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Internal adjustments decrease the fatigue failure load of bonded simplified lithium disilicate restorations

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ABSTRACT

Objective. To investigate the effect of intaglio surface adjustment of simplified lithium disilicate ceramic restorations adhesively cemented to a dentin-like material on its fatigue behavior.

Methods. Ceramic discs (IPS e.max CAD) were prepared and an in-Lab simulation of machining roughness was performed by grinding with SiC paper (#60). Ceramic discs were divided into 4 groups according to the internal adjustment of the cementation surface: no adjustments (CTRL); adjustment with a medium (M), fine (F), or extra fine (FF) diamond bur. Dentin-like material discs were also produced. Ceramic disc intaglio surfaces were etched (5% hydrofluoric acid; 20 s) and received a silane coating. Dentin-like material discs were etched (10% hydrofluoric acid; 1 min) and received a primer coating. Pairs of ceramic/dentin-like material were adhesively cemented (Multilink Automix), and fatigue failure load tests were performed using the Staircase approach (250,000 cycles; 20 Hz). Roughness, topographic and fractographic analyses were performed. Statistical analyses were carried out through ANOVA tests.

Results. All ground groups (M = 521.3 N; F = 536.9 N; FF = 676.2 N) presented lower fatigue failure load values than the control (1241.6 N). M diamond bur created a rougher surface than F (Ra and Rz parameters). However, FF was similar to F and M for Ra, and similar to F for Rz.

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Significance. Bur adjustments on the intaglio surface of simplified lithium disilicate ceramic restorations greatly decreased the fatigue failure load even using an extra-fine diamond bur. Care should be taken when internal adjustments are needed.

1. Introduction

Monolithic restorations present great advantages when compared to bilayer ceramic systems due to fewer steps in the fabrication process, and the absent susceptibility to chipping [1]. In addition, lithium disilicate glass-ceramics stand out for combining satisfactory aesthetic and mechanical properties among ceramic materials available to produce monolithic restorations [2]. Lithium disilicate ceramic is indicated to produce inlays, onlays, anterior and posterior single crowns and three-unit bridges (up to the second premolar) [3]. Literature shows success rates for single crowns of 94.8% in a follow-up of 8 years [4].

According to Seydler and Schmitter [5], the use of a CAD/CAM (Computer Aided Design/Computer Aided Manufacturing) system allows producing ceramic restorations with a decreased number of internal defects. However, previous studies reported that the machining process generates defects in the intaglio ceramic surface, being associated with lower strength values [6–8]. Moreover, when indirect ceramic restorations are machined, the technique used to copy the tooth preparation (printing/molding/scanning) may affect its final fit [9]. In those cases, internal adjustments could improve the ceramic restoration fitting, although it is already known that diamond burs can introduce new defects onto the ceramic surface, leading to increased roughness [10,11] and thicker resin cement layer.

As is known, brittle materials such as glass-ceramics are less resistant to tensile stresses. In glass-ceramic indirect restorations, tensile stresses are observed in the cementation (intaglio) surface which is the region where failure begins, as previously confirmed through finite element and fractographic analysis of clinically fractured crowns [12–14]. In this sense, internal adjustments could decrease the mechanical strength of ceramic restorations [15,16], since the material resistance is directly related to the size of its flaws [17].

Adhesively cementation has been indicated to improve long-term survival of dental ceramic restorations [18–20]. For glass-ceramics, it associates micro-mechanical (hydrofluoric acid etching) and chemical (silane-coupling agent) approaches for resin bond improvements [21,22]. For lithium disilicate ceramics, hydrofluoric acid etching removes the superficial glass matrix and detaches some superficial lithium disilicate grains [23]. This procedure creates micro retentions, and consequently increases the area available for adhesion [24]. Organosilane is a bifunctional molecule that allows joining the inorganic phase (siliceous) of the ceramic to the organic matrix of the resin cement through siloxane bonds [25,26].

Although studies have found rougher surfaces after hydrofluoric acid etching [27–29] which could contribute to propagating flaws, the literature is still controversial about the effect of hydrofluoric acid on the glass-ceramic strength [24,27,30–32]. In the same way, it is not well established if hydrofluoric acid can increase the internal defects produced by internal adjustments, and consequently decrease glass-ceramic strength. Ruschel et al. [33] showed that internal adjustments with diamond burs did not affect the flexural strength of lithium disilicate samples. However, the aforementioned authors did not perform hydrofluoric acid etching, which does not represent a clinical situation.

Thus, there is no report in the literature approaching these factors together: the presence or simulation of defects produced by CAD/CAM milling, the internal adjustment of the ceramic restoration, and cementation with previous hydrofluoric acid etching. Considering this scenario, one question remains: Can internal adjustment with diamond burs change the fatigue behavior of an adhesively cemented lithium disilicate restoration? Therefore, the present study aimed to evaluate the effect of the internal adjustment by burs with different diamond grit sizes on the fatigue failure load of lithium disilicate simplified restorations adhesively cemented to a dentin-like material. The study hypotheses were: (1) the internal adjustment will not influence the fatigue failure load; and (2) the diamond bur grit sizes will not affect the fatigue failure load.

2. Materials and methods

2.1. Experimental design

The analyzed factor in this *in vitro* study was the internal adjustment of simplified ceramic restorations at four levels: no internal adjustments for the control group (CTRL), and grinding with medium (M), fine (F), and extra fine (FF) diamond bur grit sizes. The main response variable was fatigue failure load.

2.2. Production of ceramic discs

Pre-fabricated ceramic blocks of a lithium disilicate-based glass-ceramic (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) were shaped into cylinders by a diamond drill (10 mm in Ø; Diamant Boart, Brussels, Belgium) under water-cooling. The cylinders were cut into discs (1.5 mm thick; IsoMet 1000, Buehler, Lake Bluff, EUA) under water-cooling, producing a total of a hundred slices. Ceramic discs were polished (EcoMet/AutoMet 250, Buehler) on both sides with #400, #600, and #1200 grit SiC papers (Carborundum Abrasives, Guarulhos, Brazil) to make standardized surfaces (mean roughness of polished ceramic discs: $Ra = 0.18 \pm 0.09$; $Rz = 1.83 \pm 0.97$). Initial thicknesses were recorded from the specimens' center with a digital caliper after polishing procedures. A single trained operator performed all the polishing procedures.

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