Original Article

Effect of Different Etching Periods on Fracture Strength of Machinable Lithium Disilicate

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Abstract

The aim of our study was to evaluate the effect of different etching times of hydrofluoric acid on the fracture strength of machinable lithium disilicate glass-ceramic (IPS e.max CAD). 80 IPS e.max CAD (5×5×2mm) specimens were divided into 5 groups (15 specimens in each group), using 5% Hydrofluoric acid (HF) to etch the groups (0 s, 20 s, 60 s, 120 s, 180 s). Then for 7 specimens of each group, silane was applied on the etched surface followed by a thin layer (0.1 mm) of resin cement. Fracture load was determined for all specimens using a universal testing machine with the use of a specially designed metal plate to hold the specimen during testing. All data were statistically analyzed using one-way ANOVA and paired t-test with a confidence interval of 95%. Etching IPS e.max CAD for 20 seconds did not decrease the fracture strength. While the other etching times showed a significant decrease in fracture strength with an increase in etching time. Resin cement significantly increased the fracture strength of each group.

Keywords: Etching, Fracture strength, Lithium disilicate, Dental materials, E.max.

Introduction

Glass-ceramic restorations have been used widely in dentistry for restoring lost, fractured, and decayed teeth. The addition of lithium disilicate crystals to glass ceramics was to increase strength and durability over conventional dental ceramics [1]. Lithium disilicate glass ceramics have shown excellent clinical results with great mechanical and optical properties [2-4] with high survival rates [5, 6]. Lithium disilicate glass ceramics are widely used by dentists for their optimum properties, high aesthetics, adhesion to the tooth structure, biocompatibility, and similar thermal expansion to the tooth structure [7-10]. The retention of glass ceramic restoration is strongly dependent on the surface treatment of the internal surface prior to bonding the restoration to the tooth using resin cement [11]. The ideal surface treatment of lithium disilicate glass-ceramic is achieved with the sum of etching with hydrofluoric acid (HF) followed by a silane coupling agent. This protocol has been recognized as the most accepted surface treatment for glass ceramics. The HF acid condition the surface by reacting with the glass matrix that contains silica forming hexafluoro silicates. Then, this glass matrix is removed exposing the crystalline structure. As a result, the surface of the ceramic becomes rough for micromechanical retention [12, 13]. This rough surface also provides more surface energy before the application of a silane coupling agent [14]. On the other hand, prolonged etching of glass ceramics has been shown to decrease their mechanical properties due to the created microcracks on the etched surface [15]. Therefore, it is essential to determine the Many studies that have tested the effect of different etching periods on strength of pressed lithium disilicate glass ceramics [11, 16]. Only a few studies are available on machinable lithium disilicate glass ceramics and none of them bonded the specimens [17, 18]. Therefore, we are focusing in our study on machinable lithium disilicate glass ceramics (IPS e.max CAD) considering bonding the specimens. The aim of our study was to evaluate the effect of different etching times of hydrofluoric acid on the fracture strength of machinable lithium disilicate glass-ceramic (IPS e.max CAD).

Materials and Methods

This research was an in-vitro study. 80 IPS e.max CAD (Ivoclar Vivadent, Schaan, Liechtenstein) (5×5×2mm) specimens were prepared from sectioning IPS e.max CAD

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blocks using a low-speed diamond wheel. All specimens then were polished using 600 grit silicon carbide papers and then fired in a vacuum pump furnace (Programat CS2) (Ivoclar Vivadent, Schaan, Liechtenstein) following the manufacturer's instructions. 5% hydrofluoric acid (IPS ceramic etching gel) (Ivoclar Vivadent, Schaan, Liechtenstein) was used to etch the specimens. The specimens were divided into 5 groups (15 specimens in each group) according to etching duration which is group 1 (no etching: control), group 2 (etching for 20 seconds), group 3 (etching for 60 seconds), group 4 (etching for 120 seconds) and group 5 (etching for 180 seconds). After etching, specimens were cleaned with running water for 15 seconds. Then for 7 specimens of each group, silane (Monobond Plus) (Ivoclar Vivadent, Schaan, Liechtenstein) was applied on the etched surface followed by a thin layer (0.1 mm) of dual-cure resin cement (Variolink II) (Ivoclar Vivadent, Schaan, Liechtenstein). Resin cement then was cured for 40 seconds using LED curing light (3M, St. Paul, Minnesota). Fracture load was determined for all specimens using a universal testing machine with the use of a specially designed metal plate to hold the specimen during testing. The bonded surface was facing downward, and a flat jig was centered on top of the specimen. Then fracture strength was calculated according to the formula fracture strength= maximum load/surface area. All data were statistically analyzed using one-way ANOVA and paired t-test with a confidence interval of 95%.

Results and Discussion

No significant difference was found in fracture strength of control (no etching) and 20 seconds etching groups. Those two groups (control and 20 sec.) showed significantly higher strength than 60, 120, and 180 sec. groups (p=0.001). A decrease in fracture strength was noticed with an increase in etching time of 60,120 and 180 sec. etching groups.

Table 1. Fracture strength in megapascal (Mpa) according to etching time without cement.

Group	Mean (Mpa)	SD
Control	48.8	5.1
20 sec.	45.7	4.4
60 sec.	23.9	1.7
120 sec.	20.6	1.4
180 sec.	18.2	1.6

The 20 sec. etching group showed significantly the highest fracture strength among the cemented groups (60, 120, and 180 sec.) (p=0.001). While the 180 sec. etching group showed significantly the lowest fracture strength (p=0.001). There was a significant increase in fracture strength of each group after cement application.

Table 2. Fracture strength in megapascal (Mpa) according to etching time with cement application

Group	Mean (Mpa)	SD
20 sec.	51.5	4.3
60 sec.	42.2	5.9
120 sec.	43.7	4.5

The standard method for the cementation of glass ceramics depends on etching and silanating the internal surface of the restoration [19]. Some studies recommended etching with HF acid over phosphoric acid [19, 20]. Many studies have been done evaluating the effect of HF acid on strength of lithium disilicate glass ceramics [11, 16-18]. Hooshmand *et al*. found that etching pressed lithium disilicate ceramic with 9% HF acid for 2 minutes significantly reduced the biaxial flexural strength11. Xiaoping et. used 9.5% HF acid for different times (0 s,20 s,40 s,60 s, 120 s) on pressed lithium disilicate ceramic and found increasing etching time decreased the flexural strength but resin cement bonding on the etched surfaces significantly strengthened the ceramics [16]. Zogheib *et al*., also found etching machinable lithium disilicate ceramics with 4.9% HF acid for different times (20 s, 40 s, 60 s, 180 s) significantly reduced the flexural strength as the etching time increased [17]. Menees *et al*., explored the effect of etching machinable glass ceramic using 5% and 9,5% HF acid for (20 s and 120 s) and found no significant difference in the flexural strength between the groups [18].

In the present study, we used 5% HF acid to etch machinable lithium disilicate glass-ceramic (IPS e.max CAD) for different etching times (0 s, 20 s, 60 s, 120 s, 180 s) part of the specimens were bonded using resin cement. Based on our results, etching IPS e.max CAD for 20 seconds does not decrease the fracture strength. While the other etching times showed a significant decrease in fracture strength with an increase in etching time. This agrees with Xiaoping *et al*., who found a significant decrease in the flexural strength of IPS e.max Press with increased etching time [16]. Also, Zogheib *et al*., concluded that increasing the etching time of IPS e.max CAD significantly decreases the flexural strength [17]. On the other hand, our finding disagrees with Menees *et al*., which they found no significant difference in the flexural strength of IPS e.max CAD With different etching times [18]. Additionally, we found resin cement significantly increases the fracture strength of each group. This finding also agrees with Xiaoping *et al*., who found resin cement bonding would strengthen etched IPS e.max Press [16]. The manufacturer of IPS e.max CAD recommended using 5% HF acid for 20 seconds for etching. According to our results, we emphasize not exceeding 20 seconds for etching IPS e.max CAD to avoid any weakening effect that might happen with long etching times.

The main limitation of our study is that only one HF acid concentration was examined. Further future study to evaluate the combination of different concentrations with different etching times is recommended.

Conclusion

Increasing HF acid etching time beyond the manufacturer's instructions might have a weakening effect on IPS e.max CAD. Etching IPS e.max CAD for 20 seconds is safe and recommended.

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