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Force to Debond Brackets from High-fusing and Low-fusing Porcelain Systems

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ABSTRACT

The purpose of this study was to test the hypothesis that porcelain surface finishing, ie, low- and high-fusing porcelain, has an effect on the amount of force required to debond orthodontic brackets. A total of 20 high-fusing and 20 low-fusing porcelain specimens were prepared, polished, and bonded with standard edgewise brackets using a suggested porcelain bonding protocol. The brackets were debonded with a universal testing machine at shear mode. Resin removal was performed using two methods: a multifluted carbide bur with and without the use of Sof-Lex polishing discs. Representative specimens were studied under a scanning electron microscope before and after debonding to assess the surface morphology and potential surface damage. Statistical analysis with a *t*-test revealed that there was no difference between the two porcelain treatments on the force to debond values and no qualitative differences were observed on the porcelain surface between the two resin clean-up methods. From a clinical perspective, the practitioner can bond ceramic restorations without previous knowledge of the porcelain type used.

KEY WORDS: Porcelain, Bond strength, Surface characteristics.

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INTRODUCTION Return to TOC

With the advent of new technologies in porcelain fabrication methods and the growing number of adult patients seeking orthodontic treatment, the likelihood of bonding orthodontic brackets to porcelain is increasing.[1] The demand for highly esthetic restorations has generated the development of more advanced porcelain systems that can be used for both all-ceramic and porcelain-fused-to-metal restorations. The newest porcelains, made of low-fusing porcelain, provide many greater advantages vs traditional porcelains, including increased opalescence, the ability to polish chairside, and less abrasive wear on opposing teeth and materials.[2,3] Conventional bonding systems typically give very low force to debond values, and companies have marketed products that use a stronger etchant and a silane-coupling agent to improve the amount of force to debond.[4–6]

Although many studies have addressed the issue of the force to debond brackets bonded to porcelain, there is a notable lack of evidence of investigations assessing the variability of the forces to debond among different porcelain types as well as failure mode of new porcelain systems. This issue receives greater importance considering that in most cases, the orthodontist is faced with the problem of bonding to a surface for which there is no information regarding its structure and type (traditional vs new).

Thus, the purpose of this study was to determine whether there is a difference in force to debond between two different porcelain systems as well as to determine the site of bond failure.

MATERIALS AND METHODS Return to TOC

A total of 40 porcelain facets were prepared and polished. The samples were divided into two groups of 20 on the basis of porcelain type. Group A was of a high-fusing, vitadur alpha dentine shade A3 porcelain (Vident, Brea, Calif), and group B was a vita omega 900 dentine shade A3 low-fusing porcelain (Vident)

The porcelain samples were stacked using a preformed metal die, which created a flat surface layer. All samples from both groups were then fired and baked in a ceramic oven (Centurion VPC NEY, Dentsply, Burlington, NJ) according to manufacturer's specifications. The 40 samples were polished using the Dialite porcelain polishing system (Brasseler, Savannah, Ga) and embedded in acrylic using a custom-made jig so that the porcelain surfaces are horizontal to the floor, thus providing a means to standardize the orientation of the prospective bonding substrate.

Representative samples from the two groups were examined under a scanning electron microscope (SEM) (Quanta 200, FEI, Hillsboro, Ore) at 50× and 100× magnifications to assess the porcelain surface topography before bonding. Standard edgewise, upper maxillary incisor brackets of 0.022-inch slot (0° torque and 0° tip) with mesh pads (Victory Series, 3M/Unitek Corporation, Monrovia, Calif) were bonded to the porcelain surfaces. For this purpose, a porcelain bonding system consisting of a hydrofluoric acid (Porc-Etch, Reliance Orthodontic Products Inc, Itasca, Ill) and a silane-coupling agent (Porcelain Conditioner, Reliance Orthodontics) were used according to the manufacturer's instructions. Brackets were bonded with a Transbond XT Light Cure Adhesive Primer (3M/Unitek) and the Transbond XT adhesive (3M/Unitek) and light cured for 40 seconds.

Shear bond testing

A universal testing machine (Monsanto Tensometer Model T10, Swindon, Wiltshire, UK) was used to evaluate the force to debond the brackets bonded to the porcelain samples, using a shear load at a crosshead speed of 1 mm/min. The specimens were loaded in the machine such that the blade loaded the bracket parallel to the bonded surface. The maximum load for each sample was recorded in Newtons.

Polishing

After debonding, the two porcelain groups were further divided into two subgroups each. In the first subgroup, the resin was ground with an eight-fluted carbide finishing bur using a high-speed handpiece (Fressima, FIT, Turin, Italy) In the second subgroup, both an eight-fluted bur in a high-speed handpiece and the fine Sof-Lex finishing discs (3M/Unitek) in a slow-speed handpiece were used. After debonding and resin clean-up, representative samples of the debonded porcelain were examined under the SEM to assess the potential surface alteration induced by the process.

Statistical analysis

A *t*-test was used to analyze the data collected for the force to debond between the two samples at $\alpha = .05$ level of significance.

RESULTS Return to TOC

The forces to debond for the high-fusing and low-fusing porcelain samples are shown in Table 1. The *t*-test showed no significant difference in bond strength between the two groups.

Figure 1 depicts the surface of a high-fused porcelain after polishing with the fluted bur (a) and with fluted-bur and Sof-Lex discs (b), whereas the appearance of low-fused porcelain is shown in Figure 2a,b. Bond strength testing revealed the failure mode, which in many cases involved porcelain fractures. In these cases, the strength results were excluded from the pool of data.

DISCUSSION Return to TOC

In this study, the results of force to debond testing are expressed in force units (N) as opposed to pressure units (Pa) because the transformation of force to pressure requires the estimation of the actual surface contact area. The actual surface contact area is far from being effectively approximated by the surface area of the rectangular base because of the base mesh design patterns. Moreover, dividing the force values by the base surface area to estimate the pressure values implies that the distribution of the load applied is homogeneous across the entire bracket base, a hypothesis which was proved to be erroneous.[7] Finally, the practicality of reporting pressure units, which are clinically irrelevant, is questionable.

From a compositional perspective, the main difference between high- and low-fusing porcelains is the leucite content.[2] The addition of leucite raises the coefficient of thermal expansion; thus, high-fusing porcelains have higher leucite content than low-fusing porcelains.[2] The percentage difference of leucite probably does not significantly alter the surface characteristics enough to create a difference in bond strength between the two systems. Other contributing factors, such as surface roughness and the bonding system used most likely play a role. Both porcelains were polished and bonded using the same methods. Visual inspection of the SEMs showed they had similar roughness, which possibly leads to similar forces to debond.

The bonding provided surpassed the resin cohesive strength. The majority showed cohesive failures. Adhesive failures are rarely observed due to the difficulty of verifying that all the resin has remained on the enamel or porcelain surface, because even if small layers of adhesive may have been removed, it is not known how the resin looked like when it was intact.

From a clinical perspective, the results of this study suggest that it is not necessary for the practitioner to have previous knowledge of the type of porcelain that will be bonded, because no difference is expected with a standard bonding protocol.

The images obtained from the SEM showed that there was no surface damage to the porcelain. However, the porcelain surface appeared similar to the enamel after etching with hydrofluoric acid and debonding, and this may indicate the presence of resin tags. As has been reported in other studies, the presence of these resin tags will have an effect on the surface characteristics of the porcelain.[8,9] The method of polishing after debonding will also affect the surface topography and color characterization of the area that was bonded.[8,9] Other polishing methods may provide different topographical patterns, and the alterations described in this study are only indicative of the effects of the specific polishing protocol used and should not be applied to any other resin-removal protocol. These are important considerations regarding the superior chairside polish ability of low-fusing porcelains.

CONCLUSIONS Return to TOC

- There is no difference in bond strength between low- and high-fusing porcelain restorations. From a clinical perspective, the operator can bond ceramic restorations without previous knowledge of the porcelain type.
- The SEM indicates that there was significant adhesive left on the porcelain surface and bracket, so the site of failure was cohesive rather than adhesive.

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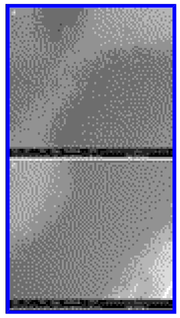
TABLES Return to TOC

TABLE 1. Mean Force to Debond (Newtons)

Porcelain Type	Grouping*	Number	Mean	SD
Low fusing	A	15	79.489	11.985
High fusing	A	14	86.755	13.963

* Means with same letters are not significantly different at the 0.05 level of significance.

FIGURES Return to TOC



Click on thumbnail for full-sized image.

FIGURE 1. (a) Scanning electron microscope (SEM) image of high-fusing porcelain polished with fluted bur (50×). (b) SEM image of high-fusing porcelain polished with fluted bur and Sof-Lex discs (50×)

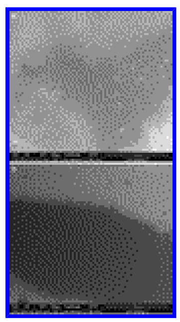


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FIGURE 2. (a) Scanning electron microscope (SEM) image of low-fusing porcelain polished with fluted bur (50×). (b) SEM image of low-fusing porcelain polished with fluted bur and Sof-Lex discs (50×)

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