International Journal of Health Research and Medico-Legal Practice
Opne Access Full-Text Article.
Available at www.ijhrmlp.org

REVIEW PAPER

Enamel surface damage during debonding of ceramic brackets: a brief review

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***Received on**: Jan 19, 2021*
***Editorial approval on**: Feb 25, 2021*
***Plagiarism checked**: Yes*
***Peer review process**: Blinded*
***Peer review comments**: Three*
***Editor who approved**:*
Prof. Putul Mahanta

ABSTRACT

Like general dentistry, the orthodontic speciality also felt the need for aesthetic orthodontic appliances due to increased demand among adult patients, which has led to the development of various aesthetically superior devices. Since the ceramic brackets (CB) were introduced to the orthodontic speciality, they have become an integral part of the armamentarium for this speciality. The makeup and clinical performance have greatly improved. Compared to conventional stainless-steel brackets (SSB), the superior aesthetics of CBare not only well accepted by the patient, particularly by adults. However, the brittle nature of CB has resulted in a high incidence of bracket failure like a fracture during debonding using different techniques. This review paper has reread the effectiveness of different debonding strategies for CB and appraises the enamel surface damages caused by it.

***Keywords**: Debonding techniques; scanning electron microscopy (SEM); effectiveness.*

Cite this article: *Bora Neelutpal, Konwar Ranjumoni . Enamel surface damage during debonding of ceramic brackets: a brief review. Int J Health Res Medico Leg Prae 2021 Jan-Jun;7(1):101-104. Doi: 10.31741/ijhrmlp.v7.i1.2021.19*

INTRODUCTION

Ceramic brackets (CBs) were introduced to an orthodontic speciality in the mid-1980s; it has become an integral part of the orthodontic profession.[1]

The CB has the unique characteristic of being more esthetic than metal brackets. There are two types of these brackets, viz. polycrystalline and monocrystalline, composed of 99.9% aluminium oxide. The most apparent difference between polycrystalline and single crystal brackets is in their optical clarity. Single crystal brackets are noticeably more precise than polycrystalline brackets, which tend to be translucent.[2]

Effectiveness of different debonding techniques for ceramic brackets

Although CB is more esthetic, many clinicians refrain from using them because of many potential problems and difficulty encountered during debonding. The brittle nature of CB has resulted in a high incidence of bracket failure like a fracture during debonding. Debonding may be time-consuming, painful damaging the enamel surface if performed with improper technique.[3-7]

Reports of enamel fracture and cracks during debonding have raised questions about the safety of various procedures used to remove these attachments,[6,8.] However, the tensile strength of ceramic is greater than that of stainless steel; less energy is used to cause fracture of CB compared with conventional SSBs.[9] This phenomenon is related to fracture toughness or the ability of a material to resist fracture. The CB has substantially less fracture toughness when compared to SSBs.[1,2]

During loading, CB will elongate approximately 20% of its original length before failing.[2] A shallow scratch on the surface or microscopic crack will drastically reduce the load required for fracture of CBs.[2,10] Stresses introduced during the ligation and archwire activation, forces of mastication and occlusion, and forces applied during bracket removal with pliers or debracketing instruments are all capable of creating microcracks in CBs that can lead to failure.[7,11,12]

The adhesion between the resin and CB base has increased to a point where the most common bond failure site during debonding has shifted from bracket base adhesive interface to enamel adhesive interface, increasing the risk of enamel damage less desirable.[7,13]This shift has led to an increase in the incidence of bond failures within the enamel surface.[14] Enamel surface damage is a common problem during debonding of CBs.[1,2,6-8]

Monocrystalline CBs display more enamel loss than polycrystalline brackets because the bonding mechanism in monocrystalline brackets only involves chemical adhesion. Still, in the case of polycrystalline, it is by both micromechanical and chemical adhesion.[6]

CBs with chemical retention causes more enamel damage than those with mechanical retention[2,] and several other studies have reported the injuries during debonding procedures1,2,6-8. Investigators who have attempted to develop an optimal method of removing orthodontic metal brackets have concluded that applying a force that peels the bracket base away from the tooth and causes bond failure at the adhesive-bracket interface is the most consistently atraumatic debonding technique. However, because of the nature of the CBs, the debonding method that employs such force often results in a fracture.

Hence, various debonding techniques were initiated, especially for CBs, including debonding pliers and ligature cutting pliers to apply a squeezing force at the bracket base and using a shear torsion force with a specially designed instrument.[2,15] Alternate debonding techniques that minimize the potential for bracket failure and trauma to the enamel surface during debonding have also been initiated. Ultrasonic debracketing tips specially designed tips applied at the bracket adhesive junction.[1,7,8]Thermal debonding has also been suggested as a method for debonding CBs.[16]

Apart from understanding the amount of enamel surface damage caused by the debonding instruments, it is necessary to assess the ease and time required in debonding CBs they all function in different principles.

After debonding orthodontic brackets, the quality of enamel surfaces was assessed under clinical and experimental conditions utilizing stereomicroscope and SEM. Orthodontic attachments were direct-bonded with either of two diacrylate resin adhesives. After bracket removal with a ligature cutter, remnants of adhesive on the tooth surface were removed employing various rotating instruments at low speed.[12]A particular replica technique made it possible to make sequential assessments of step-by-step polishing procedures and directly follow the gradual reduction and possible disappearance of individual scratches in the microscope.[12]

The cracks are more in both debonded and debonded groups than the untreated teeth. The majority of the cracks were oriented in a vertical direction, and most were localized in the gingival, two-thirds of the facial surface of the teeth. Few horizontal and oblique cracks were observed, mainly on the central incisors of both arches. They showed that post-treatment presence of many horizontal cracks or pronounced vertical cracks may indicate improper debonding technique.[17]

The SEM showed that the fracture site upon removing the bracket runs mainly in a heterogeneous way, partly along with the bracket/adhesive interface within the adhesive material and the adhesive/enamel interface and within the enamel.[2]

In some cases, localized enamel fracture was seen reaching down to a maximal depth of 100 micrometres. In bracket removal cases, 13.3% of enamel tear-off were visible in the form of a rippled or terraced surface roughness. The terrace-like appearance of enamel detachments may be caused by the specific arrangement of the striae of retzius. Brackets with enamel fracture needed tensile forces of 9 to 11 N/ $mm^2$for removal. Areas of fractured enamel could not be repaired by thoroughly enamel polishing with various instrumentation TC bur, scalar, and green rubber. About 55um of enamel surface is lost through acid etching, bracket removal, and enamel polishing. The micromorphological findings showed clearly that the direct-bonding technique entails an artificial weakening of the superficial enamel structure.[18]

The electrothermic debracketing method can be an alternative to conventional methods of removing bonded brackets. Here the unit induces sufficient heat in the bonded bracket to alter the bracket-adhesive interface without causing an excessive increase in pulpal wall temperatures.[19]

The debonding of CBs with a mechanical retention base is much easier because of the lack of bond strength. During debonding, compressing the wings as in metal brackets will result in a brittle fracture of CB. Increasing the load to the adhesive-enamel interface also increases the risk of enamel surface damage. A slow, gradual compression mesiodistal to the base would seem to offer the best chance for inducing crack propagation within the bonding adhesive rather than the enamel.[3]

The comparison of the shear bond strength values of commercially available CBs with those of metal brackets and also noted the site of bond failure. Polycrystalline brackets were bonded with a concise orthodontic bonding system, and the test was carried out on an Instron Machine. The study showed mean shear bond strength of 18.3 MPa for

Allure brackets,18.8 MPa for Transcend brackets, and the failure site was resin/bracket for Allure, primarily at resin/enamel for transcending brackets. Metal brackets showed a mean shear strength of 12.9 MPa and failure at the resin/bracket interface.[9]

The enamel loss resulting from orthodontic removal is minimized by first debonding the bracket with the bracket removing pliers followed by ultrasonic technique. It also showed that the ultrasonic method is the most time consuming, and the combined plier ultrasonic process takes the least time to debond.[20]

The tensile strength of ceramics is not a simple bulk material property. It is dependent on the condition of the surface of the ceramics. A shallow scratch on the ceramic surface will drastically reduce the load required for fracture, whereas the same scratch on a metal surface will have little effect on fracture under load. The fracture toughness for stainless steel is more than that for polycrystalline alumina.[21]

The possibility of enamel fracture after removal of CBs with silane couplers is also seen. The bond failure at the bracket/resin interface was considered preferable. If the failure occurs heterogeneously at the resin/enamel interface, it may lead to uncontrolled fracture within the enamel. Clinicians should avoid debonding over craze lines, which may be inherently weakened areas that lead directly into areas of fractured enamel.[5]

The three different debonding techniques on CBs are the debonding pliers, ultrasonic method and electrothermal method. The maximum amount of adhesive remaining after bracket removal was with debonding pliers. The debonding time was minimal for debonding pliers. The enamel damage resulting from adhesive removal was not significantly different among the three techniques used.[7]

As enamel fracture on the debonding of SSBs is not frequently reported, it can be concluded that the shear bond strength of the CBs to enamel is not, by itself, the cause of these reported enamel fractures. The highest predictability and the highest bond strength were both found with the polycrystalline bracket system.[22]

When stretched, the failure loads and the strength of monocrystalline brackets dropped dramatically while the strength of polycrystalline brackets remained about the same. Polycrystalline brackets had many more initial surface flaws, making them weaker than single-crystal brackets. Still, after scratching, the strength remained relatively unchanged, indicating a higher fracture toughness for polycrystalline brackets. Different ligation had no significant effect.[23]

The risk of enamel damage when debonding CBs is not greater than the risk when debonding metal brackets. There was a significant difference in the adhesive remnant index scores between metal and the chemically retained ceramic bracket, but there was no significant difference in the adhesive remnant index scores was found between the metal and the mechanically retained CBs.[24]

The SEM detect more enamel damage caused by debonding of CBs than standard twin metal brackets. However, CBs using mechanical retention appears to cause enamel damage less often than those using mechanical than those using chemical retention. It was also showed that the pistol type debonding instrumental is more comfortable for patients and less potential for enamel damage.[11]

Brackets were bonded and removed by grinding with high and slow speed burs with or without air or coolant. When high-speed diamond bur and water spray cooling was used, pulpal temperature dropped from an initial 37°C to 23.5°C at completion. Removal of CBs with low-speed green stone burs and no coolant may cause permanent damage or necrosis of the dental pulp. Water coolant provides the most significant cooling of the grinding sites in high speed and low bracket removal.[25]

Most bond failures occurred at the tooth-adhesive interface with the light cure for Transcend Brackets in shear mode. In a tensile manner, monocrystalline brackets experienced a large number of wing fractures. The polycrystalline transcend brackets that underwent wing fracture did so at the highest base stress, a mean of 16.0 MPa. The study showed that the shear bond strength of ceramic was not significantly affected by the bonding system.[26]

The older silane coated brackets require a wrench type tool to be used with torsional or rotational force. Transcend 2000 mechanical retention brackets use a pistol grip debonding tool. This technique in removing ceramic material is least traumatic to the patients.[27]

Further, the ultrasonic technique requires increased debonding time, applying force levels possibly uncomfortable to patients with sensitive teeth, the potential for soft tissue injury, and a need for a water spray to avoid pulpal damage from heat build-up. When the bracket fractures, grinding with high-speed diamond bur is carried out, which is time-consuming, and the heat may affect the pulp and vitality of the tooth. Brackets with mechanical retention are fibrous, crusty, or dimpled. Polycrystalline brackets are more suitable for orthodontic use because their use does not drop dramatically following scratching. If load application tends to fracture CBs breaking the adhesive-bracket interface would minimize damage to the enamel surface.[4]The enamel surface quality before and after debonding with chemical retention also a cause for enamel damage.[14]

Thus, from the above review, it is clear that the enamel surface damage during debonding of CBs by different technique, though occur still it is a preferred choice for the practitioners due to its unique characteristics.

CONCLUSION

The different literature reviews suggest that in debonding CBs, ligature cutter is the most superior technique compared to the other three methods since it takes the least time to debond the brackets with minimal enamel damage and residual adhesive remaining on the enamel surface.

Conflict of interest: None declared.

Source of funding: None declared.

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