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Influence of Different Surface Treatment and preparation design on Translucency and Surface Topography of CAD/CAM Monolithic Zirconia Laminate Veneer: In-vitro Study

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Abstract
Purpose*: the study was aimed to evaluate wether design of preparation and surface treatment affect translucency and roughness of zirconia laminate veneers.*
Materials and Methods: *Atotal 28zirconia laminate veneers were prepared with even 0.5 mm thickness and A_3 shade. The veneers were divided into four groups .Group L S: Line angle preparation and recieved selective infiltration etching ; Group CS: Middle contact preparation and selective infiltration etching; Group LF: line angle preparation and fusion sputtering ;Group CF: Middle contact preparation and fusion sputtering. Veneers translucency were measured with spectrophotometer and TP evaluated before and after surface treatment . Surface roughness was examined with non contact optical profilometer. Scanning electron microscope was used for examination of surface topography after surface treatment. One way ANOVA and t test were used.*
Results: *There was significant difference in transluceney between preparation design ($P = 0.001$). There were also significant difference after suface treatment($P<0.001$) .One way ANOVA revealed no significant difference in roughness($P=0.583$). Scanning electron microscope revealed nanoporous surface of selective infiltration etching and granular surface of fusion sputtering surface treatment.*
Conclusion: *Selective infiltration etching and fusion sputtering caused laminate veneers to become more opaque and rougher. Line angle preparation was more translucent than middle contact preparation.*
Keywords: *Surface treatment, Preparation design, Translucency, Surface topography, Laminate veneer, Zirconia.*

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I. Introduction:

Laminate veneer is conservative procedure for anterior teeth restoration to provide excellent esthetic with minimal tooth reduction.[1] Zirconia restoration has excellent bio-compatibility and mechanical properties.[2] Modifying the microstructure and composition of zirconia results to the development of highly translucent material.[3] Available preparation designs for laminate veneer are window, incisal shoulder, and incisal palatal chamfer.[4] The microroughness of internal surface of laminate veneers leads to the improvement of micromechanical retention between the cement and restoration .[5] Roughness and micromechanical retention have been created by different surface treatment such as hydrofluoric acid etching, sandblasting with Al_2O_3 particles, silica coating, laser treatment, selective infiltration etching and fusion sputtering.[6] Reproducing the translucency of the natural teeth is very important for optimum esthetic to provide restoration with natural appearance.[7] Translucency could be described as a state between complete opacity and transparency as the substance allows the light passage, but it may also scatter the light so that object cannot be seen clearly through the material.[8] Translucency parameter (TP) is usually used to determine the material translucency. [9] Therefore, this study was aimed to evaluate The influence of different types of surface treatment(selective infiltration etching and fusion sputtering) and type of preparation on Translucency and Surface topography of zirconia laminate veneer.

II. Materials and Methods:

Two natural teeth were selected and prepared into two different designs with even 0.5mm thickness , 1.5mm incisal buttjoint and differed in proximal extension (just beyond line angle and middle contact preparation designs). Each tooth was scanned using dental scanner(3D dental scanner FULL HD, DOF Inc. South Korea) and saved as STL file. Trinia 98×25mm disc(Bicon Europe, USA) was milled into 28 abutments using CAD/CAM system (14 abutments with just beyond line angle preparation design and 14 abutments with middle contact preparation design). Twenty eight zirconia laminate veneers were fabricated from katana ultra translucency multilayered blank (Kuraray Noritake Dental Inc, Japan) using CAD/ CAM. Laminate veneers were divided into two groups according to preparation design . Group L: just beyond line angle, Group C : middle contact preparation . Samples of each group were divided into two sub group according to surface treatment of internal surface of laminate, Sub group S recieved selective infiltration etching, and sub group F recieved fusion sputtering. Translucency was evaluated with translucency parameter (TP) using spectrophotometer before and after the surface treatment of the samples .TP value was determined by calculating the color difference between readings for each sample when it was placed over ablack back ground (L*=2.06, a*= -0.46, b*= 1.10, Chroma=0.90, Hue=255.31) and then over white background (L*=99.85, a*= -0.01, b*= -0.15, Chroma=0.25, Hue=269.76), According to CIELAB color difference formula (TP_{ab}).

TP_{ab}= [(L*$_B$-L*$_w$)2 +(a*$_B$-a*$_w$)2 + (b*$_B$-b*$_w$)2] 1/2

Where the subscripts " B" and " w" refer to color coordinates over the black and the white backgrounds, respectively.[10]

In addition, CIE DE2000 color difference formula :

$$TP_{00} = \left[\left(\frac{L'_B - L'_W}{K_L S_L} \right)^2 + \left(\frac{C'_B - C'_W}{K_C S_C} \right)^2 + \left(\frac{H'_B - H'_W}{K_H S_H} \right)^2 + R_T \left(\frac{C'_B - C'_W}{K_C S_C} \right) \left(\frac{H'_B - H'_W}{K_H S_H} \right) \right]^{1/2}$$

Where the subscripts" B" and" w" refer to Lightness (L), Chroma (C), and Hue (H) of the sample over the black and white backgrounds, respectively. RT is the rotation function that accounts for the interaction between chroma and hue differences in the blue region. Weighting functions, SL, SC, SH adjust the total color difference for variation in the location of the color difference sample over the B and W backgrounds in L* ,a* ,b* coordinates and the parametric factor, KL,KC,KH, are correction terms for experimental conditions.[11]Then , surface treatment for LS and CS groups with selective infiltration etching. , the internal surface of the sample was coated with athin layer of infiltration agent under pressure of 1 bar on distance of 10 mm for 30 seconds. The samples were heated to 750°C cooled to 650°C for 1minute, reheated to 750°C for 1 minute , then cooled to room temperature . Samples placed in a5% hydrofluoric acid solution in an ultrasonic bath for 15 minutes for complete dissolution of infiltration agent traces, then washed under demineralized water for 5 minutes.[12] Group LF and CF were treated with fusion sputtering. Ten grams of fine grinding zirconia powder (7 μm to12 μm particles) were added to aglass jar filled with 10ml of 50% ethyl alcohol and the mixture was placed on an ultrasonic shaker to allow homogenous distribution of the particles. The suspension was transferred to acompression glass container immediately after mixing, and the air pressure was adjusted to 0.3 MPa. The sample was sprayed for 30 seconds, Then stored at 60°C for 2 h to allow proper surface drying. Then, heated at 950°C for 4 minutes.[13] Samples were examined with scanning electron microscope and non contact optical profilometer . For multiple comparison , t test was used.

III. Results:

According to preparation design, One way ANOVA showed that there were significant difference in translucency as provided in **Table 1**.

Table 1: One way ANOVA for translucency of different preparation designs

Dependant variables		**Group LS**	**Group LF**	**Group CS**	**Group CF**	**F**	**P**
□ L*	**Mean (SD)**	5.77 (±0.31)^{A}	5.57 (±0.16)	5.54 (±0.16) ^{A}	5.60 (±0.16)	1.77	0.179
□ a*	**Mean (SD)**	1.28 (±0.11)	1.33 (±0.13)	1.27 (±0.11)	1.24 (±0.08)	0.964	0.426
□ b*	**Mean (SD)**	4.65 (±0.09)^{AB}	4.60 (±0.17)^{CD}	4.31 (±0.13)^{AC}	4.31 (±0.15)^{BD}	12.46	<0.001*
TP_{ab}	**Mean (SD)**	7.53 (±0.27)^{AB}	7.35 (±0.19)^{C}	7.14 (±0.12)^{AC}	7.18 (±0.14)^{B}	6.17	0.003*

TP_{00}	**Mean (SD)**	5.496 (±0.176)^{AB}	5.370 (±0.114)^{CD}	5.127 (±0.105)^{AC}	5.171 (±0.108)^{BD}	12.46	<0.0001*
□ C	**Mean (SD)**	4.76 (±0.085)^{AB}	4.72 (±0.159)^{CD}	4.427 (±0.126)^{AC}	4.422 (±0.156)^{BD}	12.78	<0.001*
□ H	**Mean (SD)**	0.804 (±0.098)	0.836 (±0.113)	0.769 (±0.099)	0.744 (±0.082)	1.153	0.348

similar superscripted letters denote significant difference between groups with Post Hoc Tukey test.
One way ANOVA showed that there were significant differences in translucency after surface treatment. The mean and standard deviation values of translucency dependant variables are showed in Table 2 .

Table 2: One way ANOVA after surface treatment of all groups.

Dependant variables		**Group LS**	**Group LF**	**Group CS**	**Group CF**	**F**	**P**
□ L*	**Mean (SD)**	4.63 (±0.18)^{A}	4.869 (±0.15)^{A}	4.69 (±0.19)	4.80 (±0.15)	2.72	0.067
□ a*	**Mean (SD)**	1.78 (±0.10)	1.82 (±0.09)	1.74 (±0.08)	1.80 (±0.08)	0.919	0.446
□ b*	**Mean (SD)**	3.19 (±0.14) ^{A}	3.36 (±0.15) ^{BC}	2.67 (±0.15) ^{ABD}	3.15 (±0.25)^{CD}	19.13	<0.001*
TP_{ab}	**Mean (SD)**	5.91 (±0.15)^{ABC}	6.18 (±0.16)^{ADE}	5.67 (±0.15)^{BDF}	5.49 (±0.15)^{CEF}	27.19	<0.001*
TP_{00}	**Mean (SD)**	4.659 (±0.125)^{AB}	4.850 (±0.111)^{ACE}	4.481 (±0.104)^{BDE}	4.656 (±0.112)^{CD}	12.26	<0.001*
□ C	**Mean (SD)**	3.32 (±0.202)^{AB}	3.10 (±0.24)^{C}	2.84 (±0.26)^{AD}	2.36 (±0.27)^{BCD}	19.59	<0.001*
□ H	**Mean (SD)**	1.34 (±0.078)^{AB}	1.32 (±0.09)^{CD}	0.941 (±0.135)^{AC}	0.831 (±0.154)^{BD}	34.19	<0.001*

similar superscripted letters denote significant difference between groups with Post Hoc Tukey test.
The highest translucency dependant variables occured after fusion sputtering surface treatment of line angle preparation design and The lowest occurred after selective infiltration etching of middle contact preparation.
According to roughness, there was no significant difference between studied groups.

IV. Discussion:

Spectrophotometer was used for measurements in this study because the spectrophotometer has been reported to be the most useful , applicable, and accurate device for dental color measurement.[14]

TP decreased significantly (P<0.001) after selective infiltration etching and samples became more opaque. Glass infiltrates selectively between the boundaries of the surface grains, allowing rearrangement of the surface grains, and results in the creation of a 3-dimensional network of inter grain porosity. [12]The increase in the number of micropores may resulted from an increase in the grain size that can be related to light scattering activity because there is a difference between the refractive indexes of air and zirconia .[15]

In the present study, fusion sputtering surface treatment decreased TP value and samples became more opaque. The outer surface of the samples fused with rounded irregular zirconia particles.[13]Scattering coefficient of zirconia is higher than absorption, Thus light scattering is more predominant than absorption. Light scattering is inversely proportional to translucency.[15]

Preparation design had great influence on translucency , TP values of line angle preparation were more than middle contact preparation. Possible edge loss would have affected the color measurement.[16] In the present study, roughness after surface treatment(0.2520 ±0.0012) had no statistical significant difference between all groups.

Scanning electron microscope examination of fusion sputtering revealed microrough surface of zirconia with rounded beads fused to the outer surface, which became apart of zirconia surface. On the other hand, selective infiltration etching revealed a nanoporous surface yielding a honey comb like texture as a result of grain microarrangement movements influenced by the glass infiltration.

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