Original Article

Porcelain Surface Roughness, Color and Gloss Changes after Orthodontic Bonding

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ABSTRACT
The purpose of this study was to evaluate the alteration in surface characteristics after orthodontic debonding of two types of porcelain systems commonly used in prosthetic dentistry. For this purpose, porcelain specimens were fabricated from low-fusing (n = 20) and high-fusing (n = 20) porcelain. The baseline surface roughness, color, and gloss were evaluated using profilometry, color shade index, and gloss study. All specimens were bonded with brackets and debonded using a testing machine at a rate of 0.1 mm/minute crosshead speed. The porcelain surfaces were polished using a 12-fluted carbide composite removal bur (low-fusing, n = 20; high-fusing, n = 20). In addition, half of each porcelain group was further polished using a series of Sof-Lex discs (low-fusing, n = 10; high-fusing, n = 10). The postdebond porcelain surface characteristics roughness, color, and gloss were reevaluated and compared with baseline measurements. The results were analyzed with two-way analysis of variance and Tukey multiple comparisons test, with porcelain type (low-fusing or high-fusing) and polishing protocol (carbide bur or carbide bur and discs) serving as discriminate variables at $\alpha = 0.05$ level of significance. Bonding and debonding increased all roughness parameters tested; however, no change was revealed between the two polishing protocols. Similarly, gloss and color index changes were significantly altered after resin grinding, regardless of the polishing method used. No difference was identified between the two porcelain types with respect to roughness, color index, or gloss. Orthodontic bonding alters the porcelain surfaces, and postdebond polishing does not restore the surface to the prebond state. (*Angle Orthod* 2006;76:274–277.)

KEY WORDS: Porcelain; Debonding; Low-fusing; High-fusing; Surface; Gloss

INTRODUCTION

Porcelain is an important esthetic material used in prosthetic dentistry, and patients today insist on esthetic as well as functional results. Traditional high-fusing porcelain systems have encountered problems with fracture resistance as an all-ceramic restoration.[1] Because the cosmetic trends in dentistry continue, there is great demand for new techniques and materials. Low-fusing porcelain is becoming more popular as a porcelain system because of its ability to be used in both porcelain fused to metal restorations and all-ceramic restorations.[1] Low-fusing porcelains have also shown the characteristic of being less abrasive to the opposing dentition. The low firing temperature of low-fusing porcelain also gives it the ability to achieve a high degree of polish without glazing.[2–4]

In most porcelain bonding systems, hydrofluoric acid is used to prepare the surface and as a porcelain conditioner.[5] Some systems recommend roughening the glazed surface to help retention of the bracket.[5,6] Eustaquio et al[7] concluded that irreversible damage may be caused by the orthodontic bonding to a porcelain surface. Patients should be informed that the porcelain restoration may be damaged or fractured at the time of bracket debonding.

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Reasonable success has been reported for restoring damaged porcelain restorations with the new porcelain repair systems that are available to the clinician.[8] Many factors influence the incidence of porcelain restoration damage after bracket debond.[7,9] These factors include (1) porcelain type, (2) whether the surface is roughened or glazed, (3) porcelain conditioning system used, (4) type of orthodontic adhesive used, and (5) debond force.[10] Of these factors, the practicing orthodontist usually only varies the surface roughness and debonding force. Most orthodontists do not know the type of porcelain system they are bonding to, and few use multiple bonding systems or orthodontic adhesives. The standard polishing protocol in most offices relies on composite polishing materials to restore the porcelain surface after debonding.

Characteristics that affect porcelain restoration esthetics and are of primary concern are (1) surface roughness, (2) gloss variants, and (3) color shade. Winchester[6] and Eustaquio et al[7] concluded that diamond polishing paste was better in restoring the porcelain surface than ceramic polishing stones. The porcelain system types used in these studies were not of the newer low-fusing systems.[6,7]

The purpose of this study was to evaluate the surface roughness, gloss, and color of two types of porcelain systems commonly used in prosthetic dentistry after orthodontic bracket debonding. Two commonly used polishing systems were used to restore the porcelain samples: a 12-fluted carbide composite removal bur and a carbide bur used along with a series of three Sof-Lex paper polishing discs.

MATERIALS AND METHODS

Twenty samples of high-fusing Vita dur Alpha dentine shade A3 and 20 low-fusing Vita Omega 900 shade A3 porcelain were used in this study, for a total of 40 porcelain specimens (Vident, Brea, Calif). The porcelain was stacked using a preformed metal cylinder, cut into facet wedges and fired according to the manufacturer's directions. Each facet sample was wedge shaped and had a flat surface dimension of 6 $\times$ 4 mm. The samples were polished with the Dialite (Brasseler, Savannah, Ga) porcelain polishing series of three porcelain finishing wheels, ie, medium, fine, and extra fine, and left unglazed. Each polishing wheel was used with moderate hand pressure for 10 seconds. The porcelain samples were then embedded in cold-cure acrylic using a jig to standardize the surface angle for all samples during the debonding process.

Both high-fusing and low-fusing porcelain groups were evaluated for surface roughness, gloss, and color before bonding brackets. For the determination of porcelain surface roughness, a stylus profilometer (Diavite DH-5, Witherfur, Germany) was used, operated under 1.2-mm maximum length and 0.25-mm cut off parameters, assessing three roughness parameters, Ra, Rz, and Rt, defined as follows:[11,12]

- Ra is the average overall surface roughness and can be defined by a mean of all absolute distances of the roughness profile from the center line with in the sampling parameters.
- Rz describes the average maximum peak to valley heights of five consecutive sampling sites within the sampling parameters.
- Rt represents the maximum roughness depths on the sample surface.

Each porcelain sample was measured thrice in both the width direction and the length direction. These six values were then averaged to give a mean value for Ra, Rz, and Rt for each of the 40 porcelain samples.

The color of the porcelain samples was analyzed digitally using a Shade Eye NCC (Makota Yamaoto, Kyoto, Japan). With this method, the color is registered regardless of the presence of ambient light, and the data is then transmitted to the base via infrared interface. The value of color is recorded in the quantitative form of shade and hue. The software instantaneously calculates the appropriate mixtures for the vintage halo porcelain system and the corresponding shades for other standard guides displayed.

Gloss values were measured using a gloss meter (Horiba Handy Gloss Checker, Miyanohigashi, Kisshoin, Minami-ku, Kyoto, Japan). The gloss checker measures the reflection of a beam of light reaching the porcelain surface at an inclination of 60°. The measurement is determined by the ratio of the intensity of light reflected from a measured spot to that of the reference plane. The units of gloss are in percentage (%) of the incident light beam vs the reflected light beam.

The porcelain samples were prepared for bonding using hydrofluoric acid etchant, Reliance Porc-Etch, and Porcelain conditioner porcelain etching system (Reliance, Itasca, Ill) according to manufacturer's instructions. Stainless steel brackets with 0.022-inch slots, a 0° angulation, and 0° inclination (Victory Series, 3M/Unitek Corporation, Monrovia, Calif) were bonded to the porcelain facets using the orthodontic adhesive system Transbond XT and Transbond XT Light Cure Adhesive Primer (3M/Unitek). The samples were light cured for 20 seconds on both the mesial and distal of the brackets, for a total time of 40 seconds, and stored in water for 24 hours.

All samples were debonded using a mechanical testing machine (Monsato, Tensometer 10, Weltshie, UK), with a crosshead speed of 1 mm/minute parallel to the porcelain surface to standardize the force application and loading rate. After debonding, the two groups of high- and low-fusing porcelain were divided

TABLE 1. Porcelain Roughness Parameters Changes Induced by Bonding and Debonding

				Debonded			
		Baseline		Carbide		Soft Flex	
Group	Mean	SD	Mean	SD	Mean	SD	
High-fusing	Ra	0.38 A	0.13	1.48 B	0.65	1.15 B	0.82
	Rz	2.18 A	1.07	7.54 B	2.29	8.80 B	6.83
	Rt	4.00 A	1.82	13.20 B	4.03	12.98 B	9.20
Low-fusing	Ra	0.45 A	0.16	1.44 B	0.74	0.97 B	0.78
	Rz	1.97 A	0.60	7.08 B	4.51	7.76 B	6.53
	Rt	4.44 A	2.21	12.40 B	5.98	11.83 B	9.10

A, Prebond value; B, Postbond value.

into subgroups; in the first, resin grinding was performed with a 12-fluted tungsten carbide bur (Brasseler, Savannah, Ga), whereas in the second, after the application of the carbide bur, polishing included a series (medium, fine, and extra fine) of Sof-Lex diamond polishing discs (3M/Unitek).

Composite removal and polishing was performed until a visually smooth surface was obtained.

After resin removal, the surface roughness parameters, color shade index, and gloss values were recorded again. The results were analyzed with two-way analysis of variance and Tukey multiple comparisons test, with porcelain type (low- or high-fusing) and polishing protocol (carbide bur or carbide and discs) serving as discriminate variables at $\alpha = 0.05$ level of significance.

RESULTS

Table 1 shows the mean profilometry values for Ra, Rt, and Rz. For all *R* values, there is a difference in prebond and postbond values. These results indicate that there is damage to the porcelain surface from orthodontic bonding and debonding. The results of the two-way variance for both porcelain types (data not shown), indicated that the difference in surface roughness between high-fusing and low-fusing may be explained by random sampling. On the contrary, *R* values for surface treatment (Ra, Rt, and Rz) imply that there is a significant difference between the baseline and postdebonding roughness parameters, regardless of the porcelain surface treatment. The results of a Tukey comparison test for surface roughness parameters showed that there is no difference between the polishing techniques used with respect to roughness variation ($P < .05$).

Table 2 displays the mean porcelain gloss values for variables in this study. The statistical analysis showed that differences noted among porcelain types and treatments are a result of random sampling ($P = .681$). This indicates that the different treatments did not affect the gloss values.

In Table 3, the overall change in color shade is presented for each porcelain group. The table indicates the percentage of specimens showing change in color indices (shade, value, and hue) from baseline values, where significant alterations are noted. The use of Sof-Lex discs in this case seems to be capable of restoring the induced changes to some extent.

TABLE 2. Porcelain Gloss Changes Induced by Bonding and Debonding. Measured by Percent (%) Incident Beam vs Refracted Beam

			Debonded			
	Baseline		Carbide		Soft Flex	
Group	Mean	SD	Mean	SD	Mean	SD
High-fusing	7.80 A	5.93	2.8 B	1.75	11.9 B	5.36
Low-fusing	22.15 A	9.31	16.8 B	8.13	25.5 B	9.55

TABLE 3. Percentage of Specimens Showing Color Index Changes After Debonding and Polishing

Group	Percent Change	Carbide	Carbide + Sof-Lex
High-fusing	Shade	70%	30%
	Value	40%	20%
	Hue	40%	60%
Low-fusing	Shade	50%	10%
	Value	60%	20%
	Hue	90%	60%

DISCUSSION

It has been suggested that the low-fusing porcelain systems, rather than the traditional high-fusing porcelain, provide a porcelain surface that is easier to finish by manual polishing.[1] It is important to polish debonded restorations because a roughened surface affects the cosmetic appearance of the restoration. Also, knowledge of the limitations of polishing techniques for prosthetic restorations is critical for the longevity and esthetics of the restoration because rough surfaces attract plaque and staining factors. As indicated in this study, no difference was observed between low- and high-fusing porcelain with respect to roughness, gloss, and color alterations after polishing.

The mean baseline surface roughness measurements suggest that there is no difference between the nonglazed high- and low-fusing porcelain systems used in this study before bracket placement. Both were polished to an adequate level. The profilometry values in Table 1 indicate that there is a considerable difference in the initial and postdebonding measurements. The surface texture *R* values indicate a statistically significant alteration in the both porcelain system surfaces. Five of the total 40 facet wedges demonstrated a fracture, which may be due to the nonglazed surface. It can be concluded that orthodontic bonding and debonding alters the surface roughness of porcelain in an irreversible manner, regardless of the porcelain type or polishing method used to restore the surface.

The porcelain surfaces were polished to a comparable level with both the carbide bur and the Sof-Lex discs, used to polish the porcelain facets. The carbide composite removal burs used in this study are commonly used to remove orthodontic adhesive from enamel and are known for their predictable result.[12,13] Although the use of these discs has been found to be capable of polishing other dental materials, in this study there was no statistical difference found for the carbide bur and the use of carbide with Sof-Lex discs. Thus, incorporation of this additional stage in resin grinding may not be justified.

The results for the gloss values for this study indicate no difference between the high-fusing and low-fusing porcelain systems. Both systems had considerable change from baseline levels after both polishing techniques were applied to restore the surfaces. Clinically, a roughened surface can give the appearance of a lighter and less-dense porcelain surface, and this may change the esthetic appearance of a ceramic restoration. It could be that the variation in resin grinding, amount of adhesive or composite tags left, induced the alterations in the porcelain surface. The extent of this variability is evidenced by the increased standard deviation, which precluded the extrapolation of significance for these values. However, further research into a more sophisticated porcelain polishing system may indeed show a difference between high-fusing and low-fusing porcelain systems.

The orthodontic bonding to enamel surfaces does not clinically alter the color of the tooth.[14] However, the color values in this study were altered by bonding and debonding process. The color for this study was a quantitative measure because the color is intrinsic to the porcelain used and can be influenced by the texture of the porcelain surface. Remaining adhesive and composite tags play a role in the color changes. The value, hue, and chroma will appear altered depending on how smooth or rough the surface appears to a clinician and other observers. Further research evaluating the clinical significance of these changes should be performed.

CONCLUSIONS

- There is considerable change in the three roughness parameters after debonding, implying that the polishing regimens did not restore the surface of the porcelain to its prebonding state.
- There was no statistical difference in porcelain surface roughness between the two porcelain systems used regardless of the polishing method.
- Porcelain gloss was not altered significantly between the baseline and postdebonding states.
- Porcelain shade, value, and hue were significantly altered after orthodontic bonding.
- No previous knowledge of porcelain type is necessary to bond orthodontic brackets because both low- and high-fusing porcelain responded in a similar manner to surface alterations.
- There is a need to standardize a polishing protocol for porcelain polishing after debonding.

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