ORIGINAL ARTICLE

A new multipurpose dental adhesive for orthodontic use: An in vitro bond-strength study

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The purpose of this study was to evaluate the compatibility of a new dental adhesive, High-Q-Bond (HQB) adhesive, for the bonding of orthodontic brackets by determining its bond strength and the mode of bond failure after debonding. Eighty extracted human premolars were divided into 4 groups, 20 in each group. In groups 1 and 2, stainless steel brackets were bonded to etched enamel with HQB and Right-On adhesives respectively. In groups 3 and 4, the same adhesives were used to bond stainless-steel brackets to roughened, old amalgam restorations prepared in the teeth. After 72 hours of incubation in saline solution at 37°C, debonding was performed with a shearing force. The force at bond failure was recorded, and the mode of bond failure was examined. Results showed that when bonding to enamel, both the HQB and the Right-On material achieved adequate bond strength, and no significant difference was found between the two. However, after debonding, the HQB material left no adhesive on the enamel, whereas the Right-On material left significant amounts of adhesive on the enamel. When bonding to amalgam, the HQB material had a significantly higher shear bond strength than did the Right-On adhesive. It is suggested that HQB can be applied for orthodontic use, but further clinical studies are required to evaluate its efficacy. (Am J Orthod Dentofacial Orthop 2000;118:307-10)

Direct bonding of orthodontic brackets is the most significant development in orthodontics over the past 3 decades. The direct bonding procedure is based on the nature of the enamel's microstructure. The enamel has to be treated with acid before bonding to produce mechanical retention for the orthodontic adhesive.[1] Bonding and debonding of orthodontic attachments are potentially damaging to the surface of the enamel, especially while the bonding material remnants are cleaned from the tooth after the debonding procedure. Campbell[2] reported that scarring of the enamel after the removal of bonded brackets is inevitable and that the scarred enamel should be polished by a specific polishing sequence, to produce an esthetically pleasing enamel surface with minimal loss of enamel.

Young and adult orthodontic patients are often seen with buccal amalgam restorations of posterior teeth. In such cases, it would be advantageous to bond the brackets directly to the amalgam restoration, as is done to enamel with the same bonding material, rather than banding the tooth or using an additional dental adhesive. Until recently, a reliable bonding of orthodontic attachments to amalgam restorations was considered inconceivable, and there are no published studies relating to the effectiveness of bonding to amalgam with use of orthodontic bonding materials.[3] Successful bonding of orthodontic attachments to an amalgam surface requires both the conditioning of the amalgam (eg, sandblasting, roughening) and use of specific non-orthodontic dental adhesives or resins, such as Super-Bond C&B, Panavia, All-Bond 2, and other bonding systems.[4,5]

Over the years, various bonding materials have been developed in an attempt to increase their bond strength.[6] Several generations of bonding materials were developed for restorative purpose and later were applied to orthodontics.[7]

Recently, a new adhesive material named High-Q-Bond (HQB, BJM Laboratories Ltd, Or-Yehuda, Israel) has been produced. HQB is a dentin-bonding agent, that belongs to the fourth generation of dental adhesives.[8] It is composed of acrylic monomers *methylmethacrylate* (MMA) cross-linked with a multifunctional agent (trimethylolpropanetriacrylate), an adhesion promoter (glycidoxypropyltromethoxysilane), a co-monomer-aliphatic polyester (urethane acrylate), and initiators for self-curing process (dimethyl-*p*-toluidine and benzoyl peroxide). According to the manufacturer, HQB provides high-tensile bond strength and can be used for bonding to various

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Table I. Shear bond strength of HQB and Right-On used to bond stainless steel bracket to enamel and amalgam

Group	Bonding material	Bonding surface	No. of teeth	Mean MPa	SD
1	HQB	Enamel	20	9.90	2.09
2	Right-On	Enamel	20	8.29	3.18
3	HQB	Amalgam	20	6.89*	1.82
4	Right-On	Amalgam	20	5.48*	1.77

*Student *t* test with Bonferroni correction.

substrates, such as dentin, enamel, noble and base metal alloys, amalgam, composite, and porcelain.[8] The efficacy of this adhesive in bonding orthodontic brackets to porcelain has been recently established.[9]

The objective of this study was to test the compatibility of HQB for orthodontic purposes. Consequently, the shear bond strength (SBS) of the adhesive in direct bonding of orthodontic metal brackets to enamel and amalgam was evaluated, as was the mode of failure after the debonding of the brackets.

MATERIAL AND METHODS

Eighty noncarious human premolars, extracted for orthodontic reasons and stored in saline solution, were used in this study. The roots of the teeth were removed with separating disks, and the crowns were embedded in self-curing acrylic. Eighty stainless steel orthodontic premolar brackets (GAC Orthodontic Products, New York) with a mesh base area of 11.5 mm^2 were directly bonded to the crowns of the teeth. The teeth were divided into 4 groups, 20 teeth per group. In the first 2 groups, the brackets were bonded to the enamel after the enamel surface had been polished with non-fluoride and oil-free pumice, rinsed and dried, and acid etched with 37% phosphoric acid for 20 seconds, washed for 10 seconds, and dried. In the first group, HQB adhesive was used for bonding, according to the manufacturer's instructions: liquid and powder were mixed for 10 seconds. The mixture was put on the bracket mesh and placed on the already prepared enamel. In the second group, Right-On material (Right-On; TP Orthodontic Inc, La Porte, Ind), a no-mix orthodontic bonding material, was used according to the manufacturer's instructions. In the third and fourth groups, the brackets were bonded to old amalgam fillings, previously prepared in these teeth. The amalgam fillings were roughened by diamond burs before bonding, and then the brackets were bonded with either HQB or Right-On.

After bonding, all the teeth were incubated in saline solution at 37°C for 72 hours to permit adequate water absorption and equilibration. Debonding was then performed with a shearing force with use of an Instron universal testing machine (Segensworth, Fareham, England) and a shearing instrument (Bencor multi-T, testing device for dental restorative materials; Danville Engineering, San Ramon, Calif), (Fig 1). Crosshead speed was set at 0.5 mm/min. The force was recorded at bond failure. The significance of the results was evaluated by means of Student *t* test.

The mode of bond failure was analyzed macroscopically after debonding, and the locations of the residual bonding material were determined.

Table II. Mode of bonding failure expressed as percentage of samples in each group

	Failure interface		
Group	Enamel-bonding material (E/BM)	Bracket-bonding material (B/BM)	Amalgam-bonding material (A/BM)
1. HQB – Enamel	100%		
2. Right-On Enamel	50%	50%	
3. HQB – Amalgam			100%
4. Right-On Amalgam			100%

E/BM and *A/BM*, The bonding material remained on the brackets; *B/BM*, the bonding material remained on the teeth.

RESULTS

In the first group, in which the brackets were bonded to enamel with HQB, the mean shear bond strength was 9.90 mega pascal (MPa). In the second group, in which brackets were bonded to enamel with Right-On, the mean bond strength was 8.92 MPa. The difference between the groups was not statistically significant (Table I). In the third group, in which the brackets were bonded to amalgam with HQB, the mean shear bond strength was 6.89 MPa, and in the fourth group, in which the brackets were bonded to amalgam with Right-On, the mean shear bond strength was 5.48 MPa. The difference between these groups was statistically significant ($P < .05$, Table I). In both the third and the fourth groups, in which brackets were bonded to amalgam, the shear bond strength was significantly lower than in the first and second groups, in which brackets were bonded to enamel ($P < .05$, Table I).

The failure mode of the bonding materials after the debonding was as follows: In all brackets bonded by means of HQB both to enamel and to amalgam, most of the bonding material remained adhered to the bracket base, thus leaving the teeth clean of the adhesives. When Right-On was used on enamel, in half of

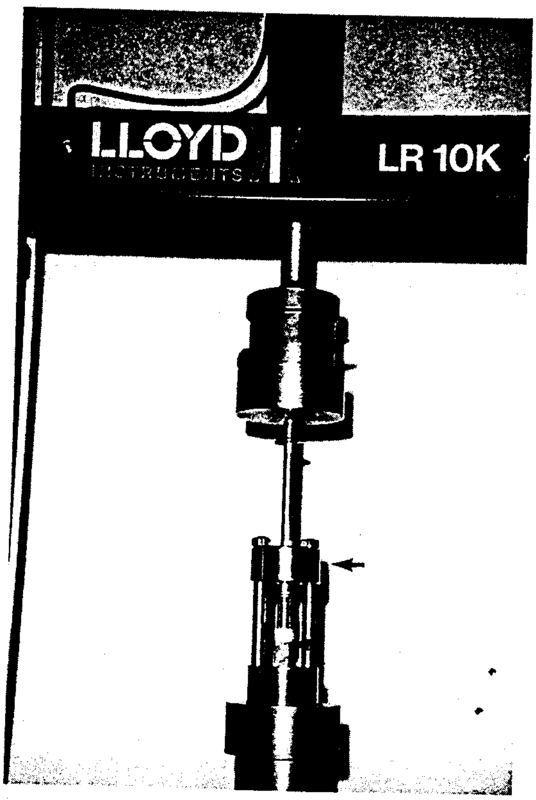

Fig 1. The Instron testing machine with a shearing instrument *(arrow)* resting on a bracket bonded to the tooth *(arrowhead)*.

the teeth the bonding material remained on the enamel and in the other half the adhesive remained on the bracket base. When Right-On was used on amalgam, the bonding material always remained on the bracket base (Table II).

DISCUSSION

This in vitro study demonstrated the high efficacy of the new dental adhesive HQB in direct bonding of stainless-steel orthodontic brackets to etched enamel. Previous studies have mentioned 6 to 10 MPa as the optimal range for bond strength of brackets to enamel.[10] In our study, all the SBS values achieved were in this range. No difference was found between the SBS of Right-On and HQB.

Adequate SBS is a prerequisite to successful orthodontic treatment. However, another important advantage of the adhesive is its ability to debond by clear separation from the tooth. The preferable situation would be that after removing the bonding material, the enamel surface would be restored as closely as possible to its pretreatment condition without causing any damage to it. In that aspect HQB was slightly superior to Right-On. The mode of failure in all the cases bonded

Fig 2. Severe mesial angulation of the right lower first molar. Note the extensive amalgam restoration on the buccal surface of the tooth.

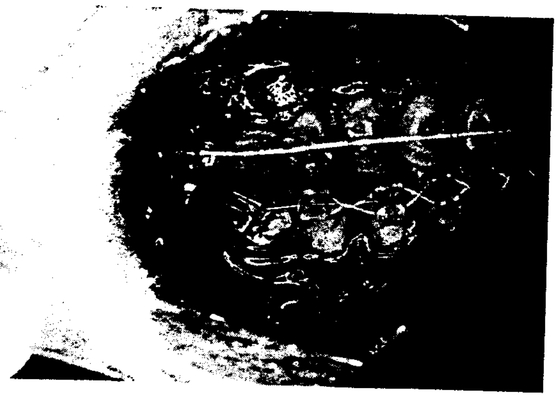

Fig 3. A buccal tube was bonded with HQB to the amalgam restoration to allow uprighting of the tooth.

with HQB occurred between the enamel and the adhesive, thus leaving a clean enamel surface. In the Right-On group bonded to enamel, only 50% of the separation occurred between the enamel and the adhesive. This mode of bond failure is in accordance with earlier data showing a mixed failure separation of Right-On.[11]

When one is bonding to amalgam, the SBS is of greater clinical importance than the mode of failure, since amalgam can be either repolished or replaced. The results of this study showed that the SBS of HQB bonded to roughened amalgam and indicates an adequate bond strength. The SBS achieved when using Right-On was at the lower border of the optimal range and was significantly lower than that of HQB. HQB has been recently used to bond a buccal tube to an amalgam surface of a lower first molar. Banding the tooth was impossible, because of the severe angulation of the tooth (Fig 2). The tube was replaced with a molar band after the uprighting of the tooth (Fig 3).

The advantage of HQB is that it can bond stainless steel brackets to both enamel and amalgam, the latter requiring only coarse diamond roughening before the bonding.

Our results justify further clinical evaluation of HQB. Indeed, such studies are currently in progress in our department.

CONCLUSIONS

1. Like Right-On, HQB has an adequate SBS when bonded to etched enamel.
2. The mode of failure after the debonding of HQB leaves teeth clean of the adhesive material.
3. When bonded to roughened amalgam, HQB has a higher SBS than does Right-On.

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