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ORIGINAL ARTICLE

Effect of the precrack preparation with an ultrasonic instrument on the ceramic bracket removal

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Background/Purpose: In terms of fracture mechanics, a precrack preparation may facilitate the propagation of a break through the expected fracture plane during the bracket debonding process. The purpose of this study was to evaluate the effect of an ultrasonic precrack preparation on the debonding force and failure modes of ceramic bracket removal.
Methods: Eighty extracted premolars were assigned to four groups: Inspire, precrack Inspire, Clarity, and precrack Clarity groups, with each group containing 20 teeth. The precrack preparations were made at the mesial gingival line angle of Inspire brackets and on the mesial side of Clarity brackets with an ultrasonic tip. Debonding force, failure modes, and bracket breakage score were measured and recorded. Fracture surfaces after bracket debonding were observed with scanning electron microscopy (SEM).
Results: We found that the ultrasonic precrack preparation could significantly decrease the average debonding force and the mean bracket breakage scores of both kinds of ceramic brackets. After bracket debonding, 80% of brackets in the precrack Inspire group and 100% of brackets in the precrack Clarity group showed no bracket failure. However, only 25% of brackets in the Inspire group and 75% of brackets in the Clarity group showed no bracket failure. SEM micrographs showed a precrack notch at the adhesive resin after precrack preparation, and no enamel damage was noted after the bracket debonding.

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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Conclusion: The ultrasonic precrack preparation can significantly decrease the debonding force and may guide the bracket debonding through a favorable fracture plane without damage to either the bracket or the enamel.

Introduction

The ceramic bracket was introduced in the 1980s.[1] It is more esthetic than other kinds of bracket and also resists distortion and discoloration. However, the hardness and brittleness of ceramics could cause a fracture of the bracket, and the fracture piece may retain on tooth surface. The removal of the bracket or residual adhesive resin is time-consuming and may require a high-speed machine.[2,3] In addition, the high-speed bur used to remove the residual resin may sometimes damage the enamel.[4–6]

For facilitating the removal procedure of the ceramic bracket, some manufactures use a modified ceramic bracket design such as the vertical debonding slot of the Clarity bracket (3M Unitek, Monrovia, CA, USA) and the ball-base of the Inspire bracket (Ormco, Orange, CA, USA). Ultrasonic instruments have been tried for the removal of brackets, and the results showed a significant reduction of the debonding strength and a favorable failure mode of the ceramic bracket. However, ultrasonic removal is time-consuming and is not generally accepted in clinical applications.[7,8]

Fracture mechanics is an engineering discipline; its aim is to give a quantitative description of the broken bracket by crack growth. Fracture mechanics is primarily used to prevent and predict catastrophic failure of the structures of man-made materials such as metals, plastics, and ceramics. The fracture mechanics theory assumes that the existence of a defect or crack in the solid can further grow or propagate to cause failure. It then considers the conditions of stress or energy under which propagation will occur.[9]

The bracket removal depends on the failure of the adhesive between the bracket and the enamel surface. According to the fracture mechanics, a surface crack or defect that is capable of propagation can cause the failure. Therefore, the precrack preparation may create a defect on the adhesive layer and facilitate adhesion fracture. The purpose of this study was to evaluate the effect of an ultrasonic precrack preparation on debonding force and failure mode of ceramic bracket removal.

Materials and methods

Eighty extracted premolars free of restorations and caries were collected and stored in (0.1% wt/vol) thymol solution to prevent dehydration and bacterial growth. The teeth were randomly assigned to four groups: Inspire, precrack Inspire, Clarity, and precrack Clarity groups, with each group containing 20 teeth. The upper premolar ceramic brackets with 0.018-in. slots were used in this study. The characteristics of the brackets are summarized in Table 1.

Prior to bonding the ceramic bracket, each tooth was scaled and cleaned by a rubber cup with pumice on a low-speed handpiece. After rinsing, the teeth were etched with 37% phosphoric acid gel (gel etchant, Kerr, Orange, CA) for 30 seconds according to the instruction of the manufacturer. The etching gel was washed out with an air-water spray for 20 seconds, and then the teeth were dried with air until they showed a chalky-white appearance.

A bonding primer (Orthosolo; Ormco) was applied on the etched enamel surface and the teeth were dried with air. Next, the dual-cure adhesive (ENLight, Ormco) was applied between the bracket and the center of the etched enamel surface, and then cured with a light cure unit (L.E. Demetron I, Kerr, Orange, CA, USA) as close to the bracket as possible for 10 seconds (according to the instruction manual) with 800 mw/cm^2 output.

An ultrasonic tip (S13R, Satelec Acteon, Merignac, France) powered by an ultrasonic device (ProphyMax, Satelec Acteon) with a power setting of 10 was used for the preparation of the precrack notch. The precrack notch was made at the interface of the bracket and the enamel surface at the gingival line angles of the Inspire brackets (Fig. 1A) and on the mesial sides of the Clarity brackets (Fig. 1B). Each notch was carefully prepared with 10 strokes.

All brackets were removed with the pliers recommended by the manufacturers. The pliers used for debonding Inspire ceramic bracket were plastic pliers. However, Howe pliers were applied for Clarity bracket debonding. For measuring the debonding force, a universal test machine (Instron 5566; Instron Ltd., High Wycombe, England) was used with a crosshead speed of 5 mm/min. The force of the bracket removal was recorded as the debonding force.

The debonded ceramic bracket and enamel surface were observed under a stereomicroscope (MZ8; Leica, Bensheim, Germany). The types of failure mode, as modified by Eliades et al in 1993,[10] were characterized as follows: Type I, cohesive fracture of bracket; Type II, cohesive fracture of resin; Type III, cohesive fracture of enamel; Type IV,

Table 1 The ceramic brackets used in this study and their characteristics.

	3M Unitek Clarity	Ormco Inspire
Type of bond	Mechanical	Mechanical
Material	Polycrystal AlO_2	Polycrystal AlO_2
Slotsize (inch)	0.018 × 0.022	0.018 × 0.022
Type of wing	Twin	Twin
Color	Opaque	Clear
Base area (mm^2)	11.83	11.67
Recommended debonding instrument	Howe or Weingart hand instrument	A specifically designed plastic