Influence of chisel width on shear bond strength of composite to enamel

Influência da largura do cinzel sobre a resistência ao cisalhamento da união esmalte/resina composta

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Abstract

Purpose: To evaluate the effect of chisel width on shear bond strength of composite to dental enamel.

Methods: Sixty crowns of bovine incisors were embedded in acrylic resin, and their enamel surfaces were flattened and etched with 35% phosphoric acid. Single Bond (3M/ESPE) adhesive system and Z-250 (3M/ESPE) composite were used to build a cylindrical-shaped restoration perpendicular to the conditioned enamel flat surface. Specimens were divided into four groups and subjected to the shear bond strength testing using a chisel-shaped shearing blade with a 0.5, 1.0, 2.0, or 3.0 mm-width blunt edge in a universal testing machine at crosshead speed of 0.5 mm/min. Data on shear bond strength were analyzed by ANOVA and Duncan's test (α=0.05).

Results: Shear bond strength means for the experimental groups were: 0.5 mm – 19.66 MPa; 1 mm – 18.78 MPa; 2 mm – 16.77 MPa; 3 mm – 16.06 MPa. Bond strength was significantly different between the groups tested with chisels of 0.5 and 3 mm-width (P=0.045) showing an inverse relationship between shear bond strength and chisel width.

Conclusion: The results suggest that shear bond strength varies as a function of chisel width.

Key words: Dental materials; mechanical properties; shear strength

Resumo

Objetivo: Avaliar a influência de diferentes larguras de cinzel sobre a resistência de união ao cisalhamento na interface esmalte dental/resina composta.

Metodologia: As coroas de 60 dentes incisivos bovinos foram incluídas em resina acrílica e as superfícies vestibulares de esmalte foram planificadas e condicionadas com ácido fosfórico a 35%. O sistema adesivo Single Bond (3M/ESPE) e de resina composta Z-250 (3M/ESPE) foram utilizados para fabricar restaurações cilíndricas de resina composta perpendiculares à superfície plana do esmalte condicionado. Para o teste de cisalhamento, os espécimes foram submetidos ao ensaio mecânico com cinzéis de 0,5 mm, 1,0 mm, 2,0 mm ou 3,0 mm de largura da parte ativa romba, em uma máquina de ensaio universal à velocidade de 0,5 mm/min. Os dados obtidos foram analisados por análise de variância e teste de Duncan ao nível de significância de 5%.

Resultados: As médias de resistência de união ao cisalhamento dos grupos testados foram: 0,5 mm – 19,66 MPa; 1,0 mm – 18,78 MPa; 2,0 mm – 16,77 MPa; 3,0 mm –16,06 MPa. Houve diferença estatisticamente significativa entre os grupos de 0,5 e 3,0 mm (P=0,045), com uma relação inversa entre resistência de união ao cisalhamento e largura do cinzel.

Conclusão: Os resultados sugerem que a resistência de união ao cisalhamento sofre influência da largura do cinzel utilizado no ensaio.

Palavras-chave: Materiais dentários; propriedades mecânicas; cisalhamento

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Introduction

Although clinical trials would provide the ultimate evidence of clinical performance of dental restorations, preliminary and safety studies on dental materials should be conducted *in vitro*. Laboratory results cannot be extrapolated directly to the clinics, but they can be useful to establish a clinical research protocol with a more rational approach to subject recruitment and follow-up, outcome measures, study length, and budget. Laboratory studies are designed to assess physical properties and mechanism of action of dental materials recently marketed (1,2). Because frequent modifications of material composition may jeopardize its clinical evaluation for a period of time longer than the commercial availability, laboratory testing is suitable for evaluating bond strength of composite to dental tissues, marginal gap, and leakage (3).
Tensile and shear strength tests are widely used to assess bond strength to dental substrates, yet data reported in the literature often are controversial and cannot be directly compared due to lack of standardized testing methods (4,5). For example, many variables may affect bond strength values, such as dental surface treatment (6,7), thermocycling (8), acid-etching material and procedures (9-11), testing load, and material elastic properties (12). Another aspect that has been overlooked is the apparatus used for the mechanical assays, which varies in shape and dimensions and may affect bond strength for the same tested material (13).
In 1991, the International Organization for Standardization (ISO) released the technical specification CD TR 11405 to standardize bond strength tests on dental substrate, and chisels with a width of 0.5, 1.0, 2.0, and 3.0 mm were recommended for shear bond strength tests. Nevertheless, many studies have not complied with this specification due to some criticisms raised against the parameters established and its applicability for mechanical testing (14).
Shear bond strength test has been the most used method to measure bond strength reported in the dental literature, but the direct comparison of results from studies using different methods is very difficult because of large variability and controversial findings (15-17). Therefore, it is necessary to adopt standardized methods to evaluate bond strength using the most appropriate instruments. The present study aimed to evaluate the effect of chisel width on shear bond strength of composite to dental enamel.

Methods

Sixty bovine incisors with no visible defects in enamel were used to prepare the test specimens. The teeth were cleaned with pumice slurry using a Robinson brush in low speed and stored up to 6 months in saline solution. The crowns were cut and embedded in acrylic resin using a cylindrical mold (20×20 mm), with the buccal face positioned upwards and projected 1 mm beyond the cylinder border. The buccal enamel surface were ground with 180-, 220-, and 400-grit sandpaper with gentle pressure and water cooling until a minimum of 5 mm-diameter flat area was obtained. An adhesive tape with a 5 mm-diameter central hole was placed over the enamel surface to limit the bonding area.
The enamel surfaces were conditioned with 35 % phosphoric acid (3M/ESPE, St Paul, MN, USA) for 15 s, washed, and gently dried according to the manufacturer's directions. The adhesive system Single Bond® (3M/ESPE, St Paul, MN, USA) was applied on the etched enamel using a microbrush and photoactivated with halogen light (XL 3000, 3M/ESPE, St Paul, MN, USA) at 500 mW/cm^2. A cylindrical-shaped composite restoration was built with four incremental 2.5 mm-thick layers of composite Z-250 (3M, St Paul, MN, USA) using a split Teflon mold (5 mm-diameter and 9 mm-height). Each composite layer was cured for 20 s using halogen light at 500 mW/cm^2. The specimens were stored for 1 h at 37ºC and 100 % relative humidity and afterwards immersed in distilled water at 37ºC for 23 h before mechanical testing.
Four experimental groups were tested as a function of chisel width (0.5, 1.0, 2.0, and 3.0 mm). The specimens were subjected to the shear strength test in a universal testing machine (EMIC DL 2000, EMIC, São José dos Pinhais, PR, Brazil) at a crosshead speed of 0.5 mm/min (12). Each specimen was placed into a metallic cylindrical support fixed to the inferior jig of the universal testing machine so that the adhesive interface was vertical. In the superior jig, a chisel-shaped shearing blade with a 0.5, 1.0, 2.0, or 3.0 mm-width blunt edge was aligned parallel with the flat enamel surface of the bonded specimen, and the edge was positioned adjacent to the enamel/composite interface. The rupture force was recorded to calculate the shear bond strength (MPa) considering the cross-sectional bonding area. Data were statistically analyzed using ANOVA and pos-hoc Duncan test at the 5 % significance level.

Results

Table 1 displays the comparison of shear bond strength as a function of chisel width. Bond strength was statistically different among the tested groups (P=0.045) and showed an inverse relationship with chisel width. The highest bond strength was recorded for the 0.5 mm-width group, and the lowest mean value was found for the 3.0 mm-width group.

Table 1. Comparison of shear bond strength (MPa) as a function of chisel width.

Chisel width (mm)	n	Shear bond strength mean (MPa)	SD (MPa)
0.5	13	19.66 [a]	3.01
1.0	15	18.78 [ab]	4.23
2.0	15	16.77 [ab]	2.88
3.0	15	16.06 [b]	4.47

* Means followed by different letters are statistically different at the 5% significance level (ANOVA and Ducan's test).

Discussion

This study showed that the different chisel width cited in ISO specification CD TR 11405 had a significant effect on the variability of shear bond strength of composite to dental enamel. Mean bond strength values increased more than 20% when a 0.5 mm-width chisel was used in comparison with a 3.0 mm-width chisel, which suggests that there is a dissipation of tensions through the chisel/composite interface.

Such findings are in agreement with those reported by Sinhoreti et al. (18), who evaluated three different apparatus for the shear bond strength test (metallic tape, orthodontic wire, and chisel) and showed that the smaller the contact interface, the greater the bond strength values. However, orthodontic wire has been mainly used in dentin (19,20), and the present study tested shear bond strength of composite to enamel. Enamel was chosen because the adhesive procedures are simpler than those in dentin due to differences in mineral content; thus, the influence of substrate variability on bond strength could be reduced.

The chisel blade was positioned next to the adhesive interface to minimize the flexion effect during the mechanical testing. The chisel blunt edge induces a cleavage effort; tensions initially are concentrated close to the loading area and then evolve to more complex tensions in the entire system (18). Plácido (21) showed in a finite element study that shear bond strength had an inverse relationship with distance of load application at the adhesive interface, and the most appropriate loading distance was 1.0 mm. The present findings and previous studies (3,5,16,18,22,23) show that different shape and dimensions of the loading apparatus for shear strength bond testing may introduce confounding variables resulting in different bond strength values for the same material. Therefore, there is an urgent need for standardization of procedures to test bond strength.

One limitation of this study is that all specimens were fabricated with one type of adhesive system and one composite. It is possible that other materials have different performance, particularly when testing bond strength to other substrates than enamel, such as dentin, porcelain, or old composite. Further investigations are then warranted to help to develop the most appropriate method to test shear bond strength.

Conclusions

Within the limitations of this study, the results suggest that shear bond strength of composite to dental enamel varies as a function of chisel width.

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