium. The gingival third zone of natural teeth showed marginally higher redness than Micerium and significantly higher redness than Shufo. The results indicate variations in tooth redness across different zones and materials, with natural teeth exhibiting higher redness in the middle and gingival thirds compared to the artificial materials tested.

Table (3). Comparing the redness factor of teeth in Gingival, Middle, and Incisal zones

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	P-Value	Adj. Sig. A
Middle Third Natural - Middle Third Micerium	50.150	11.620	4.316	0.000	0.001
Middle Third Natural - Middle Third Shufo	58.000	11.620	4.991	0.000	0.000
Incisal Third Micerium - Incisal Third Natural	-10.000	11.620	-0.861	0.389	1.000
Incisal Third Micerium - Incisal Third Shufo	67.000	11.620	5.766	0.000	0.000
Incisal Third Natural - Incisal Third Shufo	57.000	11.620	4.905	0.000	0.000
Gingival Third Natural - Gingival Third Micerium	20.150	11.620	1.734	0.083	1.000
Gingival Third Natural - Gingival Third Shufo	31.700	11.620	2.728	0.006	0.229
Middle Third Micerium - Middle Third Shufo	7.850	11.620	0.676	0.499	1.000
Gingival Third Micerium - Gingival Third Shufo	11.550	11.620	0.994	0.320	1.000

Figure (3) revealed that the gingival zone exhibits the highest yellowness values, with the distribution skewed towards the right, indicating more yellow teeth in this region. The middle zone has a more centralized distribution, suggesting moderate yellowness. The incisal zone distribution is shifted leftward, indicating lower yellowness values or whiter teeth in this area.

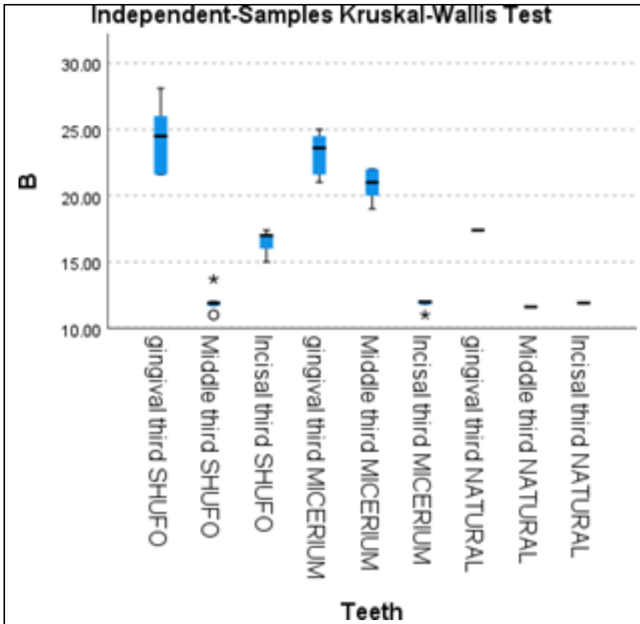

Figure (3). Distribution of yellowness of teeth in Gingival, Middle, and Incisal zones

The results show statistically significant differences in the middle third zone between NATURAL and MICERIUM and between SHUFO and MICERIUM, with MICERIUM having a higher yellowness factor. In the gingival third zone, there is a significant difference between NATURAL and SHUFO, with SHUFO exhibiting a higher yellowness factor. However, no significant differences were found in the incisal third zone among the three groups (Table 4).

Table (4). Comparing the yellowness factor of teeth in Gingival, Middle, and Incisal zones

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	P-Value	Adj. Sig. A
Middle Third Natural - Middle Third Shufo	15.300	11.635	1.315	0.189	1.000
Middle Third Natural - Middle Third Micerium	60.550	11.635	5.204	0.000	0.000
Middle Third Shufo - Middle Third Micerium	-45.250	11.635	-3.889	0.000	0.004
Incisal Third Natural - Incisal Third Micerium	2.700	11.635	0.232	0.816	1.000
Incisal Third Natural - Incisal Third Shufo	21.500	11.635	1.848	0.065	1.000
Incisal Third Micerium - Incisal Third Shufo	18.800	11.635	1.616	0.106	1.000
Gingival Third Natural - Gingival Third Micerium	22.750	11.635	1.955	0.051	1.000
Gingival Third Natural - Gingival Third Shufo	25.700	11.635	2.209	0.027	0.979
Gingival Third Micerium - Gingival Third Shufo	2.950	11.635	0.254	0.800	1.000

Discussion

Conversely, the dentin layer is pivotal in determining a tooth's color (12). Light traversal through dentin is more limited, and its optical properties are more heavily influenced by this tissue's organic content and tubular structure, which is approximately 20% less translucent than enamel (13).

The effectiveness of direct anterior restorations is contingent on their ability to seamlessly blend with the natural dentition in both form and appearance. To faithfully replicate the nuanced visual attributes innate to human teeth, practitioners must judiciously select from an array of restorative materials that span the spectrum from translucent to opaque. The varying degrees of transparency across different regions of the natural tooth necessitate a measured approach, as sections closer to the pulp often exhibit more excellent opacity than those nearer the enamel surface.

The results of this in-vitro study provide valuable insights into the color properties of different types of resin composites and natural teeth. The findings reveal that the mean color values for the NATURAL group are generally lower than those for the SHUFO and MICERIUM groups. Specifically, the NATURAL group has lower mean color values for the gingival third, indicating a more natural appearance. In contrast, the SHUFO and MICERIUM groups have higher mean color values, suggesting a more artificial appearance. The results also highlight the importance of considering the specific location within the tooth, as the color values vary significantly between the gingival, middle, and incisal thirds. These findings are consistent with those reported by Islam et al. (14), who stated that resin composites have different color properties than natural teeth. They also said that natural teeth and resin composite share three basic color parameters termed lightness (L*), chroma (C*), and hue (H*). Other color parameters such as opacity, translucency, fluorescence, and surface gloss necessitate optimization during the manufacturing process of resin-based composite materials.

The study's findings reveal distinct color properties across different tooth zones. The gingival zone exhibits darker shades, while the incisal zone displays lighter hues. The middle zone demonstrates a more balanced color distribution. These variations align with the natural tooth color gradients, emphasizing the importance of considering zonal differences in achieving optimal esthetic outcomes when using resin composites. This finding is in line with those reported by Mourouzis et al. (15), who stated that resin-based composites allow the grading of the color, ensuring an adequate restoration fitted to the tooth shad. Moreover, they reported that resin composites with higher diffused light transmission properties showed higher color shifting at the border for deep cavities. In contrast, for shallow cavities, the straight-line and diffused light transmission of resin composite affected the color shifting at the border.

Our investigation revealed that the resin composite samples also exhibited lower dry values. Notably, the natural dental tissues, especially the dry enamel, demonstrated the highest values across the study groups. This discrepancy could be attributed to several factors, including variations in the tubular structure of the dentin, the age of the samples, the specific location within the tooth from which the sections were obtained, differences in inorganic or organic content, and the method used to extract the teeth of different people.

The resin composites examined in our study, except the Micerium group (a micro-hybrid formulation), were composed of nanohybrid and nanofiller materials. In line with the findings of Paravina et al. (16), which indicated that most natural teeth correspond to the A shade within the

VITA classical shade system, particularly in the enamel region, we selected the lighter enamel shades for testing.

The findings suggest natural tooth enamel exhibits superior lightness properties compared to the tested resin composites, particularly in the incisal and middle third zones. While the nanohybrid materials (SHUFO and MICERIUM) demonstrated varied lightness, none matched the inherent luminosity of natural dentition. In line with the findings from this study, Islam et al. (17) stated that resin composites' optical and physical stability may vary according to filler characteristics. Clinicians should choose the composite based on the desired outcome. Moreover, they reported that resin composite restorative materials have superior aesthetic and functional properties over traditional dental amalgam. One of the main advantages of resin composite is its ability to match the natural color of teeth.

The study's findings indicate that the gingival zone exhibits the highest redness values, while the incisal zone has the lowest. The middle zone displays a broader distribution of redness values.

Based on our findings, the tested materials exhibited distinct CIE Lab values. Notably, all the values obtained were lower than those of natural dental tissues in the dry state. Among the resin composites evaluated, the Micerium group had the lowest mean dry values, while the Shufo group presented the second lowest.

The results demonstrate variations in the color properties of natural teeth and resin composite materials. Natural teeth exhibited significantly higher redness in the middle and gingival thirds than the Micerium and Shufo composites. The incisal third of the Shufo composite also showed higher redness than natural teeth. These findings highlight the need to match composite shades to natural tooth zones carefully.

The light enamel shade of the Micerium resin composite was observed to have lower transparency than the light enamel shade of the Shufo resin composite. As a result, our initial null hypothesis was rejected, which stated that there would be no difference in the translucencies of the tested resin composites. A similar study by Naeimi Akbar et al. (18) suggested that small particle size reduces resin composites' transparency when comparing enamel shade materials. However, based on their findings, information on the transparency of different shades of composite resins can be beneficial for clinicians in achieving optimal esthetic restorative outcomes.

The results show apparent variations in tooth yellowness across different zones. The gingival region exhibits the highest yellowness, with a right-skewed distribution indicating more yellow teeth in this area. In contrast, the incisal zone has a leftward-shifted distribution, signaling lower yellowness or a whiter appearance.

Prior research has revealed that resin composites labeled with the same Vita shade designation can exhibit significant disparities in their CIE Lab values despite a general trend of decreasing translucency across enamel and dentin-colored shades (19).

The results reveal significant variations in yellowness between materials in the middle and gingival zones. Micerium showed higher yellowness than natural teeth and Shufo in the middle third, while Shufo had greater yellowness than natural teeth in the gingival third. No differences were observed in the incisal zone.

Our findings align with the observation that although the Micerium and Shufo resin composites share a high light value enamel shade, their CIE Lab values differ significantly, with the natural tooth exhibiting lower translucency. Interestingly, the CIE Lab values of the natural tooth samples were not vastly dissimilar between the Micerium and Shufo groups. In a similar study, Ferraris et al. (20) reported that these new Universal Dentin shades have a high brightness (higher value) and are calibrated to match the fluorescence and opacity of natural dentin. Moreover, they stated that the high refractive index enamel composite exhibits different optical behavior than the traditional one. High refractive index enamel behaves more like natural enamel as the value also increases by increasing the thickness of the enamel layer.

Conclusion

The study's findings provide valuable insights into the color properties of different resin composites and natural teeth. The results demonstrate that natural tooth enamel exhibits superior lightness compared to the tested resin composites, particularly in the incisal and middle third zones. While the nanohybrid materials (SHUFO and MICERIUM) displayed varied lightness, none matched the inherent luminosity of natural dentition. Regarding redness, the gingival zone exhibited the highest values, while the incisal zone had the lowest. The middle zone displayed a broader distribution of redness values. Natural teeth exhibited significantly higher redness in the middle and gingival thirds than the MICERIUM and SHUFO composites. The study also revealed distinct variations in yellowness across different tooth zones. The gingival region exhibited the highest yellowness, while the incisal zone appeared whiter. Significant differences in yellowness were observed between materials in the middle and gingival zones. The findings highlight the importance of carefully matching composite shades to natural tooth zones to achieve optimal esthetic outcomes. The study underscores the need for further research and development in resin composite materials better to replicate the nuanced color properties of natural teeth.

References

1. Mackenzie L, Parmar D, Shortall ACC, Burke FJT. Direct anterior composites: a practical guide. Dent Update. 2013;40: 297-299.

2. Browning WD, Contreras-Bulnes R, Brackett MG, Brackett WW. Color differences: polymerized composite and corresponding Vitapan classical shade tab. J Dent. 2009;37 (suppl1):34-39.

3. Paravina RD, Kimura M, Powers JM. Color compatibility of resin composites of identical shade designation. Quintessence Int. 2006;37(9):713-719.
4. Terry DA, Geller W, Tric O, Anderson MJ, Tourville M, Kobashigawa A. Anatomical form defines color: function, form, and aesthetics. Pract Proced Aesthet Dent. 2002;14(1):59-67.
5. Kelly JR, Benetti P. Ceramic materials in dentistry: historical evolution and current practice. Aust Dent J. 2011;56(Suppl 1): 84-96.
6. Yu B, Ahn JS, Lee YK. Measurement of translucency of tooth enamel and dentin. Acta Odontol Scand. 2009;67:57-64.
7. Winter R. Visualizing the natural dentition. J Esthet Dent. 1993;5(3):102-117.
8. Lee YK, Lim BS, Rhee SH, Yang HC, Powers JM. Color and translucency of A2 shade resin composites after curing, polishing and thermocycling. Oper Dent. 2005;30:436-442.
9. Van Noort R. Introduction to Dental Materials. 4th ed. Edin burg: Elsevier Inc. Mosby Ltd; 2013:231-246.
10. Fahl N Jr. A polychromatic composite layering approach for solving a complex Class IV/direct veneer-diastema combina tion: Part I. Pract Proced Aesthet Dent. 2006;18(10):641-645.
11. Devoto W, Pansecchi D. Composite restorations in the anterior region: clinical and aesthetic performances. Pract Proced Aesthet Dent. 2007;19(8):465-467.
12. Akbar HM, Moharamzadeh K, Wood DJ, et al. Relationship between color and translucency of multishaded dental com posite resins. Int J Dent. 2012;2012:708032.
13. Vargas MA, Lunn PS, Fortin D. Translucency of human enamel and dentin. J Dent Res. 1994;73:320 AADR Abstracts (Abstract No. 1747).
14. (Islam, M. S., Huda, N., Mahendran, S., Aryal Ac, S., Nassar, M., & Rahman, M. M. (2023a). The blending effect of single-shade composite with different shades of conventional resin composites-an in vitro study. European Journal of Dentistry, 17(2), 342–348. doi:10.1055/s-0042-1744369.
15. Mourouzis, P., Koulaouzidou, E. A., Palaghias, G., & Helvatjoglu-Antoniades, M. (2015). Color match of resin composites to intact tooth structure. Journal of Applied Biomaterials & Functional Materials, 13(3), e259-65. doi:10.5301/jabfm.5000228.
16. Paravina RD, Majkic G, Imai FH, Powers JM. Optimization of tooth color and shade guide design. J Prosthodont. 2007;16(4): 269-276.
17. Islam, M. S., Nassar, M., Elsayed, M. A., Jameel, D. B., Ahmad, T. T., & Rahman, M. M. (2023b). In vitro optical and physical stability of resin composite materials with different filler characteristics. Polymers, 15(9). doi:10.3390/polym15092121
18. Naeimi Akbar, H., Moharamzadeh, K., Wood, D. J., & Van Noort, R. (2012). Relationship between color and translucency of multishaded dental composite resins. International Journal of Dentistry, 2012, 708032. doi:10.1155/2012/708032.
19. Paravina RD, Powers JM, Fay RM. Color comparison of two shade guides. Int J Prosthodont. 2002;15(1):73-78.
20. Ferraris, F., Diamantopoulou, S., Acunzo, R., & Alcidi, R. (2014). Influence of enamel composite thickness on value, chroma and translucency of a high and a nonhigh refractive index resin composite. The International Journal of Esthetic Dentistry, 9(3), 382–401. Retrieved from https://pubmed.ncbi.nlm.nih.gov/25126618.