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Comparative evaluation of shade matching of single, group and multi-shade composite material in acrylic teeth at two depths of preparation, using spectrophotometry- An In-vitro study

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ABSTRACT

Background: Buonocore bought about a revolution in restorative dentistry when he introduced the principle of bonding to teeth. Ever since, composite resin restoration materials have evolved in various regards. Recently, the concept of single-shade composites that show unique color matching abilities have been developed. Shade matching of composites is a time-consuming, and subjective process, and with the use of a universal shade that matches all teeth, the clinician would save on overall armamentarium and have reduced chair-side time. Thus, the objective of this in-vitro study is to evaluate the shade-matching ability of the single shade composite when compared with multi-shade and group-shade composite resin material.
Materials and methods: Three composite materials—Filtek Z350 XT (3M) a multi-shade composite, Synergy Duo D6 (Coltene) a group shade composite and Omnichroma (Tokuyama) a single shade composite, were placed into occlusal preparations. (5 mm diameter, 1.5mm and 3mm depth) on 18 acrylic teeth per each shade of A2 and A3. The composites were placed in a single increment and cured using LED light. The L*, a*, and b* readings were obtained using VITA Easyshade V for the acrylic teeth and restorations; mean ΔE00 values were calculated and assessed using two-way analysis of variance with a test of simple effects with multiple comparisons for significance ($P < .05$).
Results: In the spectrophotometric evaluation, Filtek Z350 XT showed the lowest ΔE00 values for both the shades and depths, whereas Omnichroma showed intermediate and similar ΔE00 values for both shades and depths and Synergy duo D6 showed the highest ΔE00 values.
Conclusion: Shade matching in composites is a challenge and universal shade can help in making the process easier. Overall, Filtek Z350XT matched the multiple shades better than the other two materials. However, Omnichroma did have favourable shade matching in both shades.
Keywords: Shade matching, Omnichroma, Synergy duo D6, Universal composite, Posterior composites.

INTRODUCTION

In everyday practice, composite is the most used aesthetic restorative material. It's used for direct and indirect restorations, diastemas closure, cementation, and build-up. [1-9] Due tomaterial science advancements in the form of nano-filled resins, improved filler loading, and newer activator-initiator systems, composite resin restoration materials in dentistry have found an array of applications. It is extremely difficult to find accurate systems that can assist the clinician in matching the color of the composite restorative material. There are various methods of shade

matching systems and a few of them are discussed as follows- Custom shade tabs:the shade guides provide printed formulas or recipes with most composite kits. As a result, stock shade guides do not reveal the true shade, translucency, or opacity of the composite resin. Hence, a more ideal solution to address the issue is to make a custom shade guide out of the resin itself. Fabrication of custom shade guides was previously a time-consuming and inefficient method.[1] Prefabricated shade guides:the VITA Classical Shade Guide is the most universally used shade guide and widely used guide. VITA (VITA-Zahnfabrik in Bad Säckingen, Germany), still produces this guide, which was first introduced in 1927. The manufacturer never developed this guide using a rational, systematic, or empirical method based on a selection of recognized human tooth shades. In addition, the drawback of this shade guide is that it has been confirmed to cover only 6% of the color spectrum of human teeth. [2]

The polychromatic nature of natural teeth makes shade selection more challenging. [10] Since natural teeth vary in color, manufacturers created composites systems with multiple shades, sometimes using the Vita Classical shade guide as a reference. [11]

Furthermore, resin composites are available in a variety of opacities, which are commonly referred to as dentin, opaque or body, and enamel and are intended to emulate the optical properties of dentin and enamel. [12] However, finding a perfect combination of materials to match the optical properties of the tooth in aesthetic areas is a difficult task. As shade guides use value-based systems and others use chroma-based systems.

However, among the most experienced practitioners, placing tooth-colored direct composite restorations is a clinical challenge. Aside from the technique sensitivity involved in adhesive bonding, choosing a hue that consistently suits the natural tooth, whether single or layered, can be extremely difficult.Requirements for shade selection are as follows [3]-

1. The best time to choose shade is during the middle of the day, when the light is most balanced and all the bright light is eliminated from the working area.
2. To avoid eye fatigue, one should not look at the shade comparison for more than 7 seconds.
3. When choosing a shade, the clinician should stand 28-33 cm away from the patient.
4. Shade should be determined when the teeth are at their most hydrated, as dehydration reduces enamel translucency by 82 percent, leading to clinician misinterpretation.
5. Shade comparisons should be done between the hours of 10 a.m. and 2.m. when the color temperature is around 5500 K, and then under color corrected light to ensure accuracy of the match.
6. Shade tabs should be placed above or below the tooth to be matched during the shade comparison; never place shade tabs adjacent to the tooth to avoid the binocular effect.
7. Value is always examined first, followed by chroma, and finally hue.
8. Shade selection should not be done right after bleaching; instead, the patient should be recalled for a shade comparison after 2-3 weeks.
9. Teeth should always be divided into three regions when choosing a shade. Gingival area (provides accurate dentinal chroma determination), Body area, and Incisal area (enamel is thickest here and varies from translucent to transparent)
10. The tooth should always be cleaned with prophylaxis paste before choosing a shade.

The tendency of a substance to obtain a color identical to that of its surrounding tooth structure is referred to as the "blending effect" (BE) or "chameleon effect." [13-14] As a result, composite materials with altered optical properties and a reduced number of shades have been created. Omnichroma is the first “omnichromatic” composite material where one shade of composite will virtually match any shade on any patient. Studies conducted by Sanchez et al showed that omnichroma possessed the best color mating potential compared to other composites.

The word "single-shade composite" is used in this study to refer to a composite material that is available in a single universal shade and has been designed to blend with all 16 VITA classical shades, resulting in a shade match for every tooth color. A “group-shade composite” refers to a composite scheme of fewer shades, each of which is used for a specific collection of VITA classical shades. A composite system with a composite shade for each of the 16 VITA classical shades is referred to as a "multi-shade composite.” [15]

This study would use the formula developed by CIE (Commission Internationale de l'Eclairage), which transforms a sample's color values into L*, a*, and b* coordinates, allowing color to be quantified. L* denotes the sample's lightness, which ranges from 0 (black) to 100 (white); a* and b* denote the sample's hue and chroma values; a* denotes the red (+)/green () coordinate, and b* denotes the yellow (+)/blue () coordinate.[15] The total color difference between two specimens is represented by ΔE.[16] The purpose of this study was to evaluate and compare the shade matching ability of the single, group, and multiple-shade composite resin restorative materials to acrylic teeth at two depths of preparation, instrumentally using a spectrophotometer.

MATERIALS AND METHODOLOGY

Study design: In-vitro study
Study Location: This study was performed in the Department of Conservative Dentistry and Endodontics, Y.M.T Dental College and Hospital, Kharghar, Navi Mumbai, India.
Study Duration: December 2021 to June 2022.
Sample size: 216 acrylic teeth

Procedure methodology:
The shade match of the three composite materials was tested relative to acrylic teeth of two different shades (A2, A3) at two different depths using instrumental readings.

The commercially available composite materials as shown in fig 1 was evaluated in this study. OM (Tokuyama Dental, Japan) is a single-shade material, with composition and optical properties that enable it to blend in with the entire spectrum of tooth color, from A1 to D4.SYNERGY® Duo Shade Nano Composite (Coltene) has a special feature that is a duo-shade system which applies to 6 of the dentin shades. Thanks to the excellent optical self-blending properties one duo shade matches 2 Vita™ shades this allows the system to achieve a shade match with the full range of VITA shades. Filtek™ Z350 XT Universal Restorative Composite is a multi-shade composite available in 36 shades and 4 opacities. In this study, a total of 216 molar acrylic teeth were used to evaluate shade matching of three different composite materials at two different depths of 1.5 mm and 3 mm. The two shades chosen by order of value were A2 and A3. Thus, the groups were as follows**Group 1-Shade A2:***Subgroup 1*: Filtek Z350 XT 1.5mm depth, *Subgroup 2*: Synergy Duo 1.5mm depth, and *Subgroup 3*: Omnichroma 1.5mm depth; **Group 2- Shade A2:***Subgroup 1*: Filtek Z350 XT 3.0 mm depth, *Subgroup 2*: Synergy Duo 3.0mm depth, and *Subgroup 3*: Omnichroma 3.0mm depth; **Group 3-Shade A3:***Subgroup 1*: Filtek Z350 XT 1.5mm depth, *Subgroup 2*: Synergy Duo 1.5mm depth and *Subgroup 3*: Omnichroma 1.5mm depth. **Group 4-Shade A3:***Subgroup 1*: Filtek Z350 XT 3.0mm depth, *Subgroup 2*: Synergy Duo 3.0mm depth and *Subgroup 3*: Omnichroma 3.0mm depth. Each subgroup had 18 acrylic teeth each, thus making it a total of 216 teeth in all. The acrylic teeth replicated the natural teeth as closely as possible and make the color readings more realistic. The color parameters (L, a, and b values) of the acrylic teeth were measured on the flat buccal surface (Baseline measurement of an unrestored tooth) using an intraoral spectrophotometer (VITA Easyshade V, VITA Zahnfabrik, BädSackingen, Germany). Circular preparations, of 1.5 mm and 3 mm in depth (measured at the lingual groove on the occlusal surface) and 5 mm in diameter, were cut on the occlusal surfaces of all the teeth using a No. 245 carbide bur.

The composites were applied in a single increment, and the occlusal surface of the restoration was flattened to allow the measurement of shade by the spectrophotometer as shown in figure 2. This was the closest approximation to the flat buccal surface from which the Baseline reading was taken. The composite restorations were polymerized with a light-curing unit for 20 seconds. Color parameters of the restorations were measured using the intraoral spectrophotometer by placing its measuring tip perpendicular to the occlusal restoration. Readings were taken for each composite restoration of each shade, and the values were averaged as a single data point. The parametric factors of the formula were set to 1. A ΔE00 value greater than 1.8 was chosen to indicate a clinically unacceptable match. The ΔE values obtained for each shade were averaged to obtain one mean ΔE00 value for each of the two shades at two different depths of the three composite materials.

Statistical analysis: Mean ΔE00 values were compared to assess which of the three materials was the closest match for each shade of the acrylic teeth using a two-way analysis of variance (ANOVA) test to determine if there was a significant difference for material vs shade or an interaction between them. A test of simple effects using estimated marginal means was used to make pairwise comparisons with a Bonferroni adjustment at $P < .05$ for significance.

Fig no 1: Armamentarium

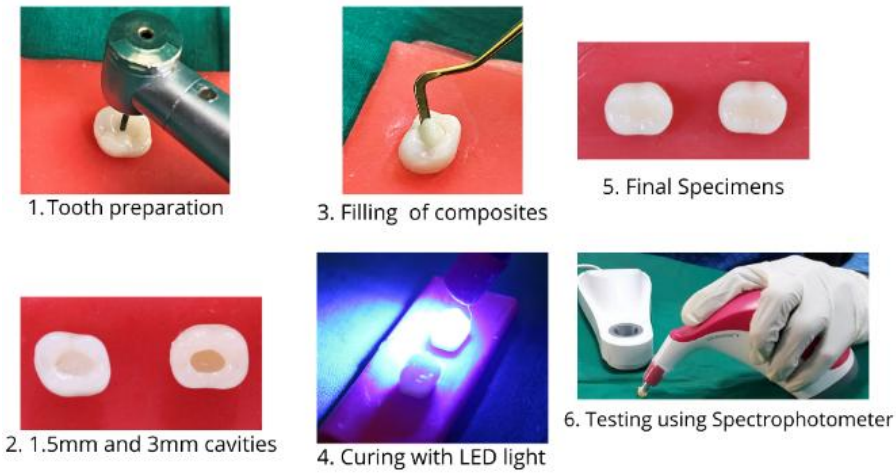

Fig no 2: Methodology

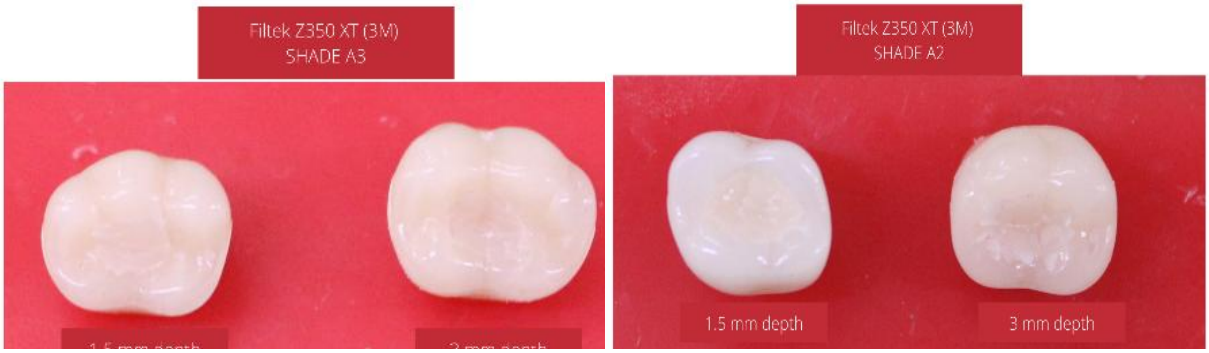

Fig no 3 and 4: Use of Filtek Z350 XT composite

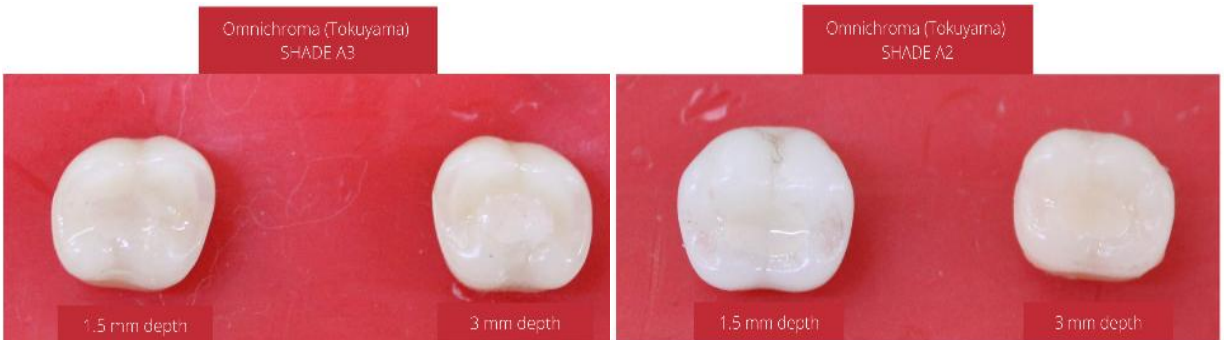

Fig no 5 and 6: Use of Omnichroma composite

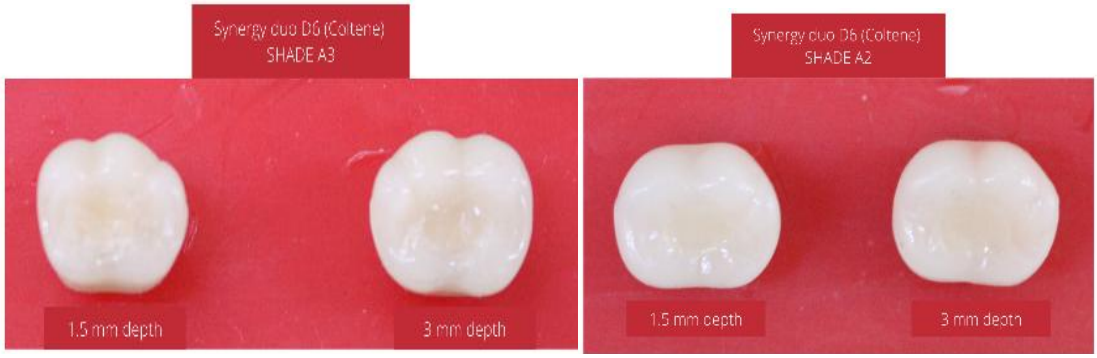

Fig no. 7 and 8: Use of Synergy Duo composite

RESULTS

Mean color differences (ΔE00) between baseline tooth and restored composite for each of the two shades at two depths of the three composite materials are presented in Table I and Fig 9 and 10.

The two-way ANOVA revealed a significant difference between materials ($P < .001$), a significant difference between shades ($P < .001$), and a significant interaction between materials at different depths ($P < .001$). When the ΔE00 values for the two shades of the three composite materials were compared using the simple effects tests for multi-comparison (Table 1), for shade match within each material, Omnichroma showed a shorter range of color difference (6.6-10.8) than either SD (16.4-22.9) or Filtek Z350XT (0.7-9.8). In general, Filtek Z350 XT showed a trend for lower ΔE values for both shade A2 and A3 at both depths of preparation, as compared to Omnichroma and Synergy duo D6. Synergy duo D6 had the highest ΔE values indicating a poor color match.

Table no 1: Mean color differences(ΔE00) for the two shades at two depths of the three composite materials tested in the study

BRAND	SHADE A2		SHADE A3	
	1.5mm	3.0mm	1.5mm	3.0mm
Filtek Z350 XT- 3M ESPE	6.6	0.7	9.8	5.4
Synergy D6- Coltene	19.4	16.4	20.6	22.9
Omnichroma- Tokuyama	8.9	6.6	10.8	9.9

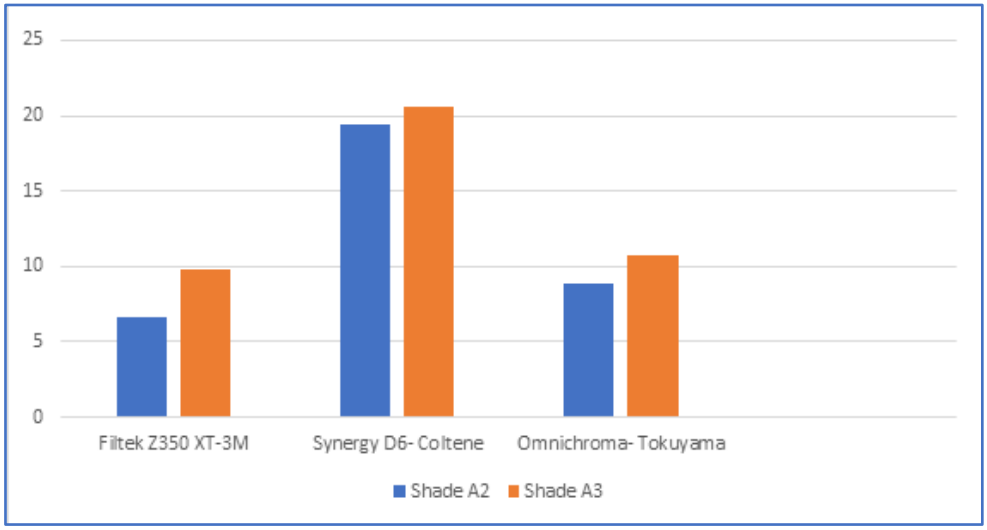

Fig no 9: ΔE values for three composites at 1.5mm depth.

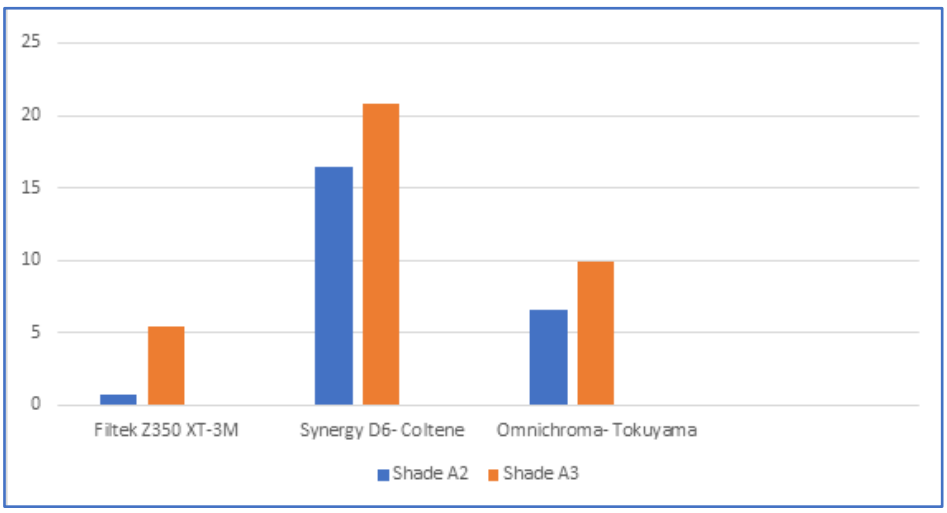

Fig no 10: ΔE values for three composites at 3mm depth.

Discussion

Color matching is paramount for the success of resin composite aesthetic restorations.[17]Successful determination and transfer of color to an aesthetic reproduction of the natural dentition requires an understanding of the inter-relationship of optical properties and the anatomical morphology of the teeth. The results from the present study showed significant differences in color matching between the multi-shade and single-shade universal composites, for all chosen teeth shades and at all depths of preparation. It demonstrated that single shade composites showed acceptable color matching in posterior restorations and overperformed group shade composites however multi-shade composites still outshined and proved to be the most reliable and aesthetic material for restoring teeth. This can be attributed to the nano-composite nature and to the wide range of shades and opacities provided by Filtek Z350 XT which help in better replicating the natural tooth color and translucency. [18] Dentin and Enamel have dramatically different optical properties and the relative contribution of each should be considered separately during the fabrication of aesthetic restoration. [19] Synergy Duo which functions on this property of natural teeth had the weakest match and its dual shade nature failed to satisfactorily match the opacities of the teeth and the blending at the margin of the restoration was the poorest of the three materials. A possible explanation for obtaining these results could lie in the use of acrylic teeth which lack layering as seen in dentin and enamel on which the nano-filled dual shade composite system claims to operate. The information provided is of great importance to fulfilling partially the lack of data regarding the use of this new generation of universal composites in posterior restorations at different thicknesses.

Recently introduced single-shade universal resin composite (Omnichroma, Tokuyama Dental, Tokyo, Japan), supposedly matches all Vita Classical shades (Vita, Vita Zahnfabrik, BadSäckingen, Germany), from A1 to D4. According to the manufacturer, this ability can be achieved due to the inclusion of uniformly sized 260 nm spherical fillers in the composite, which could generate red to- yellow color as ambient light passes through the composite, which has been patented as Smart Chromatic Technology.[20] The results from the present study evidenced the intermediate color match values for instrumental evaluation for Omnichroma composite in comparison to the other groups, without significant differences between the denture teeth shades tested (A2, and A3), which were demonstrated to be the most frequent Vita shades for posterior teeth.[21] Although these findings may show some potential of this resin composite to blend similarly to different shades, there is a significant concern regarding its translucency parameter (TP), which could be improved for allowing better mimic of the resin composite with the adjacent tooth substrate in restorations. One possible solution for this issue may be a “blocker” developed by the manufacturer that could be used in class III restorations, which may have the potential to compensate the dark background of the oral cavity. A study by Lucena C et al[22] evaluated the optical behaviour of this single shade composite to determine its Translucency parameter at different depths and concluded that with increase in thickness of restoration, translucency decreased and Omnichroma showed the highest ΔTP values. Sanchez et al evaluated the instrumental and visual color adjustment potential (CAP-I and CAP-V) of five composites (Omnichroma [OM], Filtek Supreme Ultra, TPH Spectra, Herculite Ultra, and TetricEvoCeram [TE]) across the 16 VITA classical A1-D4 shades.

They found that Omnichroma (a single-shade material) had a more positive CAP-I and CAP-V than the other materials which had been developed for specific shades. This meant that Omnichroma blended in with the surrounding tooth structure, resulting in a reduced color difference between the two [20] These results are in accordance to our in-vitro study and further potentiate Omnichroma as a promising restorative material in the field of aesthetic dentistry. However, results from an analysis of the color matching of universal resin composites in anterior restorations performed by Abreu et al were not in favour of Omnichroma. A possible explanation for the difference in result could lie in the methodology adapted i.e., the use of restorations in anterior denture teeth which have a different optical behaviour as compared to the posterior segment of the dental arcade. The improper level of translucency in anterior restorations can be more affected by the dark background of the oral cavity, resulting in greyish restorations. This aspect was addressed in our in-vitro study by choosing two different thickness for the composite restoration thus evaluating the effect of the color of the cavity floor on the shade of the material. Tsubone et al evaluated color shifting of composites at different depths of preparation and concluded that a minimum thickness of resin composite of over 2.56 mm is required in order to avoid unfavourable color changes by the background color.[23] The results obtained in our study are in accordance with this finding as the ΔE values for 3mm preparation are significantly lower as compared to 1.5mm.

Another deciding factor was the method of measurement. Spectrophotometric analysis was chosen for this study as it is amongst the most accurate, useful and flexible instruments for overall color matching in dentistry[24] Compared with observations by the human eye, or conventional techniques, it was found that spectrophotometers offered a 33% increase in accuracy and a more objective match in 93.3% of cases.[25] They are more reliable than colorimeters, as they are not affected by object metamerism[26] VITA Easyshade V (VITA Zahnfabrik, BädSackingen, Germany) is an intraoral spectrophotometer that provides reliability and accuracy as documented in

a study done by Dozic et al, which found VITA Easyshade to be the most precise among five other commercially available devices, both in vitro (VITA shade tabs) and in vivo. [27]

The choice of acrylic denture teeth as specimens was made to avoid subjective bias in selection of natural teeth of the said shade. Extracted human teeth also lack lustre and translucency and would thus negatively affect the results. Abdelraouf et al [28] assessed the color match and BE of a universal shade composite (X-TraFil) placed in composite resin models of different shades (Grandio; A1, A2, A3, A3.5, and A4) and cavity sizes, and in natural teeth and found a satisfactory shade match in patients. However, the selection of baseline shade of the natural human teeth for comparison would be subject to investigator bias and lead to skewed and unfair results. To avoid this prejudice, standardized and pre-determined shades of denture teeth were selected in this in-vitro study.

In conclusion, this in-vitro analysis of shade matching will prove significant in the use of single-shade composites and help better understand its performance and functionality for composite restorations in patients with aesthetic needs.

Further studies should be performed to evaluate these composites in other parameters, such as TP, optical scattering, and color stability. The in-vivo analysis of this novel composite can also help its use further and clinical studies to enforce the conclusions of this in vitro analysis are needed.

CONCLUSION

The use of single shade composite showed favourable results and thus can be used in restoration of teeth. The shade matching ability of Omnichroma was better than Synergy Duo D6, and hence reduces clinicians chair-side time, armamentarium and subjectivity in shade selection.

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