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Comparison of Optical Properties of Laminate Veneers Made of Zolid FX and Katana UTML Zirconia and Lithium Disilicate Ceramics

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A B S T R A C T

Objectives: This study aimed to compare the optical properties of Zolid FX, Katana UTML, and lithium disilicate laminate veneers.

Materials and Methods: In this in-vitro experimental study, the maxillary left lateral incisor of a phantom received a laminate veneer preparation. An impression was made, and a die was fabricated using dental stone. The die was scanned using a computer-aided design/computer-aided manufacturing scanner. Ten dies were fabricated from each of the A1, A2, and A3 shades of composite resin. Laminate veneers were fabricated using A1 shade of Katana UTML, Zolid FX, and IPS e.max CAD ceramics (n=10) and placed on composite abutments using bleach and white colors of trial insertion paste (TIP). The optical properties were measured at the incisal, middle, and cervical thirds using a spectrophotometer. Data were analyzed using three-way analysis of variance and Tukey's test.

Results: The effect of laminate material on the L*, a*, and b* parameters was significant in all areas ($P<0.001$), except for the L* parameter in the middle and cervical thirds. All color parameters were affected by TIP color in all three regions in most samples ($P<0.05$). The effect of composite abutment shade was also significant in most cases ($P<0.05$). The effect of laminate material, abutment shade, and TIP color on the b* parameter was significant ($P<0.001$). The L* parameter was almost the same in the two zirconia and lithium disilicate ceramic groups.

Conclusion: The composite abutment shade, TIP color, and laminate material should be carefully selected to achieve optimal aesthetics in laminate veneers.

Keywords: Laminate Veneers; Zirconia; Optical Properties; Ceramics

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INTRODUCTION

Due to the complex optical properties of natural teeth, achieving optimal color match and favorable aesthetics in use of dental restorations has always been challenging for dental clinicians. Successful fabrication of aesthetic restorations requires adequate knowledge about the instructions for use and optical properties of dental materials [1,2].

On the other hand, tooth preparation for a prosthetic crown requires removal of a large amount of tooth structure (63% to 73%) [3] and can cause pulpal irritation and even irreversible pulpitis [4]. Laminate veneers are more conservative than prosthetic crowns in this regard [5] and their application, whenever possible, can better preserve the biomechanics of the teeth. The pattern of stress distribution in laminate veneers is similar to that in prosthetic crowns and they reportedly have a 93% clinical success rate during 15 years of clinical service [6].

Since the introduction of ceramic restorations in the 20th century, restoring the natural aesthetic appearance of the teeth has been a challenge for dental clinicians [7]. In metal-ceramic restorations, light reflection from the opaque porcelain, which is used to mask the metal, confers an opaque appearance to the teeth. Thus, these restorations have limitations for use in the aesthetic zone [8]. Use of ceramic restorations without a metal framework results in better passage of light and consequently superior aesthetics [9]. Despite the optimal aesthetics of ceramics, they are brittle, and thus, the demand for stronger ceramic restorations has increased. For this purpose, high-strength zirconia-based ceramics fabricated by the computer-aided design/computer-aided manufacturing (CAD/CAM) technology are gaining increasing popularity [10].

Zirconium oxide is increasingly used in dental restorations [11,12]. It has excellent physical, mechanical, biological, and chemical properties [13]. Zirconia laminate veneers fabricated by the CAD/CAM technology can be very thin (0.2 to 0.3 mm) and are therefore perfectly suitable for clinical management of a wide diastema or a broken tooth (due to trauma or caries) with a sound lingual surface. In teeth that have lost a large portion of their structure and require a restoration thickness >2 mm, a zirconia core is used to support the veneering porcelain. Otherwise, the conventional feldspathic porcelain cannot serve the purpose, and a prosthetic crown would be the only available choice. Feldspathic veneers cannot be used in areas under parafunctional occlusal forces as in edge-to-edge occlusion or reverse overjet, which create stress during function [14]. The conventional porcelain veneers are brittle, and their adaptation and contouring before cementation are difficult. However, due to the high strength of zirconia, adjustment of the veneering before cementation is easy [15].

Zirconia is often the material of choice in restorative dentistry due to its excellent mechanical properties. However, due to high density, the presence of chemical elements, and high crystallinity, it has a high refractive index and is rather opaque [16,17]. Thus, fabrication of anatomical zirconia restorations is limited due to the low translucency of zirconia, which is much lower than the translucency of lithium disilicate ceramics. The conventional standard zirconia has 70% of the translucency of lithium disilicate ceramics [18].

Determination of color parameters and achieving optical color match are important in cosmetic dentistry. Color match is among the most valuable parameters taken into account by patients when judging the quality of their dental restorations. Thus, achieving an excellent color match between the restoration and adjacent natural teeth is a major goal in restorative dentistry. For this purpose, dental clinicians should have a full understanding of all factors related to the color of teeth and restorative materials [19]. Achieving an optimal color match requires a successful clinical and laboratory performance in fabrication of restorations [20]. Since the enamel and dentin have natural translucency, it is important to mimic their optical properties when fabricating a restoration. Special attention must be paid to translucency in addition to the morphology and surface topography of restorations [21].

In recent years, some new zirconia ceramics, such as Zolid FX and Katana UTML, have been introduced to the market. The manufacturers claim that they can provide optimal translucency even in low thicknesses as in laminate veneers. Given that the claims of the manufacturers are true and these zirconia ceramics can provide a translucency comparable or superior to that of lithium disilicate ceramics, they can serve as a suitable alternative to lithium disilicate ceramics due to their higher mechanical properties and fracture strength. Moreover, they require a more conservative tooth preparation since they have a higher capability in masking the underlying color, which is a great advantage. Considering the gap of information regarding the use of zirconia for laminate veneers, this in-vitro study aimed to compare the optical properties of laminate veneers fabricated from two types of zirconia and lithium disilicate ceramics.

MATERIALS AND METHODS

In this in-vitro experimental study, the sample size was calculated to be 10 in each group according to a previous study [22] assuming 90% study power. According to Alghazzawi et al [22], the maxillary left lateral incisor of a phantom received a laminate veneer preparation. Prior to preparation, an index was obtained from the tooth to standardize the thickness of laminate veneers to be fabricated. The preparation included 1.5 mm of incisal reduction and 0.5 mm of buccal reduction (Fig. 1).

Fig. 1. Preparation of laminate veneer restoration

An impression was made of the tooth using silicone elastomeric impression material (Speedex Putty, Speedex Light Body; Colténe/Whaledent AG, Altstätten, Switzerland). A die was poured with type IV dental stone. The die was then scanned by a CAD/CAM scanner (InLab MC XL, Dentsply Sirona, Cologne, Germany). Ten dies were fabricated from each of the A1, A2, and A3 shades of composite resin (a total of 30 dies; Paradigm MZ 100; 3M ESPE, St. Paul, MN, USA; Fig. 2) [22].

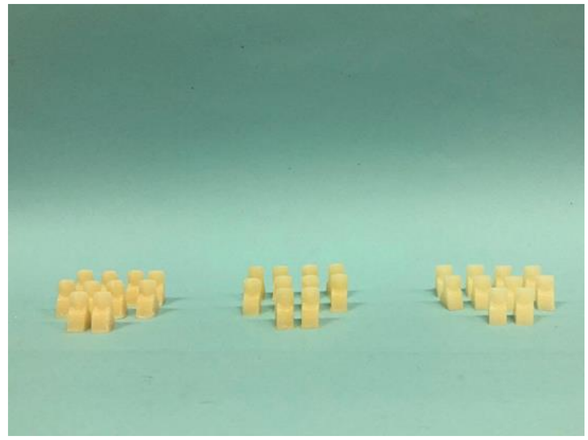

Fig. 2. Resin dies (A1, A2, and A3 from right to left)

Next, 10 laminate veneers were fabricated from the A1 shade of Katana UTML (Kuraray Noritake Dental Inc., Miyoshi, Japan), 10 laminate veneers were fabricated from the A1 shade of Zolid FX Multilayer (Amann Girrbach AG, Koblach, Austria), and 10 laminate veneers were fabricated from the A1 shade of lithium disilicate ceramic IPS e.max CAD (Ivoclar Vivadent AG, Schaan, Liechtenstein; Fig. 3).

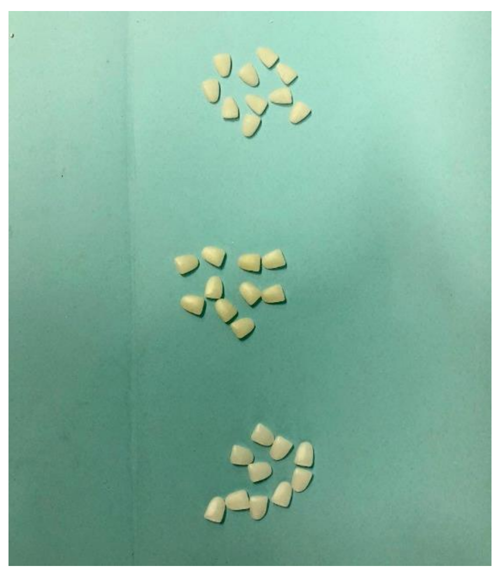

Fig. 3. Laminate veneers (IPS e.max, Katana UTML, and Zolid FX from top to bottom)

The trial insertion paste (TIP; Variolink II;

Ivoclar Vivadent Inc., Schaan, Liechtenstein) in two colors of bleach and white was used to simulate the cement color. Next, the laminate veneers fabricated of different materials were placed on abutments made of different shades of composite resin using the two TIP colors. The optical properties of the samples were measured at the incisal, middle, and cervical thirds using a spectrophotometer (Vita. Easyshade, Vident, Brea, CA, USA).

Data were analyzed using SPSS version 25 (SPSS Inc., Chicago, IL, USA). The mean values of L*, a*, and b* color parameters were calculated based on the laminate material, TIP color, and composite abutment shade in the cervical, middle, and incisal thirds.

Three-way analysis of variance (ANOVA) was applied to assess the effect of laminate material, TIP color, and composite abutment shade on the optical properties of the laminate veneers.

Pairwise comparisons of laminate materials were made using the Tukey's multiple comparisons test. The level of significance was set at 0.05.

RESULTS

The a parameter:*

Table 1 presents the mean values of the a* parameter in the cervical third, middle third, and incisal third for the three laminates, composite abutment shade, and TIP color.

Table 1. Mean value of the a* parameter in the cervical third, middle third, and incisal third for the three laminate materials, composite abutment shade, and trial insertion paste (TIP) color (n=10)

Laminate material	Abutment shade	TIP color	Mean±SD (cervical third)	Mean±SD (middle third)	Mean±SD (incisal third)
Lithium disilicate	A1	Bleach	-0.83±0.74	-1.05±0.36	-0.57±0.64
		White	0.51±1.13	-0.12±1.37	0.59±1.35
	A2	Bleach	-0.77±0.49	-0.96±0.31	-0.71±0.32
		White	0.52±1.69	0.14±1.11	0.77±1.42
	A3	Bleach	-0.19±0.36	-0.54±0.49	-0.37±0.41
		White	0.43±1.01	-0.51±0.36	-0.08±0.57
Katana UTML	A1	Bleach	-1.7±0.53	-1.44±0.42	-1.16±0.37
		White	-1.28±1.16	-1.49±0.45	-1.3±0.39
	A2	Bleach	-1.32±0.34	-0.95±0.44	-0.93±0.42
		White	-1.43±0.46	-1.16±0.51	-1.21±0.37
	A3	Bleach	-1.24±0.44	-0.96±0.4	-0.76±0.55
		White	-1.42±0.34	-1.33±0.23	-1.06±0.49
Zolid FX	A1	Bleach	-0.46±0.29	0.07±0.23	0.4±0.31
		White	.0.24±0.32	0.61±0.25	0.93±0.49
	A2	Bleach	0.11±0.69	0.31±0.49	0.36±0.47
		White	-0.32±0.37	0.23±0.39	0.66±0.44
	A3	Bleach	-0.02±0.46	0.3±0.27	0.51±0.37
		White	-0.37±0.55	.0.12±0.41	0.39±0.57
P-values					
Three-way ANOVA	Laminate		<0.001	<0.001	<0.001
	TIP		0.001	0.025	0.001
	Abutment		0.676	0.218	0.891
	Laminate vs TIP		<0.001	<0.001	<0.001
	Laminate vsAbutment		0.801	0.333	0.240
	Abutment vs TIP		0.011	0.006	0.024
	Laminate vs TIP vs Abutment		0.538	0.192	0.317

SD: Standard Deviation, TIP: Trial Insertion Paste, ANOVA: Analysis of Variance

Mean value of the a parameter in the cervical third:*

According to three-way ANOVA, the effect of laminate material (P<0.001) and TIP color (P<0.001) on the a* parameter in the cervical third was significant but the effect of composite abutment shade on the a* parameter was not significant (P=0.68). The interaction effects of laminate material and color (P=0.8) and laminate material, composite abutment shade, and TIP color (P=0.54) on the a* parameter were not significant. However, the interaction effects of laminate material and TIP (P<0.001) and composite abutment shade and TIP color (P<0.01) on the a* parameter were significant in the cervical region. Since two-way ANOVA revealed that the interaction effect of laminate material and TIP (P<0.001) on the a* parameter was significant, subgroup analysis was carried out to compare different laminates based on the color of the TIP. The results showed that all pairwise comparisons of the three types of laminates were significant for both bleach and white colors of the TIP (P<0.05).

Mean value of the a parameter in the middle third:*

The effect of laminate material (P<0.001) and TIP color (P<0.03) on the a* parameter was significant in the middle third but the effect of composite abutment shade was not significant (P=0.22). The interaction effects of laminate material and abutment shade (P=0.33) and laminate material, abutment shade, and TIP color (P=0.19) on the a* parameter in the middle third were not significant either. However, the interaction effects of laminate material and TIP color (P<0.001) and composite abutment shade and TIP color (P<0.006) on the a* parameter in the middle third were significant. Subgroup analysis of different laminate types based on the TIP color was then performed, which revealed that the differences between Zolid FX and lithium disilicate and between Zolid FX and Katana UTML were significant concerning the bleach color of the TIP (P<0.001). However, the difference between lithium disilicate and Katana UTML was not significant (P=0.19). All pairwise comparisons of the three laminate types were significant for the white color of the TIP (P<0.05).

Mean value of the a parameter in the incisal third:*

The effect of laminate material (P<0.001) and TIP color (P<0.001) on the a* parameter in the incisal third was significant but the effect of composite abutment shade was not significant (P=0.89). The interaction effects of laminate material and composite abutment shade (P=0.24) and laminate material, composite abutment shade, and TIP color (P=0.32) on a* parameter in the incisal third were not significant either. But the interaction effects of laminate material and TIP color (P<0.001) and also composite abutment shade and TIP color (P=0.02) on the a* parameter in the incisal third were statistically significant. Pairwise comparisons revealed significant differences in this respect between lithium disilicate and Katana UTML (P<0.001), between Katana UTML and Zolid FX (P<0.001), and between lithium disilicate and Zolid FX (P<0.001). Subgroup analysis of the three laminate types for different colors of the TIP revealed that all pairwise comparisons of the three laminate types were significant for the bleach color of the TIP (P<0.05). With the white color of the TIP, the difference between Zolid FX and lithium disilicate was not significant (P=0.466). However, the differences between Zolid FX and Katana UTML and between lithium disilicate and Katana UTML were significant (P<0.001).

The b parameter:*

Table 2 presents the mean value of the b* parameter in the cervical third, middle third, and incisal third for the three laminate materials, composite abutment shade, and TIP color.

Mean value of the b parameter in the cervical third:*

The effect of laminate material (P<0.001), TIP color (P<0.002), and composite abutment shade (P<0.001) on the b* parameter in the cervical third was significant. On the other hand, the interaction effects of laminate

Table 2. Mean value of the b* parameter in the cervical third, middle third, and incisal third for the three laminate materials, composite abutment shade, and trial insertion paste (TIP) color (n=10)

Laminate material	Abutment shade	TIP color	Mean±SD (cervical third)	Mean±SD (middle third)	Mean±SD (incisal third)
Lithium disilicate	A1	Bleach	10.54±1.18	10.94±1.02	11.9±0.72
		White	7.82±1.13	8.32±1.79	8.06±1.61
	A2	Bleach	12.55±1.76	12.45±0.84	12.9±0.62
		White	9.68±1.68	8.53±2.29	9.33±2.12
	A3	Bleach	13.25±0.99	12.06±1.38	11.82±1.35
		White	10.78±1.95	11.76±2.3	12.22±2.32
Katana UTML	A1	Bleach	10.4±1.17	10.41±0.96	10.95±1.03
		White	10.51±1.74	10.77±0.69	11.26±1.35
	A2	Bleach	11.72±1.18	11.56±0.87	11.52±0.62
		White	10.51±0.77	10.44±0.69	10.68±0.58
	A3	Bleach	12.12±0.86	11.18±0.57	11.14±0.64
		White	12.47±1.74	11.76±0.79	11.91±0.69
Zolid FX	A1	Bleach	3.33±0.39	1.46±0.35	1.65±0.46
		White	2.32±1.05	1.47±0.25	1.82±0.44
	A2	Bleach	2.35±1.12	1.76±0.69	1.62±0.59
		White	4.74±1.51	2.11±0.51	2.43±0.49
	A3	Bleach	3.55±1.52	1.92±0.32	2.12±0.59
		White	5.07±1.84	2.57±0.66	2.76±0.76
P-values					
Three-way ANOVA	Laminate		<0.001	<0.001	<0.001
	TIP		0.002	<0.001	0.001
	Abutment		<0.001	<0.001	<0.001
	Laminate vs TIP		<0.001	<0.001	<0.001
	Laminate vsAbutment		0.122	0.020	0.013
	Abutment vs TIP		0.131	<0.001	<0.001
	Laminate vs TIP vs Abutment		0.004	0.012	<0.001

SD=Standard Deviation, TIP=Trial Insertion Paste, ANOVA=Analysis of Variance

material and TIP color (P<0.001) and laminate material, composite abutment shade, and TIP color (P<0.004) on the b* parameter in the cervical third were significant. However, the interaction effects of laminate material and composite abutment shade (P=0.12) and composite abutment shade and TIP color on the b* parameter in the cervical third were not significant. Pairwise comparisons revealed significant differences between Katana UTML and Zolid FX (P<0.001) and between lithium disilicate and Zolid FX (P<0.001). Since three-way ANOVA showed the significant interaction effect of laminate type, composite abutment shade, and TIP color, as well as the significant interaction effect of laminate type and TIP color, on the b* parameter in the cervical third, subgroup analysis was performed to compare different laminate types regarding TIP color and composite abutment shade. The results showed that the difference between lithium disilicate and Katana UTML was not significant for the A1 shade of composite abutment and the bleach color of the TIP (P=1.00). Nevertheless, pairwise comparisons of other laminates revealed significant differences (P<0.001). The difference between lithium disilicate and Katana UTML was not significant for the A2 shade of composite abutment and the bleach color of the TIP (P=0.538). However, pairwise comparisons of other laminates revealed significant differences (P<0.001).

The difference between lithium disilicate and Katana UTML was not significant for the A3 shade of composite abutment and the bleach color of the TIP (P=0.20). However, pairwise comparisons of other laminates revealed significant differences (P<0.001).

Mean value of the b parameter in the middle third:*

The effects of laminate material (P<0.001), TIP color (P<0.002), and composite abutment shade (P<0.001) on the b* parameter in the middle third were significant. The interaction effects of laminate material and TIP color (P<0.001), laminate material and composite abutment shade (P<0.02), composite abutment shade and TIP color (P<0.001), and laminate material, composite abutment shade, and TIP color (P<0.01) were significant. The difference between Katana UTML and Zolid FX (P<0.001) and between lithium disilicate and Zolid FX (P<0.001) was significant. Since three-way ANOVA showed the significant interaction effect of laminate type, composite abutment shade, and TIP color, as well as the significant interaction effect of laminate type and TIP color, on the b* parameter in the middle third, subgroup analysis was performed to compare different laminate types regarding TIP color and composite abutment shade. The results showed that the difference between lithium disilicate and Katana UTML was not significant for the A1 shade of composite abutment and the bleach color of the TIP (P=0.871). Nevertheless, pairwise comparisons of other laminates revealed significant differences (P<0.001). The difference between lithium disilicate and Katana UTML was not significant for the A2 shade of composite abutment and the bleach color of the TIP (P=0.230). But pairwise comparisons of other laminates revealed significant differences (P<0.05). The difference between lithium disilicate and Katana UTML was not significant for the A3 shade of composite abutment and the bleach color of the TIP (P=0.240) or the A3 shade of composite abutment and the white color of the TIP (P=1.00). Nevertheless, pairwise comparisons of other laminates revealed significant differences (P<0.001).

Mean value of the b parameter in the incisal third:*

The effects of laminate material (P<0.001), TIP color (P<0.001), and composite abutment shade (P<0.001) were significant. The interaction effects of laminate material and TIP color (P<0.001), laminate material and composite abutment shade (P<0.01), composite abutment shade and TIP color (P<0.001), and laminate material, composite abutment shade, and TIP color (P<0.001) were significant on the b* parameter in the incisal third.

The difference in this respect between Katana UTML and Zolid FX (P<0.001) and between lithium disilicate and Zolid FX (P<0.001) was significant. Since three-way ANOVA showed the significant interaction effect of laminate type, composite abutment shade, and TIP color, as well as the significant interaction effect of laminate type and TIP color, on the b* parameter in the incisal third, subgroup analysis was performed to compare different laminate types regarding TIP color and composite abutment shade. The results showed that the difference between lithium disilicate and Katana UTML was not significant for the A1 shade of composite abutment and the bleach color of the TIP (P=0.163). Nevertheless, pairwise comparisons of other laminates revealed significant differences (P<0.001). For the A2 shade of composite abutment, all pairwise comparisons of laminates revealed significant differences (P<0.05).

The difference between lithium disilicate and Katana UTML was not significant for the A3 shade of composite abutment and the bleach color of the TIP (P=0.501) or the A3 shade of composite abutment and the white color of the TIP (P=1.00). However, pairwise comparisons of other laminates revealed significant differences (P<0.001).

The L parameter:*

Table 3 presents the mean value of the L* parameter in the cervical third, middle third, and incisal third for the three laminate materials, composite abutment shade, and TIP color.

Mean value of the L parameter in the cervical third:*

The effect of laminate material (P=0.74) on the L* parameter in the cervical third was not significant but the effect of TIP color

Table 3. Mean value of the L* parameter in the cervical third, middle third, and incisal third for the three laminate materials, composite abutment shade and trial insertion paste (TIP) color (n=10)

Laminate material	Abutment shade	TIP color	Mean±SD (cervical third)	Mean±SD (middle third)	Mean±SD (incisal third)
Lithium disilicate	A1	Bleach	82.83±2.48	83.41±0.86	84.71±1.5
		White	79.51±3.68	82.7±2.42	79.4±6.31
	A2	Bleach	83.59±2.81	85.44±0.83	87.27±1.26
		White	77.29±6.43	86.16±2.51	82.0±11.64
	A3	Bleach	82.35±2.57	85.07±1.01	84.03±3.39
		White	82.23±1.99	84.31±2.06	84.71±2.81
Katana UTML	A1	Bleach	80.84±2.79	80.88±1.77	81.93±1.76
		White	81.91±2.74	80.23±1.8	80.75±5.74
	A2	Bleach	81.17±3.79	79.94±1.19	79.35±1.11
		White	79.68±3.26	79.16±1.66	80.48±1.43
	A3	Bleach	82.91±2.19	155.41±1.23	81.15±2.53
		White	81.65±2.07	79.87±1.28	80.6±1.91
Zolid FX	A1	Bleach	81.31±1.84	80.94±1.13	82.17±1.24
		White	80.69±2.04	81.39±1.72	81.96±2.33
	A2	Bleach	82.42±3.07	81.54±1.47	81.45±2.08
		White	78.62±3.37	78.42±2.15	80.6±1.87
	A3	Bleach	82.1±2.91	81.62±1.61	82.86±1.9
		White	80.62±1.91	81.5±1.37	83.09±0.63
P-values					
Three-way ANOVA	Laminate		0.744	0.490	<0.001
	TIP		<0.001	0.275	0.030
	Abutment		0.028	0.329	0.336
	Laminate vs TIP		0.059	0.353	0.45
	Laminate vsAbutment		0.941	0.398	0.129
	Abutment vs TIP		0.13	0.361	0.221
	Laminate vs TIP vs Abutment		0.193	0.384	0.195

SD=Standard Deviation, TIP=Trial Insertion Paste, ANOVA=Analysis of Variance

(P<0.0001) and abutment shade (P=0.03) was significant. The interaction effect of abutment shade and TIP color (P<0.01) was also significant but other interaction effects were not significant (P>0.05). Pairwise comparisons of laminate materials showed no significant difference in this respect (P>0.05).

Mean value of the L parameter in the middle third:*

The effects of laminate material (P=0.49), TIP color (P=0.28), and abutment shade (P=0.33) on this parameter were not significant. The interaction effects were not significant either (P>0.05). Pairwise comparisons of laminate materials revealed no significant difference either (P>0.05).

Mean value of the L parameter in the incisal third:*

The effects of laminate material (P<0.001), TIP color (P=0.03) and the interaction effect of laminate material and TIP color on the L* parameter in the incisal region were significant. No other significant effect was noted. The difference between lithium disilicate and Katana UTML (P<0.001) and between lithium disilicate and Zolid FX was also significant (P<0.05) in this respect. Subgroup analysis of different types of laminates based on the TIP color revealed significant differences between Zolid FX and lithium disilicate and between lithium disilicate and Katana UTML for the bleach color of the TIP ($P<0.005$) but the difference between Zolid FX and Katana UTML was not significant ($P=0.529$). None of the pairwise comparisons revealed a significant difference for the white TIP color ($P>0.05$).

DISCUSSION

This study assessed the effect of laminate material (Katana UTML, Zolid FX, and lithium disilicate), TIP color (bleach and white), and composite abutment shade (A1, A2, and A3) on the L*, a*, and b* color parameters in the incisal, middle, and cervical thirds of laminate veneers. According to the results, the effects of laminate material and TIP color on the a* parameter in the cervical, middle, and incisal thirds were significant. In the cervical third, the a* value was higher when white TIP was used with lithium disilicate ceramic. In the Katana UTML group, the a* value was much lower when the bleach color of the TIP was used. In the middle and incisal thirds, maximum and minimum a* values were noted in the Zolid FX and Katana UTML groups, respectively, irrespective of the TIP color. The effects of laminate material, composite abutment shade, and TIP color were significant on the b* parameter such that in the cervical, middle, and incisal thirds, minimum and maximum b* values were noted in the Zolid FX and Katana UTML groups, respectively. Minimum b* value was noted when white TIP was used with lithium disilicate ceramic and Katana UTML zirconia. The effect of composite abutment shade and TIP color on the L* parameter was significant in the cervical third. The effect of laminate material and TIP color on the L* parameter was significant in the incisal third.

Since the ceramic thickness increases from the cervical towards the incisal third in zirconia laminate veneers, the color difference decreases, except for the cervical and middle thirds [22]. This is explained by increased light absorption in the thicker area and decreased volume of reflected light in this region. Chaiyabutr et al [23] also confirmed these findings, showing a reduction in the color difference of IPS e.max ceramic samples by an increase in ceramic thickness from 1 mm to 2.5 mm. In our study, the optical properties of the samples in the incisal third were less affected by the laminate material, TIP color, and composite abutment shade compared to the middle and cervical thirds. On the other hand, it should be noted that IPS e.max CAD veneers are machined, and porcelain layering is not performed for them (in contrast to what is done for zirconia laminate veneers). This factor can also affect the optical properties of laminates [22]. IPS e.max CAD laminate veneers experience greater color change than zirconia laminate veneers due to the presence of a glassy phase in their structure. On the other hand, standardization of laminate veneers thickness is difficult when various fabrication techniques are employed. Also, results cannot be accurately interpreted when different materials are used. Thus, in-vitro studies are required on restorations fabricated by different techniques, and the geometry of the tooth and its surface texture should be well simulated since both of these parameters affect the optical properties of laminate veneers [24].

The current study showed that the effect of the TIP color on the color parameters in the cervical, middle, and incisal thirds was significant in most cases. Since the color difference of zirconia veneers was smaller than the 3.7 threshold, which is perceivable by the human eye, the TIP color may not significantly affect the color parameters of zirconia laminates. In other words, zirconia laminates are completely opaque in these regions.

In the present study, the effect of the TIP color on the L* parameter was not significant in the middle third. Other studies have reported different color parameters for different zirconia groups [25,26]. Such differences can be explained by the brand of zirconia since different brands have different structures and particle sizes, which can cause differences in the amount of light absorption and emission [27]. Dozic et al [28] reported that the final color of IPS Empress Esthetic laminate veneers with a 0.6-mm thickness (glass ceramic reinforced with leucite) was not affected by the color of resin cement. Alghazzawi et al [22] showed that the final color of IPS e.max CAD and feldspathic porcelain veneers was affected by the color of the TIP. Kim and Kim [29] evaluated the optical properties of monolithic zirconia ceramics and reported significant differences in color parameters and translucency of most ceramic brands. They demonstrated that due to high L* and low a* and b* parameters, pre-colored monolithic zirconia ceramics can be used with additional staining to obtain a color match with the adjacent teeth/restorations. In the present study, the difference in the color parameters between the ceramic groups was mainly significant in the cervical, middle, and incisal thirds of laminate veneers, which was in agreement with the findings reported by Kim and Kim [29].

On the other hand, Harada et al [30] evaluated the translucency of Katana HT, Prettau Anterior, BruxZir, Katana UT, and Katana ST zirconia, as well as e.max CAD LT lithium disilicate ceramic, and showed that Katana UT samples were significantly more translucent than other zirconia samples. Also, e.max CAD LT was more translucent than the zirconia groups [30]. Similarly, our study showed the superior translucency of Katana UT. Alghazzawi et al [22] showed that the color parameters of zirconia and glass ceramic veneers were affected by the color of the TIP and composite abutment, which confirmed our findings.

The difference in the optical properties of materials can be due to variability in the grain size, yttria content, and percentage of chemical impurities. The surface texture and color change of ceramics are also affected by their degree of crystallinity, polymer matrix, filler size, and form of fillers [31]. Our results suggested that the final color of the veneer can be changed by using different TIP colors to maximize the color match with the adjacent teeth/restorations. However, our findings were different from those reported by Azer et al [31] who found no significant difference between ceramics in color parameters when different colors of composite cores and resin cements were used. The ceramic thickness seems to play a pivotal role in this respect since Shokry et al [32] indicated that increasing the ceramic thickness can decrease its lightness and increase its redness/yellowness. By an increase in ceramic thickness, the passage of light decreases.

Alghazzawi et al [22] showed that IPS e.max CAD was more translucent than other materials, which was in agreement with our findings. Translucency is an important parameter in aesthetics, which is significantly affected by the material composition, thickness, technique of fabrication, and light source [22]. Baldissara et al [18] demonstrated that lithium disilicate glass ceramics had higher translucency than zirconia-based core materials. The physical and mechanical properties of ceramics affect their optical properties such as their translucency [33,34]. Ozturk et al [35] indicated that the color parameters of IPS e.max Press and DC Zirkon were significantly affected by the frequency of firing, ceramic composition, and thickness.

In the oral cavity, restorations are subjected to cyclic mechanical and thermal stresses in an aqueous environment. These stresses cannot be well simulated in vitro. Thus, the generalization of in-vitro results to the clinical setting must be done with caution. Clinical studies are required to assess and confirm the accuracy of these findings in the clinical setting. Evaluation of the effect of environment light on color parameters of zirconia and lithium disilicate laminate veneers, the effect of coloring agents on these restorations, the effect of ceramic thickness on optical properties and the interaction effect of different underlying colors and laminate thickness on color parameters are interesting topics for future research in this respect.

CONCLUSION

Within the limitations of this in-vitro study, the results revealed the significant effect of laminate material, TIP color, and composite abutment shade on the color parameters of laminate veneers. Thus, the color shade of composite abutment, TIP color, and laminate material should be carefully selected to achieve optimal aesthetics in laminate veneers.

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CONFLICT OF INTEREST STATEMENT

None declared.

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