THE TENSILE PEEL STRENGTH OF CANTILEVER NI/CR RESIN BONDED BRIDGES

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ABSTRACT

Objective: To measure the tensile peel strength of Ni/Cr cantilever resin-bonded bridges.

Methods: Ten extracted upper sound human premolars were prepared with the wrap around preparation with occlusal rest for construction of Ni/Cr resin-bonded bridges. The metal retainers were then sandblasted with 50μm Aluminium oxide grit, cleaned in an ultrasonic bath for three minutes and bonded to the extracted teeth using Panavia 21 resin according to the manufacturer instructions and tested on an Instron universal testing machine for tensile peeling bond strength.

Results: The results of this study showed that tensile peel strength was ranged between 15.3 – 31.9 N (mean 22.5 N), which is virtually much less than the published tensile bond strength values, yet resin-bonded bridges do fail at these loads.

Conclusion: This study provided quantitative values of the tensile peeling strength by which resin-bonded bridges thought to be failing intraorally. These values showed to be well below the tensile bond strength or shear bond strength, yet it was enough to break the resin cement and to debond the resin-bonded bridges. The suggested mechanism is that the metal framework will be deformed during function, causing stress concentration in the resin layer followed by initiation of a crack, which will propagate through the bonded surface-causing breakdown by cohesive failure. This study supports the hypothesis that resin-bonded bridges do peel out of the abutment as the most likely cause of failure at normal functional masticatory loads.

Key words: Tensile peel strength, Resin-bonded bridges, Ni/Cr.

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Introduction

Most published studies in the dental literature, used single-cycle shear or tensile testing to assess retention of resin-bonded bridges, while other researchers have advocated fatigue testing [1,2]. In both cases, the results did not reflect the actual forces at which resin-bonded bridges do fail. Intraoral forces are cyclic in nature and far less than the reported in vitro bond strength measurements, which suggest that fatigue within the resin cement, is the directly responsible for bridge failure. This hypothesis gave a logical explanation about why resin-bonded bridges often fail after a period of functional activity.

Tensile bond strength of resin-bonded bridges has been evaluated to be in the region of 40 MPa [3,4]. This would require load of about 1000 Newtons to debond retainer with typical surface area of 25mm^2. Because these values are unlikely to be encountered clinically, Northeast *et al* in 1994 suggested a new theory to explain why resin-bonded bridges might fail at loads well below the tensile bond strength value, by introducing the tensile peel failure theory [3]. They measured the tensile peel failure of the Ni/Cr beams to prove their theory and found that the beam failed at tensile peeling loads ranged from 5 N to 17 N according to the thickness of the beam, causing cohesive bond failure at the adhesive-retainer interface. This principle is frequently applied in removing metal orthodontic brackets, and advocated because it is considered consistently atraumatic. In both cases, the metal framework of either resin-bonded retainers or metal orthodontic brackets will be deformed to break the bond at the metal-adhesive interface, or stress the adhesive to its ultimate strength and cause cohesive failure within the resin itself [5].

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The aim of this study was to measure the tensile peeling strength of Ni/Cr posterior cantilever resin bonded bridges.

Methods

Ten extracted upper sound human premolar teeth were selected for this study and prepared with a wrap around design with occlusal rest for construction of Ni/Cr resin-bonded retainer using the refractory die technique. The preparation was standardised by using a Ni/Cr jig, and the thickness of the retainers were 0.5mm ± 0.03mm. A standardised pontic was attached to the retainer to resemble the Intraoral cantilever resin-bonded bridges.

The bonding surfaces of all retainers were sandblasted by 50µm aluminium oxide grit and bonded to the teeth by using PANAVIA 21 (Kurary Co., Osaka, Japan) luting resin according to the manufacturer instructions. The teeth were then stored in normal saline solution at room temperature for 24 hours for maturation of the bonding resin before any testing was commenced.

Using self-curing acrylic resin, the teeth were individually mounted on a specially designed perforated aluminium plate secured to an Instron universal testing machine. Tensile peeling loads were applied to the pontics via standard loop at crosshead speed of 0.5 mm/min.

Results

Tensile peeling load at which each resin-bonded bridge has failed were summarized in Table I.

The tested specimens started to show signs of resin cracking early in the testing procedure before complete separation of the retainer from the tooth surface, where the separated metal framework showed an evidence of distortion when attempted to re-fit again

There are reasonable variations recorded in the tensile peeling failure loads between the ten samples, where the maximum peeling load recorded in this study was 31.9 N, the minimum load was 15.3N (mean 22.5).

Discussion

Panavia EX has been reported to require only air abrasion of the alloy with 50 µm aluminium oxide particles to achieve acceptable bond strength values, where tensile bond strength with Ni-Cr alloy was in the region of 73 Kg/cm^2 (6).

Many studies have reported the tensile bond strength and shear bond strength to determine the quality of adhesion in resin-bonded bridges (2,7,8,9). The bond strength was always attributed to the tooth preparation design, adhesive system and the available surface area for bonding (10,11).

El-Mowafy and Rubo (12) tested resin-bonded bridges (RBB) under tensile loading using a laboratory set up simulating load fatigue of mastication forces. In their study, conventional resin-bonded bridges with occlusal rest and lingual wing separated at loads ranged between 361-562 N (Table II).

Failure of resin-bonded bridges has been frequently attributed to technical or clinical failure. Some authors postulated that inappropriate case selection, prostheses design, and inadequate technique are the main causes for debonding (11,13,14). Few if none, looked for other possible causes of failure, which could pass unnoticed somewhere between the dental lab and the clinical procedure, such as the rigidity of the retainer. Rigid retainers would prevent metal framework deformation and stress concentration on the resin-metal interface and consequently prevent bridge debonding at regular masticatory loads (3,15).

Unless the failure of the RBB occurs in the luting resin itself, there are two interfaces at which the failure may happen, luting resin/tooth interface and luting resin/metal interface. Loads required to cause crack initiation and propagation are considerably lower than might be expected from tensile bond strength measurements (3). For the reported tensile bond strength of Panavia of 40 MPa would predict a tensile failure load of about 1000 N, the maximum load when subjected to peeling stresses was at best of the order of only 32 N. In this study the peeling loads recorded for the resin bonded bridges was ranging between 15.3N – 31.9N (mean 22.5N). The reason for this big difference is in the way of stress distribution in the vicinity of the luting resin as a result of metal framework deformation. This would result in stress concentration in the metal-resin-tooth interface near the pontic, which will lead to crack initiation and propagation (cohesive failure) followed by peeling of the metal framework.

As we noted in the result part of this study, cracking of the resin layer started before complete separation of the retainer due to metal framework distortion, which will allow gradual breakdown of the resin and consequently slow peeling of the retainer. In other words if we stopped the testing before the complete failure of the retainer, the bridge would have been considered intact in the naked eye, while it is half way to failure.

In clinical situation, the failure of the resin-bonded bridge my not be obvious until the whole metal retainer came out of the tooth. Initial fracture of the resin should have been started earlier but passed unnoticed until the adhesive bridge completely separated. From this point continuous follow up recalls helps in early diagnosis of resin failure as a preventive measure to eliminate plaque accumulation in the potential space created by the hypothetical resin layer failure suggested in this theory (peeling). The presence of stress concentration in the metal-resin-tooth interface suggesting modification of the adhesive bridge design in a way to eliminate or at least to minimize the lateral forces, which frequently cause the peeling failure.

Functional loads encountered in the oral cavity are likely to be in the range of the tensile peeling loads recorded in this study, which make the assumption of resin-bonded bridge peeling out of the tooth is not unlikely event. The masticatory loads on the cantilever free pontic, would contribute to the first crack in the Panavia luting resin in the metal-resin-tooth interface before further propagation and aggravation of the cohesive failure.

Conclusion

This study provided in vitro load values measurements of the tensile peeling strength of resin-bonded bridges. These values are well below the tensile bond strength or shear bond strength, yet it was enough to break the resin cement in the free cantilever end initially by stress concentration before growth of the crack to the rest of the retainer and debonding the resin-bonded bridge. This mood of failure might be the answer of why do these bridges debonded at the Intraoral loads study, and it came to support the hypothesis of peel bond strength as the most likely cause of resin-bonded bridges failure.

Table I. Tensile strength in Newton (N) of the ten tested samples.

Sample number	1	2	3	4	5	6	7	8	9	10	Mean
Peel Load (N)	15.3	19.3	25.2	22.4	31.9	28.2	17.7	20	18.5	26.4	22.5

Table II. Comparison of various bond strengths of Panavia to grit-blasted Ni/Cr alloy reported in the dental literature.

Author	Tensile bond strength	Shear bond strength	Tensile peel strength	Tensile fatigue strength
Aboush *et al* (4)	700 – 1000 N (28.4 – 40 Mpa)	-	-	-
Northeast *et al* (3)	-	-	5 - 17 N	-
Re *et al* (7)	-	300 – 700 N (12 –25 Mpa)	-	-
El-Mowafy *et al* (12)	361 – 562 N	-	-	-

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