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Review Article

Debonding of Orthodontic Ceramic brackets: A comprehensive review of the literature – Part 1

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ABSTRACT

The purpose of this 2 part literature review is to evaluate various debonding techniques for orthodontic ceramic bracket removal and their clinical applications. In part 1, *in vitro* and *in vivo* studies on mechanical and ultrasonic debonding techniques have been reviewed. Mechanical debonding (use of diamond burs, special pliers) is most widely applicable in clinical practice. Use of recommended pliers by manufacturers is key to minimize bracket failure modes as these pliers are designed specifically for the brackets. Ultrasonic debonding is advantageous in minimizing bracket failure but requires greater time to debond ceramic brackets than mechanical debonding and it may be uncomfortable to the patient due to longer duration of use. Studies on electrothermal and Laser debonding have been reviewed in part 2 of the literature review.

1. Introduction

Ceramic orthodontic brackets, introduced in 1986, are esthetically pleasing alternative to metal brackets.[1] Ceramic brackets are made of aluminium oxide (alumina). There are two types of ceramic brackets based on different manufacturing processes: polycrystalline and monocrystalline.[2] Polycrystalline brackets are manufactured by sintering aluminum oxide particles together. The particles are blended with a binding material, molded into shape, and cut. The molded bracket is fired to allow the binder to be burnt out and the aluminum oxide particles fuse together. This process is relatively inexpensive; however sintering may allow for imperfections at grain boundaries or incorporation of impurities during this process.[3] Monocrystalline brackets are formed by melting aluminium oxide particles and cooling them slowly to allow for crystallization. With no involvement of a binding material, impurities and imperfections are less commonly found among monocrystalline brackets. Following crystallization, the product is milled into a bracket shape.[3] Monocrystalline brackets have greater strength than polycrystalline brackets. However, when scratched, the crack propagates, causing the fracture resistance to decrease to or below that of polycrystalline brackets.[4]

Ceramic brackets have significantly lower fracture toughness than metal brackets and are more likely to shatter during debonding.[5] Even though ceramic brackets are esthetically superior, debonding of ceramic brackets presents various challenges like bracket tie wing failure, enamel fracture, pain and discomfort to the patient during debonding.[6,7] Enamel fracture is of great concern clinically, as it can lead to poor esthetics, need for further restoration and can affect long-term prognosis of the affected tooth. Bracket tie wing failure during treatment results in more clinical time spent to remove the bracket by grinding it with a diamond bur. Ceramic brackets on mandibular anterior teeth can also result in wear of opposing maxillary anterior teeth. Different debonding techniques have been studied for removal of ceramic brackets. There have been four methods utilized for debonding ceramic brackets like mechanical debonding [use of diamond burs,[8] special pliers,[9 10]],

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ultrasonic debonding,[11–17,19] electrothermal debonding and debonding with Lasers. The purpose of this 2 part literature review is to review these four methods of ceramic bracket debonding and their effect on enamel, pulp and the clinical feasibility of such methods for clinician's ease of use for patient's comfort. In part 1, studies on mechanical and ultrasonic debonding techniques have been reviewed. Studies on electrothermal and Laser debonding have been reviewed in part 2.

1.1. Mechanical debonding

This involves the debonding of ceramic brackets using mechanical force delivered through a hand-held instrument. When ceramic brackets fracture during treatment or during debonding, the residual fragments of the bracket are removed by grinding the remnants with a handpiece and a diamond bur. Grinding of ceramic bracket may generate high temperatures that can have detrimental effects on dental pulp. To evaluate this, a study was conducted using 3 types of ceramic brackets (A-Company Starfire, GAC Allure, and Unitek Transcend). A total of 122 brackets were removed by grinding with high-speed diamond burs or low-speed green stones, both with and without air or water coolant.[8] Intrapulpal temperature measurements were made on these teeth with a thermocouple probe fixed to the pulpal wall subjacent to the brackets. These measurements were compared with established threshold temperatures that have been reported to cause pulpal pathosis. The results showed that low-speed grinding without coolant resulted in a significant ($p < 0.001$) increase in pulp chamber temperature for all three types of brackets. The study concluded that neither high-speed nor low-speed grinding during bracket removal caused a rise in pulp chamber temperature when combined with air or water coolant.

It is common that the manufacturers of ceramic brackets recommend specially designed debonding pliers that apply tensile or shear force to debond the bracket from enamel surface. The influence of dimensions of the debonding plier's blade (narrow blade - 2.0 mm, wide blade - 3.2 mm) was evaluated in an *in vitro* study[9] to debond ceramic brackets. The effectiveness and the force levels generated by the use of both wide and narrow blades were studied. The study concluded that the narrow blades effectively debonded ceramic brackets with a significantly lower mean debonding force (120 kg/cm2) than the wider blades (150 kg/cm2).

Over the past decade, manufacturers have introduced collapsible ceramic brackets with metal-lined arch wire slot to reduce friction. Such designs incorporate a vertical slot to facilitate consistent bracket failure during debonding. An *in vitro* study[12] was conducted to evaluate bond failure location when debonding collapsible ceramic bracket and traditional ceramic bracket with Weingart plier. Sixty-one Clarity (3M Unitek) collapsible ceramic brackets, forty-one Transcend 6000 (3M Unitek) brackets, and twenty-one Victory Series (3M Unitek) metal brackets bonded to extracted human teeth were debonded with Weingart pliers (Ormco). The adhesive remaining after bracket removal was assessed using the Adhesive Remnant Index (ARI). The study concluded that debonding collapsible ceramic brackets can be done using Weingart pliers and there was a greater tendency for most of the adhesive to remain on the enamel surface. This decreases the probability of enamel breakage but necessitates the removal of more residual adhesive after debonding.

Another *in vitro* study[13] evaluated the positioning of the blades of debonding pliers. In this study, sixty-one Clarity (3M Unitek) collapsible ceramic brackets and sixty-six MXi (TP Orthodontics, Inc) brackets were bonded to extracted human teeth. Weingart (Ormco) and ETM 346 (Ormco) pliers also were used to debond both types of brackets and the adhesive that remained after bracket removal was assessed according to ARI. The ARI results showed that, when these brackets were debonded with the Weingart and ETM 346 pliers, there was a greater tendency for most of the adhesive to remain on the enamel surface. The study concluded that the most efficient method to debond the MXi ceramic bracket was by placing the blades of the ETM 346 pliers between the bracket base and the enamel surface. The most efficient method of debonding the Clarity bracket was by using the Weingart pliers and applying pressure to the tie wings.

The use of Howe pliers (Ormco) and manufacturer recommended plastic pliers (Ormco) were used in an *in vitro* study[14] to evaluate failure modes of ceramic brackets. Three brands of ceramic brackets (Clarity from 3M Unitek; Inspire and Inspire Ice from Ormco) bonded to extracted human premolars were utilized in this study. Clarity ceramic brackets were debonded with Howe pliers. The tips of the pliers were placed over the mesial and distal ends of the metal-lined archwire slot and not over the bracket base. The wings were squeezed until the bracket was debonded. The Inspire and Inspire Ice ceramic brackets were debonded with the specifically designed plastic pliers recommended by the manufacturer. The tips of the pliers were placed under both sets of the occlusal and gingival wings and above the bracket base. The pliers were rotated from the gingival to the occlusal aspects of the bracket until the bracket was debonded. The results showed that the brackets failed at the bracket-adhesive interface (cohesive failure). Cohesive bracket fractures were noted in all 3 types of ceramic brackets. The cohesive ceramic fractures of the Clarity brackets were located at the junction between the wings and the body, and at the slot. However, for the Inspire and the Inspire Ice brackets, the cohesive ceramic fractures were located at the occlusal aspect of the base. There was no enamel damage observed after debonding. The results of the failure modes in this study showed that the new designs with a ball reduction band in the Inspire

Ice bracket and the vertical debonding slot in the Clarity bracket significantly reduced the risk of ceramic bracket fracture during debonding. However, the force required to debond the Inspire Ice bracket was significantly lower than that of the Inspire bracket. It is also reported in literature[15] that Mathieu needle holding pliers are effective in the mechanical debonding of Clarity brackets.

In another *in vitro* study,[10] twenty bonded Clarity (3M Unitek) brackets and twenty bonded Inspire (Ormco) brackets were debonded with the pliers recommended by the manufacturers. The Clarity ceramic brackets were debonded with Weingart pliers (Ormco). The tips of the pliers were placed over the mesial and distal ends of the metal-lined arch wire slot, and the tie-wings were squeezed gently until the bracket collapsed. The Inspire ceramic brackets were debonded with the specifically designed plastic debonding instrument (Ormco). The tips of the instrument were placed under both sets of the occlusal and gingival tie-wings and above the base of the bracket. The handles of the pliers were squeezed until the angled ends of the handles met, and the instrument was rotated towards the occlusal edge of the bracket until the bracket was removed. There was no evident enamel damage when the brackets were removed with the appropriate pliers. This study concluded that the safest way to remove ceramic brackets and minimizing enamel damage was to use the debonding technique specifically designed for each ceramic bracket.

1.2. Ultrasonic debonding

Ultrasonic debonding technique uses specially designed tips to apply vibrations at the bracket-adhesive interface to erode the adhesive layer between the enamel surface and bracket base.[16] Ultrasonic debonding technique was originally developed for removing cast metal and bridge retainers.[17] This has been applied to debond ceramic brackets. Boyer et al[18] had used ultrasonic chisel tip of Cavitron and a universal testing machine to shear ceramic brackets which were bonded to extracted human incisors and canines. The degree of cure of the light-activated adhesive was systematically varied with different exposure times to the curing light. The study concluded that the ultrasonic chisel markedly reduced the force required to debond the brackets. However, the debonding time averaged about 16.6 seconds and the researchers have suggested that this method of debonding is not recommended without further development.

Chen et al[18] studied the effect of ultrasonic precrack preparation on debonding force and failure modes during ceramic bracket debonding. Eighty extracted human premolars were assigned to four groups of 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 evaluated. The results showed that ultrasonic precrack preparation could significantly decrease the average debonding force and no enamel damage was noted after debonding. The study concluded that ultrasonic precrack preparation can significantly decrease the debonding force and guide the bracket debonding through a favorable fracture plane without damage to either the bracket or the enamel.

Bishara et al[11] compared three different debonding techniques (ultrasonic, electrothermal and conventional debonding technique recommended by the manufacturer) on three different types of ceramic brackets. The results showed that the incidence of bracket failure during debonding was significantly greater with conventional debonding technique recommended by the manufacturer (10-35%), as compared with the incidence associated with either the ultrasonic or the electrothermal methods (0%). However, the debonding times for the ultrasonic method were significantly greater than the times for either the conventional or the electrothermal methods and there were no significant differences among the debonding times for the three bracket types studied.

2. Discussion

The process of debonding ceramic brackets presents various challenges in the field of orthodontics. Today the most common method of debonding ceramic brackets in practice is the conventional method through mechanical debonding. The process includes utilizing special pliers followed by diamond burs which can lead to bracket wing failure, enamel fracture or crack, pain and discomfort to the patient while debonding.

2.1. Mechanical Debonding

Conventional debonding of ceramic brackets attributes to the most enamel damage due to the direct force applied on brackets leading to different failure modes at the bracket wings, base, etc. The failure mode leads to remnants of both adhesive and bracket components that require further time to remove by the use of diamond burs. In an *in vitro* study by Vukovich et al[8] high-speed and low-speed grinding combined with water or air coolant did not affect the intrapulpal temperature. However, detrimental effects on dental pulp were noted specifically with low-speed grinding without coolant. The coolant method provides pulp safety during bracket grinding and removal, however this can become a tedious procedure for the clinician. In addition, patient discomfort is relatively common during debonding. Water-coolant with the use of diamond burs ensures acceptable physiological levels of intrapulpal temperature.

Similarly, *in vitro* studies by Bishara et al[9,13,14] investigated several specifically designed debonding pliers on different ceramic brackets to determine the effectiveness and force levels generated by wide and narrow blades, evaluating the effectiveness of newly designed ceramic brackets (collapsible), and the position of the bracket blades for optimal debonding. The studies determined that narrower blades effectively debonded ceramic brackets with less force and following manufacturer's recommendation of bracket removal with special pliers regardless of brand lead to residual adhesive after bracket removal. Furthermore, the use of Weingart pliers on collapsible brackets lead to an even greater ARI value that although beneficial in preserving the enamel structure can lead to increased chair time and possibly minor undetected adhesive residuals. When minor adhesive remnants are left on enamel surfaces following debonding, oral microflora can harbor and attach leading to white spot lesions (WSLs) on enamel in the future.

Failure modes of ceramic brackets is another critical aspect to understand when debonding ceramic brackets as this determines the fracture failure location when debonding. Chen et al[14] compared the use of Howe pliers and manufacturer recommended plastic pliers in newly designed Inspire Ice bracket and vertical debonding slot in Clarity bracket. The study found that brackets failed at the bracket-adhesive interface with no enamel damage noted. Finally, the most optimal technique of bracket removal with minimal enamel damage according to Theodorakoupoulou et al[10] is to use the debonding technique specifically designed for each bracket.

2.2. *Ultrasonic Debonding*

The use of ultrasonic debonding proved to be advantageous in minimizing bracket failure by reducing the required force to debond the bracket that may sometimes lead to enamel fracture. However, all studies determined that the time it takes to debond ceramic brackets with the use of ultrasonic debonding is significantly greater than with the conventional method[11,16,19] and it may be uncomfortable to the patient due to the prolong use.[18]

3. Conclusions

The comprehensive literature review of mechanical and ultrasonic debonding techniques for ceramic bracket debonding ultimately has lead us to conclude that

1. Mechanical debonding (use of diamond burs, special pliers) is most widely applicable in clinical practice. Use of recommended pliers by manufactures is key to minimal failure modes of bracket counterparts and debonding technique specifically designed for each bracket.
2. Ultrasonic tips are advantageous in minimizing bracket failure but requires greater time to debond ceramic brackets than with mechanical debonding method and it may be uncomfortable to the patient due to longer duration of use.
3. Electrothermal debonding and Laser debonding techniques are discussed in part 2 of this literature review.

4. Source of Funding

None.

5. Conflict of Interest

None.

References

1. Kusy RP. Orthodontic biomaterials: from the past to the present. *Angle Orthod*. 2002;72:501–12.
2. Swartz ML. Ceramic brackets. *J Clin Orthod*. 1988;22:82–8.
3. Bishara SE, Fehr DE. Ceramic brackets: Something old, something new, a review. *Semin Orthod*. 1997;3(3):178–88.
4. Flores DA, Caruso JM, Scott GE, Jeiroudi MT. The fracture strength of ceramic brackets: a comparative study. *Angle Orthod*. 1990;60:269–76.
5. Scott GE. Fracture toughness and surface cracks–the key to understanding ceramic brackets. *Angle Orthod*. 1988;58:5–8.
6. Bishara SE, Ostby AW, Laffoon J, Warren JJ. Enamel Cracks and Ceramic Bracket Failure during Debonding In Vitro. *Angle Orthod*. 2008;78(6):1078–83.
7. Normando TS, Calcada FS, Ursi WJ, Normando D. Patients' report of discomfort and pain during debonding of orthodontic brackets: a comparative study of two methods. *World J Orthod*. 2010;11:e29–34.
8. Vukovich ME, Wood DP, Daley TD. Heat generated by grinding during removal of ceramic brackets. *Am J Orthod Dentofac Orthop*. 1991;99(6):505–12.
9. Bishara SE, Ortho D, Fehr DE. Comparisons of the effectiveness of pliers with narrow and wide blades in debonding ceramic brackets. *Am J Orthod Dentofacial Orthop*. 1993;103(3):253–7.
10. Theodorakopoulou LP, Sadowsky PL, Jacobson A, Lacefield W. Evaluation of the debonding characteristics of 2 ceramic brackets: an in vitro study. *Am J Orthod Dentofacial Orthop*. 2004;125(3):329–36.
11. Bishara SE, Trulove TS. Comparisons of different debonding techniques for ceramic brackets: An in vitro study. *Am J Orthod Dentofac Orthop*. 1990;98(3):263–73.
12. Bishara SE, Olsen ME, c LVW. Evaluation of debonding characteristics of a new collapsible ceramic bracket. *Am J Orthod Dentofacial Orthop*. 1997;112(5):552–9.
13. Bishara SE, Olsen ME, VonWald L, Jakobsen JR. Comparison of the debonding characteristics of two innovative ceramic bracket designs. *Am J Orthod Dentofacial Orthop*. 1999;116(1):86–92.
14. Chen HY, Su MZ, Chang HF, Chen YJ, Lan WH, Lin CP, et al. Effects of different debonding techniques on the debonding forces and failure modes of ceramic brackets in simulated clinical set-ups. *Am J Orthod Dentofacial Orthop*. 2007;132:680–6.
15. Lee RT. How to ... debond Clarity brackets with ease. *J Orthod*. 2005;32(4):269–71.
16. Bishara SE, Truiove TS. Comparisons of different debonding techniques for ceramic brackets: An in vitro study Part I. Background and methods. *Am J Orthod Dentofacial Orthop*. 1990;98(2):145–53.
17. Krell KV, Jordan RD. Ultrasonic debonding of anterior etched-metal resin-bonded retainers. *Gen Dent*. 1986;34:378–80.
18. Boyer DB, Engelhardt G, Bishara SE. Debonding orthodontic ceramic brackets by ultrasonic instrumentation. *Am J Orthod Dentofacial Orthop*. 1995;108(3):262–6.
19. Chen YL, Chen HY, Chiang YC, Chang HH, Lin CP. Effect of the precrack preparation with an ultrasonic instrument on the ceramic bracket removal. *J Formos Med Assoc*. 2015;114:704–9.

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