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Porcelain color alteration after orthodontic bonding using three different surface preparation methods

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ABSTRACT

Background: By increasing the number of adults seeking orthodontic treatment bonding orthodontic brackets to the surfaces other than intact enamel has become necessary. The purpose of this study was to evaluate the effect of three different surface preparation methods associated with orthodontic bonding on porcelain color alteration.
Materials and Methods: In this *in vitro* study forty-five porcelain discs (6- mm diameter, 2- mm thickness) were fabricated. The color of the specimens was evaluated by means of a Vita Easyshade. Commision Internationale de l'Eclairage (CIE) L* a* b* system was used for color measurement. Then, the specimens were randomly divided into three groups (n = 15) with respect to the surface preparation methods including a 9.6% hydrofluoric acid (HF) + silane, sandblasting, and sandblasting + 9.6% HF + silane. Metal orthodontic brackets were bonded. Samples were stored in 37° c water for 24 hours. Afterward, the brackets were debonded with a debonding plier and porcelain surfaces were polished with a tungsten-carbide bur. The color assessment was done, and ΔE values were measured. ΔE = 3.7 units were considered as an acceptability threshold. Data were analyzed with Paired t-test and one-way ANOVA. Level of significance was set at $P < 0.05$.
Results: Orthodontic bonding changed the color parameters significantly. Mean L*, a* and b* difference were 1.35 ± 2.41, 0.19 ± 0.80, 0.89 ± 1.27 units, respectively (P = 0.003 for L*, $P < 0.001$ for a* and b*). There was not any significant difference in ΔE units between the groups (P = 0.456). In all the groups the mean ΔE values were below 3.7 units and within the clinically acceptable limit.
Conclusion: Orthodontic treatment changed the CIE color parameters of porcelain surface. However, the color alteration is below the clinically acceptable threshold. With regard to color alteration, there is no difference between different surface conditioning methods.

Key Words: Dental bonding, dental debonding, dental porcelain, orthodontic brackets

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INTRODUCTION

Bonding orthodontic brackets to porcelain restoration is an integral part of adult orthodontic treatment.[1,2] The adhesion between restoration and orthodontic attachment must be strong enough to withstand stresses, yet causes the least deleterious effect on the surface properties.[3,4] Eustaquio *et al.*[5] confirmed that bonding orthodontic brackets damaged the porcelain

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surface. Surface conditioning method, adhesive type, and debonding force affect the incidence of porcelain damage.[6] Besides structural defects, porcelain esthetic characteristics are also compromised.[7,8]

Color shade is one of the primary determinants of the restoration esthetics. In color analysis three parameters of value, hue and chrome are considered.[9] The Commision Internationale de I'Eclairage (CIE) L * a* b* is the standard color measurement system. The L * parameter indicates the value and ranges from 0 (black) to 100 (white); the a * parameter corresponds redness (a > 0) or greenness (a < 0); and b* parameter is a measure of yellowness (b > 0) or blueness (b < 0).[10] ΔE indicates the magnitude of color change and 1 - 3.7 units have been considered as a clinically acceptable threshold.[11-16]

Since porcelain surface is amenable to resin penetration, various surface conditioning methods have been suggested to improve the bond strength.[17-19] A systematic review proved that etching the porcelain with 9.6% hydrofluoric acid (HF) and application of silane yielded the highest bond strength. Sandblasting with aluminum oxide particles also showed an acceptable result.[20] Furthermore, surface preparation can be performed with the combination of these methods.[21]

Herion *et al*.[7] compared the effect of bonding methods on porcelain surface alteration. They used phosphoric acid with silane and sandblasting plus 9.6% HF and silane as conditioning methods. They reported that sandblasting plus 9.6% HF and silane changed the porcelain color significantly. In another study porcelain surface roughness, color and gloss alteration after orthodontic bonding was investigated. 9.6% HF was used as a surface conditioning method. The result showed that orthodontic bonding changed color parameters.[8]

Until now, most of the investigations have focused on the effect of surface conditioning methods on the bond strength of orthodontic brackets to porcelain.[21-24] However, the effect of these methods on porcelain surface properties has been neglected. Hence, the purpose of this study was to evaluate the porcelain color alteration after orthodontic bonding using three surface preparation methods including 9.6% HF + silane, sandblasting, and sandblasting + 9.6% HF + silane. The null hypothesis was there wasn't any porcelain color change after orthodontic bonding using different surface conditioning methods.

MATERIALS AND METHODS

In this *in vitro* study forty-five disc-shaped feldspathic porcelain (6 mm diameter, 2 mm thickness), shade B2 (Vitadur Alpha, Vita Zahnfabrik, Bad Sackingen, Germany) were fabricated. Spectrophotometer (Vita Easyshade, Vita Zahnfabrik) was used to measure the color of the porcelain discs on the basis of CIE L*a*b system. Before each measurement the device was calibrated and its tip was kept at right angle of the surface.

Then, the specimens were randomly divided into 3 groups (n = 15). Before any surface treatment, the glaze was removed with a diamond bur (BluWhite Diamonds, Kerr Dental, Switzerland).

In group 1, porcelain was etched with 9.6% HF (Ultradent, South Jordan, UT, USA) for 1 min. After rinsing and drying, a thin layer of silane (Ultradent, South Jordan, UT, USA) was painted on the surface with a disposable micro-brush. Group 2 was sandblasted with 50-µm aluminum oxide at 50 psi for 4 seconds at a 10 millimeter distance (Micro-Etcher ERC II, Danville Engineering, San Ramon, California, USA). In group 3 the surface was sandblasted, then etched with 9.6% HF (Ultradent, South Jordan, UT, USA) for 1 minute. After rinsing and drying, silane (Ultradent, South Jordan, UT, USA) was applied for 1 minute.

For bonding, adhesive primer (Transbond XT, 3M Unitek, Monrovia, Calif, USA) was painted on the surface of the specimens. Subsequently, metal standard edgewise maxillary central incisor bracket with 0.022-inch slot and a surface area of 12.09 mm^2 (American Orthodontics, Sheboygan, USA) was bonded with the adhesive paste (Transbond XT, 3M Unitek, Monrovia, Calif, USA). The bracket was pressured to minimize the adhesive thickness. Excessive resin was removed from the periphery with a probe. The adhesive was polymerized (Ortholux LED, 3M Unitek, Monrovia, Calif, USA) for 40 seconds (20 seconds on each wing).

The specimens were stored in 37°c water for 24 hours. Afterward, the brackets were debonded with gentle peeling force using debonding plier (Inspire Ice Debonding Kit, Ormco, Glendora, California, USA). The residual resin was removed with 12 fluted tungsten-carbide bur (Carbide bur, Dentaurum, Germany) in low-speed hand piece at

2000 rpm. Polishing was performed until the surface became visually smooth.

Again, color measurement was performed for all the specimens with the same device. The color alteration was calculated with the following equation: $\Delta E = ([\Delta L^*]^2+[\Delta a^*]^2+[\Delta b^*]^2)^{0.5}$. ΔE = 3.7 units was considered as an acceptability threshold.[9,15,16]

Statistical analysis

Data were analyzed by paired *t*-test to compare L*, a*, b* parameters at the baseline and after polishing. One-way ANOVA was used to compare different surface preparation methods. SPSS software (SPSS version 17.0, SPSS Inc; Chicago, IL, USA) was used for data analysis. Level of significance was set at $P < 0.05$.

RESULTS

The results showed that orthodontic bonding significantly changed the CIE color parameters. After debonding, mean L*, a* and b* values decreased (1.35 ± 2.41, 0.19 ± 0.80, 0.89 ± 1.27 units respectively) [$P = 0.003$ for L*, $P < 0.001$ for a* and b*; Table 1]. In all the groups the mean ΔE value was below 3.7 units, within an acceptable range. One-way ANOVA showed that there was not any significant difference in mean ΔE value between the groups [$P = 0.456$; Table 2].

DISCUSSION

Our results indicated that orthodontic bonding would change the porcelain color. This finding is in agreement with Herion *et al.*[7] They conditioned porcelain surface with two different methods including phosphoric acid with silane and sandblasting plus 9.6% HF and silane. They reported that sandblasting plus 9.6% HF and silane significantly changed the color. The mean ΔE after finishing bur was 4.37 units. In this study, the mean ΔE for this conditioning method was (2.75 ± 1.99) units. The difference may be attributed to different etching time. Herion *et al.*[7] etched the surface for 4 minutes, whereas the etching time in our study was 1 minute. Prolonged etching creates deeper resin tags. Since debonding procedure cannot remove all the resin impregnations, remnant adhesive would absorb food colorant and bracket corrosion products. In addition, resin tags modify the reflective index of the surface.[9,15,16] Furthermore, physicochemical reactions in resin composite cause the discoloration of the resin.[25] The difference in the mean ΔE may also arise from using different color measurement devices. Khashayar *et al.*[26] compared two colorimeter devices and stated that the measurements of different devices are not comparable. Dozić *et al.*[27] compared five different color measurement devices and finally concluded that Vita Easyshade is the most reliable.

We evaluated the CIE L*a*b* parameters and detected a statistically significant difference between pre bonding and post debonding measurements for all three parameters. It is in accordance with the study performed by Jarvis *et al.*[8] They worked on high-fusing and low-fusing porcelain and used 9.6% HF as a surface conditioning method. L* value, specularly reflected light component, is highly sensitive to surface roughness. Surface-localized random specular reflection increased in rough surface. Consequently, the surface appeared lighter.[11] Increased level of b* value changed the color toward yellow. Chemical component, filler content, and polymerization conversion of the adhesive resin affect the color stability. In a clinical study, higher color alteration was occurred in chemically cured composite.[28]

In comparison, the effect of different surface preparation methods on porcelain color alteration, we did not find any significant difference between the methods. In contrast, Herion *et al.*[7] reported a significant difference between sandblasting plus 9.6% HF and silane and phosphoric acid with silane.

In selection of a conditioning method, providing adequate bond strength while minimizing surface damage are two important considerations.[3,4] Saraç *et al.*[21] compared the shear bond strength (SBS) of

Table 1: Mean Commision Internationale de l'Eclairage color parameters of all the samples at the baseline and after debonding

CIE parameter	Mean±SD		Difference	95% CI of the Difference		*P**
	Baseline	Debonding		Lower	Upper	
L*	83.36±2.23	82.00±2.30	1.35±2.41	0.62	2.07	<0.003
a*	4.18±0.63	3.99±1.09	0.19±0.80	-0.05	0.43	<0.001
b*	34.81±1.56	33.92±1.50	0.89±1.27	0.50	0.27	<0.001

*Paired *t*-test. CIE: Commision Internationale de l'Eclairage; SD: Standard deviation; CI: Confidence interval

Table 2: One-way ANOVA ofΔE for the surface preparation methods

ΔE	Sum of Squares	df	Mean Square	F	Significance
Between Groups	3.088	2	1.544	0.800	0.456
Within Groups	81.072	42	1.930		
Total	84.161	44			

orthodontic brackets to porcelain with three different surface treatment methods including sandblasting plus HF and silane, sandblasting and silane, and HF with silane. The authors reported the highest SBS in the sandblasting plus HF and silane group. According to the Saraç *et al*.[21] and our results sandblasting plus HF and silane seems to be an acceptable conditioning method.

The limitations of this study include systematic and random errors in spectrophotometric measurement, lack of food colorant and inability in the simulation of the mechanical wear that brushing causes. Further research with different types of porcelain, adhesives, conditioning methods, and performing clinical studies to evaluate the clinical significance of the subject is suggested.

CONCLUSION

1. Orthodontic bonding changes L*a*b* color parameters
2. Mean ΔE value with different surface treatment methods was below the acceptable threshold
3 There was not any significant difference in color alteration induced by different conditioning methods.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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