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Comparison of Color Stability and Marginal Fidelity of Labial Partial Veneer Composite Restorations Fabricated by Two Different Techniques: An *In Vivo* Pilot Study

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ABSTRACT

Objective: *Composite labial partial veneers are an economical alternative to porcelain counterparts and also easy to repair. However, color stability and marginal fidelity of labial partial veneer composite restorations were not evaluated adequately under in vivo conditions.* ***Methods:*** *Composite laminate veneer (CLV) restorations were done in 6 maxillary anteriors for 14 subjects indicated for laminate veneers but cannot afford porcelain restorations using indirect method on right side and direct method on left side. Color stability was assessed clinically using intra oral digital spectrophotometer and marginal fidelity was assessed on epoxy resin replica of the tooth- restoration interface under scanning electron microscope. The assessments for color stability and marginal fidelity were repeated after 6 months, 9 months and 12 months respectively.* ***Results:*** *Statistically significant color change at cervical (p=0.000) and incisal (p=0.008) regions of direct CLVs and cervical regions of indirect CLVs (p=0.009). Statistically significant change in marginal fidelity was observed in both direct and indirect CLVs (p=0.031).* ***Conclusions:*** *Indirect CLVs performed better with regard to color stability whereas direct CLVs performed better with regards to marginal fidelity.* ***Clinical significance:*** *For patients who cannot afford porcelain restorations, indirect composite resins serve as better material than direct filling composites for anterior partial coverage restorations provided adequate care is taken to ensure marginal fidelity by meticulous adherence to restorative techniques.*

Keywords: Composites, Veneers, Marginal adaptation, Color stability, CIELAB, SEM

INTRODUCTION

Treatment options for managing discolored anterior teeth are diverse [1]. Superficial and mild discolorations of structurally intact teeth can be managed by vital bleaching and/or micro abrasion or macro abrasion. Laminate veneers are best indicated for moderate to severe discolorations that involve deeper layers of tooth structure. Full coverage crowns are indicated for teeth with structural defects. Laminate veneers are made from porcelain or composite resins. Even though Porcelain laminate veneers (PLVs) are more esthetic when compared to composite laminate veneers (CLVs) they are brittle and abrasive to opposing tooth structure [2,3]. PLVs cannot mask very dark discolorations due to their almost transparent nature in thin sections of 0.5 mm. Opaquing ability [4] is definitely a major advantage of composite resins over porcelain. Composite resins are susceptible to discoloration after prolonged exposure to the oral environment and marginal discoloration is a primary reason for their replacement [5]. Composite resins discoloration may be caused by intrinsic and extrinsic factors [6]. Intrinsic factors involve the discoloration of the resin material itself, such as the alteration of the resin matrix and the interface of matrix and fillers. Extrinsic factors are adsorption and absorption of stains. Marginal fidelity is a crucial factor for the long-term success of any restoration. Loss of marginal fidelity leads to secondary caries at the tooth-restoration interface apart from marginal discoloration. Although there are numerous *in-vitro* studies [3,7-10] evaluating the color stability and marginal fidelity of direct and indirect composite resins, *in-vivo* studies are limited to their use in Class I, II and V cavity preparations. This study aimed to compare the color stability and marginal fidelity of direct and indirect composite laminate veneers (CLVs) on anterior teeth [11-20].

MATERIALS AND METHODS

After considering the inclusion and exclusion criteria 1, 14 subjects with indications for laminate veneers on the

maxillary anterior teeth were included in this pilot study after obtaining informed consent. Ethical clearance was obtained from the institution ethics sub-committee (Ref, No. IESC/T-153/2010). For each subject received indirect CLVs were fabricated in the first quadrant (Group 1) and direct CLV restorations in second quadrant (Group 2). The indirect composite used was a micro filled composite with a high content (65 wt%) of nanoparticle inorganic fillers, SR Adoro (Ivoclar Vivadent, Leichenstein). The direct composite used was a nanocomposite for universal application with nano fillers (78.5 wt%) with micron scale clusters, Filtek Z350 (3M ESPE, India). Custom tray fabrication was fabricated on the diagnostic cast made during the first diagnostic appointment. Vita Shade Guide (Lumin-Vaccum, Vitapan, Vita Zahnfabrik, Germany) was used for shade selection for which the uninvolved portion of teeth or adjacent or opposing teeth were used as a guide with the consent of the patient. Window-type preparation for laminate veneers was done at a depth 0.3-0.5 mm guided by the depth cut marks. Final impression by two-step technique was made with custom tray, using heavy body and light body addition silicone impression material (Reprosil and Aquasil, Dentsply Caulk, USA). The working cast was fabricated in Type IV Gypsum product (Kalrock, Kalabhai, India). Incremental application and curing (20 seconds per increment) using the hand held visible light curing unit (Bee Cool, Germany; wavelength of 430-490 nm; maximum intensity of 7.5 W) was done for the indirect CLVs. The final curing after achieving the proper contours was done under heat and light in a special curing chamber (Lumamat 100, Ivoclar Vivadent, Liechtenstein) for 25 minutes at 104°C. The indirect CLVs were removed from the working cast, finished and polished for clinical try in. The prepared teeth surfaces in the first quadrant were etched for 15 seconds using 36% phosphoric acid gel (DeTrey Conditioner 36, Dentsply DeTrey, Germany) followed by rinsing, air drying and application of bonding agent (Prime and Bond NT, Dentsply Caulk, USA) both on the tooth surface and on the indirect CLV's inner surface. Dual cured resin cement (Calibra, Dentsply Caulk, USA) was used for luting the indirect CLVs. On the 2nd quadrant, the prepared tooth surface was etched with 37% phosphoric acid gel (Scotchbond Etchant Gel, 3M ESPE, India) for 15 seconds followed by rinsing, air drying and application of bonding agent (Adper Single bond Plus, 3M ESPE, India). Incremental buildup was done for direct CLV restoration and each increment light-cured for 20 seconds and they were finished and polished using proper protocols. The shade of the restoration was recorded using the Intra oral digital spectrophotometer (Vita Easy Shade, Vita Zahnfabrik, Germany) where readings for each tooth at cervical, middle and incisal regions were recorded in CIELAB color coordinates. The shades of all the CLVs were measured at three subsequent follow ups using the same process. Qualitative evaluation of marginal adaptation of all the laminate veneers in each group was done at baseline and at each follow-up on epoxy resin dies obtained from post restorative impressions under Scanning Electron Microscope (SEM) (Figure 1). Sputter coating with gold were done on all epoxy resin dies to form a uniform layer of thickness of about 30-40 nm over the specimens to make them conductive of electricity and help in scanning by high energy electron beam. All the four margins of the laminates (Cervical, Incisal, Mesial and Distal) were evaluated in entirety under 200x magnification. Margins were assessed as Score 0: no marginal gap and Score 1: visible gap. At the end of 6 months post restoration, first follow up was done. Three months later the second follow up was done and the final follow up was done 3 months after the second follow up. The data obtained were analyzed using Statistical Package for Social Sciences (SPSS) Version 19.0. Mann-Whitney test was used for intergroup comparison of color stability. Friedman test was used to compare the marginal fidelity of samples within each group and Pearson Chi-Square test and Fisher's exact test were used for intergroup comparison for both the parameters. Statistical significance for all tests was set at $p<0.05$.

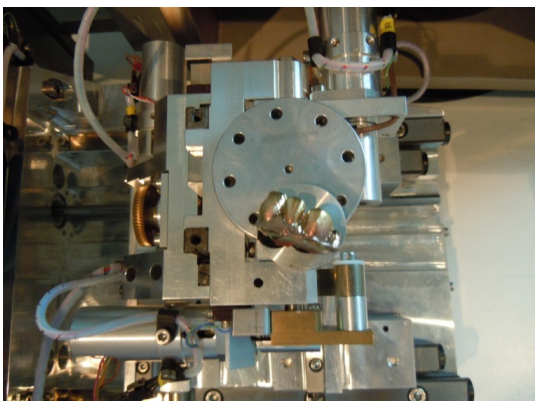

Figure 1 Epoxy resin dies placed on mounting platform of Scanning electron microscope after gold sputter coating

RESULTS

Color Stability

Among the 688 color difference readings (ΔE) obtained for each group clinically unacceptable color difference (ΔE>3.3) was greater for Group 2 (20.05%) when compared to Group 1 (4.79%) (Table 1). Among the readings showing ΔE>3.3, the percentage distribution was greatest for cervical third (60.6% for indirect and 42.02% for direct) followed by middle third (30.3% for indirect and 36.23% for direct) and incisal third (9.09% for indirect and 21.01% for direct). At 6 months after the completion of the restoration, all the composite laminate veneers showed color changes which were, even though clinically significant (ΔE>1), were statistically non-significant in both Group 1 and 2 After 3 months from the first follow up significant color changes were observed in cervical region (p=0.036) for indirect composite laminate veneers (Group 1) and in cervical (p=0.00) and incisal (p=0.002) regions of direct composite laminate veneers (Group 2) when compared with the previous follow up. On intergroup comparison (Table 2), for each follow up combination, the direct composite laminate veneers (Group 2) had greater percentage of samples showing clinically unacceptable color difference (ΔE>3.3) and this difference was statistically significant (p<0.05) (Figures 2-6).

Table 1 Distribution of samples showing clinically unacceptable (ΔE>3.3) and acceptable (ΔE ≤ 3.3) color differences in Composite Laminate Veneers fabricated by Indirect (Group 1) and Direct (Group 2) methods (N=18n)

Group	No of Samples (n)	No of recordings (18n)	No of recordings showing ΔE>3.3	% ΔE>3.3	No of readings showing ΔE ≤ 3.3	% ΔE ≤ 3.3
1 (Indirect)	38	688	33	4.79	655	95.21
2 (Direct)	38	688	138	20.05	550	79.95

Table 2 Inter-group comparison of Color differences (ΔE)

Follow up Combination and Region evaluated	Group 1 (Indirect)		Group 2 (Direct)		p-value
	% ΔE>3.3	% ΔE ≤ 3.3	% ΔE>3.3	% ΔE ≤ 3.3	
Cervical E1-0	10.5	89.5	26.3	73.7	0.041*
E2-0	7.9	92.1	31.6	68.4	0.009*
E3-0	13.2	86.8	48.6	51.4	0.001*
E2-1	10.5	89.5	21.1	78.9	0.031*
E3-1	15.8	84.2	39.5	60.5	0.021*
E3-2	10.5	89.5	28.9	71.1	0.044*
Middle E1-0	2.6	97.4	28.9	71.1	0.002*
E2-0	5.3	94.7	23.7	76.3	0.022*
E3-0	5.3	94.7	34.2	65.8	0.002*
E2-1	2.6	97.4	28.9	71.1	0.002
E3-1	5.3	94.7	26.3	73.7	0.012*
E3-2	10.5	89.5	28.9	71.1	0.005*
Incisal E1-0	2.6	97.4	10.5	89.5	0.035*
E2-0	2.6	97.4	18.4	81.6	0.038*
E3-0	2.6	97.4	34.2	65.8	0.00*
E2-1	0	100	21.1	78.9	0.005*
E3-1	0	100	21.1	78.9	0.005*
E3-2	7.9	92.1	34.2	65.8	0.003*
*p<0.05 is considered as Statistically Significant					

Marginal Fidelity

Among the 608 marginal fidelity assessments made for each group, visible marginal gap was higher for indirect (12.82%) when compared to direct (4.11%) group (Table 3) (Figures 7 and 8). Also, the cervical region (52.63% for indirect and 40% for direct) showed greater percentage of marginal gap followed by the mesial region (17.1% for indirect and 28% for direct). The changes in percentage distribution of samples at each assessment time for various margins are presented in the table. On intra group comparison for both Group 1 and Group 2, the difference between the second follow up and baseline was significant (p=0.031) and rest of the combinations for all the margins

was insignificant ($p>0.05$) in both the groups. On intergroup comparison (Table 4), the indirect composite laminate veneers (Group 1) showed greater visible marginal gap than the direct laminate veneers (Group 2) and this difference was greatest at the cervical region and was statistically significant ($p<0.05$).

Figure 2 Intra oral picture: Pre-treatment

Figure 3 Intra oral picture: post treatment

Figure 4 Intra oral picture at first follow up

Figure 5 Intra oral picture at second follow up

Figure 6 Intra oral picture at third follow up

Table 3 Distribution of samples showing marginal gap in Composite Laminate Veneers fabricated by Indirect (Group 1) and Direct (Group 2) methods (N=16n)

Group	No of Samples (n)	No of recordings (16n)	No of recordings showing visible gap (1)	% of 1	No of readings showing no visible gap (0)	% of 0
1 (Indirect)	38	608	78	12.82	530	87.18
2 (Direct)	38	608	25	4.11	583	95.89

Table 4 Inter group comparison of marginal fidelity at various assessment times between Composite Laminate Veneers fabricated by Indirect (Group 1) and Direct (Group 2) methods (n=38)

Region and Follow up	Group 1 (Indirect) n=38		Group 2 (Direct) n=38		p-value
	% of 1	% of 0	% of 1	% of 0	
Cervical 0	21.1	78.9	0	100	0.005*
1	26.3	73.7	2.6	97.4	0.003*
2	26.3	73.7	5.3	94.7	0.012*
3	36.8	63.2	15.8	8402	0.037*
Mesial 0	5.3	94.7	2.6	97.4	1#
1	5.3	94.7	2.6	97.4	1#
2	5.3	94.7	2.6	97.4	1#
3	18.4	81.6	10.5	89.5	0.32#
Distal 0	7.9	92.1	0	100	0.24#
1	7.9	92.1	0	100	0.24#
2	7.9	92.1	0	100	0.24#
3	10.5	89.5	0	100	0.115#
Incisal 0	7.9	92.1	5.3	94.7	1#
1	7.9	92.1	5.3	94.7	1#
2	7.9	92.1	5.3	94.7	1#
3	7.9	92.1	5.3	94.7	1#
*p<0.05 is considered as Statistically Significant; # Non-significant					

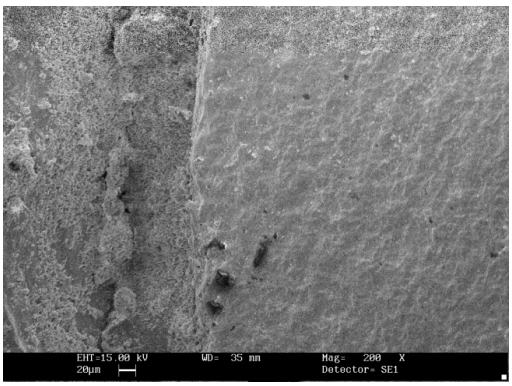

Figure 7 SEM picture of a sample showing no marginal gap

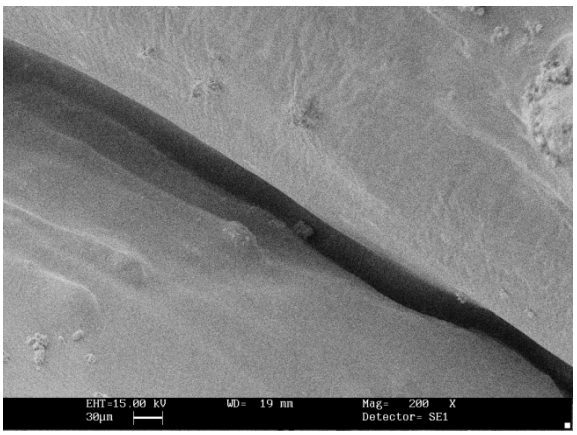

Figure 8 SEM picture of a sample showing marginal gap

DISCUSSION

Comparison of Color Stability of Direct and Indirect Composite Resins

In this *in vivo* pilot study, color instability was greater in the direct CLVs showed than indirect CLVs. The reasons can be multifold such as a lower degree of polymerization which leads to more intermolecular spaces which results in more water sorption leading to hydrolysis of matrix and penetration of extrinsic stains [18-20]. Also, the direct composite material evaluated in this study had a greater percentage of fillers (78.9 wt%) when compared to the indirect composite material (65 wt%). Ferracane [21] concluded through his study on composite polymer network lower degree of conversion resulting in larger number of double bonds and lower quality of bonds formed greater in composites with greater volume of filler particles. Therefore, the resulting composition will be more pre-disposed to the action of solvent due to greater free volume for solvent action, leading to plasticization action and a decrease in surface hardness and greater color alteration. In this study, the cervical region (42.02% for direct and 60.6% for indirect) showed greater clinically unacceptable ($\Delta E>3.3$) color changes. This could be compared with the pattern of staining of natural teeth where it is the cervical region which accumulates the maximum amount of stains. This could be due to inadequate oral hygiene practice on the part of the patient or the fact that the cervical region is always below height of contour of the teeth leading to reduced access to self-cleansing action of surrounding musculature. The cervical discoloration of composite resins may also be due to the marginal percolation which most commonly happens in this region. According to Sadowsky [3], marginal gap is more in cervical region due to frequent dentin exposure in this area, due to thin enamel and the bond strength of composite to dentin is less than that of enamel. In the case of direct CLVs, the incisal region also showed significant color changes. This trend has not yet been reported in literature. Most of the studies regarding the composite veneers *in vitro* where disk shaped composite specimens were used which does not correspond to the anatomical form of the teeth nor do the study environment mimics the intra oral environment. A variety of factors are involved such as the patient's oral hygiene, the micro biota of the oral cavity, salivary constituents and its pH, the restorative material used etc. This trend must be verified in future studies with a larger sample size and longer duration of follow-up.

Comparison of Marginal Fidelity of Direct and Indirect Composite Resins

In this *in vivo* pilot study, samples with marginal gap were higher for indirect composite laminate veneers (12.82%) as compared to direct composite laminate veneers (4.11%). This can be attributed to the inferior mechanical properties of the luting agent used for indirect composite laminate veneers. Scheibenbogen-Fuchsbrunner, et al. [22] also had this view attributing the cause to be loss of marginal integrity for indirect CLVs at baseline to polymerization shrinkage or removal of excess cement at the margins with blunt instruments. The loss of marginal integrity at baseline or direct composites, can be explained by the fact that larger the volume of composite to be polymerized, larger the residual internal stresses in the polymerized composite even if placed incrementally. Direct composites revealed better marginal integrity. Celik and Gemaalmaz [20] concluded that indirect composite laminate veneers do not have perfect marginal integrity due to polymerization shrinkage and viscosity of the material. This is concordance with the results of the present study. Also van Dijiken and Horsted [23] concluded that micro filled composites have greater

polymerization shrinkage when compared to nano filled and hybrid composites. This is comparable to the results of the current study, where a micro filled indirect composite resin had marginal integrity which was inferior when compared to a direct nano filled composite resin. Also, amongst both groups, the cervical region showed greatest percentage of samples with loss of marginal fidelity consistent with the results from previous studies [24-26]. The deviation in orientation of enamel prisms and also thin enamel in this part of the tooth can explain the pattern of greater marginal leakage at cervical margin than at other margins. At the cervical region the enamel prisms alter from vertical to oblique towards the cervical region. A preparation depth of 0.5 mm for laminate veneer may expose the dentin cervically and the failure rates are higher when the veneers are bonded to dentin [27]. Sadowsky [3] concluded through his study that the bond strength of resin to dentin is less than that of enamel. Also, the indirect composite laminate veneers demonstrated higher percentage of marginal discrepancy at the baseline when compared to direct composite laminate veneers. The limitations of the study were the shorter duration and limited follow-ups. Further studies are needed with longer duration to confirm the findings.

CONCLUSION

Within the limitations of the study, it was concluded that Direct CLVs discolored more than indirect CLVs in the oral cavity but showed better marginal fidelity. The loss of marginal fidelity and discoloration was greatest in the cervical region of the restorations and was both clinically and statistically significant. Meticulous restorative techniques must be followed to address this clinical problem.

DECLARATIONS

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Conflict of Interest

The author has disclosed no potential conflicts of interest, financial or otherwise.

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