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ORIGINAL PAPER

An in-vitro Study Comparing Shear-Peel Band Strength of Untreated and Sandblasted Orthodontic Bands using Conventional Glass Lonomer Cements

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ABSTRACT

Objectives: *To compare the shear-peel band strength of untreated (non-sandblasted) and sandblasted orthodontic bands using two conventional glass ionomer cements- Ketac™-Cem Radiopaque (3M, ESPE) and GC Gold Label Type-1 (GC, Corporation).* ***Methodology:*** *50 freshly extracted human mandibular third molars were selected and randomly assigned groups of 25 sample each for specific cements with and without sandblasting. Shear–peel band strength in megapascals were obtained by debanding the cemented bands for each group's specimen using an Instron Universal Testing Machine. Data was analyzed with ANOVA followed by a Tukey test.* ***Results:*** *An increase of 72.4% in the retentive strength was observed with sandblasted orthodontic bands cemented with Ketac™ Cem and about 76.2% of retentive strength with sandblasted one cemented with GC type-1 glass ionomer cement in comparison to untreated bands.* ***Conclusion:*** *Statistically significant differences were noted between non-sandblasted and sandblasted bands groups. The retentive force was increased to almost three quarter folds with sandblasted bands, irrespective of cement used.*

Key words: *Orthodontic bands, Glass Ionomer Cements, Shear peel strength, Sand-blast*

INTRODUCTION

Glass ionomer cements have become the most commonly used cement for retention of orthodontic bands because of their favorable properties of fluoride release and uptake, microbial inhibition and adhesion to both enamel and metal, low solubility in the oral fluids.

Despite improved retention of bands with glass ionomer cements a few literature (Norris et al;[1] Mirzahi;[2] Stirrups;[3] Durning,[4] etc.), reveals that failure still occurs in clinical orthodontic practice. The commonest site of bond failure occurs at the band- cement interface.[5] With such a kind of failure, contemporary research has focused into clinical performance of surface treatment of orthodontic bands to improve retention,[6] of which sandblasting has become the preferred one.

AIMS AND OBJECTIVES

The aims and objectives of this in vitro study was to compare the shear-peel band strength between untreated (non-sandblasted) and sandblasted stainless steel orthodontic bands using two types of conventional glass ionomer luting cements- Ketac™- Cem Radiopaque, 3M, ESPE and GC Gold Label Type-1 (GC, Corporation).

METHODS AND MATERIALS

A total of 50 freshly extracted human mandibular third molars with intact enamel surface and free of any signs of demineralization were selected and stored in 10% formalin solution before being used for the study which was conducted in Regional Dental College, Guwahati in 2009. Optimally sized stainless steel molar bands material (Size-180 × 005, 8 Feet, Libral Traders, India) were cut and closely adapted for each tooth. The teeth were randomly assigned and reassigned to four groups consisting of 25 samples in each group.

Group 1: Each tooth was banded using non-sandblasted orthodontic band material with Ketac™- Cem.

Group 2: Each tooth was banded using sandblasted orthodontic band material with Ketac™- Cem.

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Group 3- Each tooth were banded using non-sandblasted orthodontic band material with GC Type 1.

Group 4- Each tooth was banded using sandblasted orthodontic band material with GC Type 1.

Each tooth was completely embedded into a block (25x15x30mm) of self-cure acrylic resin upto the cemento-enamel junction such that the long axis of the tooth lies parallel to the long axis of the acrylic block. In order to facilitate the retention of tooth into the block, a retentive wire of 0.9 mm diameter was passed through a hole of (diameter 1-1.5 mm) drilled near the furcation area of each tooth An acrylic block of same size was specially designed consisting of two loops of 0.9 mm diameter stainless steel wire of equal lengths. This loops engages through the molar tubes of the band and allowed all forces to be directed parallel to the long axis of the tooth during debanding.

Sandblasting (**Figure 2**) of the band material was performed using a sandblaster (Renfert, Variobasic, Germany) which was held at a distance of 2cm from the blaster nozzle and then spraying with a stream of 99.6% micro aluminium oxide particles (Korox 110, Bego, Germany) against the inner (luting) surface of the metal band under 60-80psi of air pressure, until a uniform frosty appearance on the surface was achieved.

First part of the investigation involved measuring the force in an Instron machine (**Figure 1**) required to deband stainless steel non-sandblasted (NS) bands using Ketac™-Cem and GC Type-1 cements, consisting of 25 samples in each group respectively.

The de-banded teeth were cleaned with a scaler and pumice to remove any remaining cement, followed by rinsing with distilled water and then dried. The tooth was then immediately fitted with the new sandblasted bands.

Second part of the investigation involved measuring the force required to deband stainless steel sandblasted (S) bands using Ketac™-Cem and GC Type-1 cements. Each tooth, which served as the samples for the first part of the study were used again.

Calculation of Shear-Peel Band Strength (SPBS)

After twenty-four hours of cementation, the shear debanding force was applied for each specimen using an Instron Universal Testing Machine (Model 4444) in a tensile mode at a cross head speed of 1mm/min. The shear-peel band strength (SPBS) of cemented band was calculated in Megapascals (MPa) for each of the groups cemented with non-sandblasted and sandblasted bands using the following formula.

$$\textbf{Shear band strength} = \frac{\text{Breaking load (debanding force in Newton)}}{\text{Surface area of band (mm}^2\text{)}}$$

Figure 1 Debanding done in Instron

Figure 2 Sandblasting Procedure

RESULTS AND OBSERVATION

Descriptive statistics including the mean, standard deviation, minimum and maximum values for the shear-peel band strength between sandblasted and non-sandblasted bands for each group were calculated (Table I). The level of significance was established at $P < 0.05$. Statistical analyses were performed using Windows MS excel Software SPSS (v9.0) Program. A one-way analysis of variance (ANOVA) followed by multiple comparisons Tukey HSD posthoc test was used to determine whether statistically significant differences existed among the various groups.

Table 1 Summary statistics for the mean shear peel band strength of different groups

Groups	n	Breaking load (Force)		Surface area of Band (mm^2)	Retentive strength (MPa)		
		Kilogram	Newton		Mean	SD	Range
1	25	7.147	70.112	174.680	0.402^a	0.080	0.238 -0.554
2	25	12.398	121.625	176.111	0.690^b	0.221	0.345 -1.228
3	25	18.410	180.603	175.892	1.023^c	0.284	0.530 -1.896
4	25	32.565	319.460	176.542	1.803^d	0.531	1.038 -2.842
Overall	100	17.845	175.059	175.806	0.991	0.608	0.238 -2.842

Values having different superscripts (a,b,c,d) differ significantly ($p<0.05$) between groups. n- Number of samples; SD-Standard Deviation.

The order of mean SPBS with their standard deviation from greatest to least is as follows:

GC Type-1 (S) > GC Type-1 (NS) > Ketac™ Cem- (S) > Ketac™ Cem (NS).

or Gr.4 > Gr.3 > Gr.2 > Gr.1

The Tukey test **(Table II)** shows significant differences on comparison of cements between Non-Sandblasted and Sandblasted bands (n=25).

An increase of 72.4% in the retentive strength observed from non-sandblasted to sandblasted orthodontic bands cemented with Ketac™ Cem and about 76.2% of retentive strength with sandblasted GC type-1 glass ionomer cement was observed. This showed superior retention after sandblasting. **(Table III)**.

Table 2 Tukey posthoc test for statistical significance between groups

GROUPS	GROUPS			
	1	2	3	4
1	----	0.290*	0.623*	1.403*
2	0.290*	----	0.333*	1.113*
3	0.623*	0.333*	----	0.780*
4	1.403*	1.113*	0.780*	----

* p <0.05 indicates significant values; non comparable entries are designated as ----

Table 3 The percentage (%) of increase in retentive strength from non-sandblasted to sandblasted samples

Cements	NS-bands	S-bands	% Increase
Ketac™ Cem	0.400	0.690	72.414
GC-Type I	1.023	1.803	76.246

NS-Non-Sandblasted; S- Sandblasted

DISCUSSION

The present study concurs with the findings of most investigators who demonstrated an increase in band strength after sandblasting stainless steel band material.

The findings of this study are in agreement with those of Seeholzer H, Dasch W[7] who compared groups of orthodontic patients banded with either copper cement or conventional glass ionomer cement. The study showed a considerable increase (30%) in adhesion when the inner surfaces of the bands were sandblasted.

The present study also supports the findings of Millet, McCabe and Gordon[8]. The authors recorded an increase of 27% in bond strength after sandblasting the bands cemented with glass ionomer cement.

Wood and Paleczny[5] conducted an invitro investigation on twenty extracted human mandibular third molars to evaluate the force required to cause debanding of untreated and sandblasted bands using three different types of cements-zinc phosphate, polycarboxylate and glass lonomer cements. The same bands were then sandblasted and reused. They observed that there was a phenomenal increase of almost 100% in band retention strength after sandblasting the inner surface of the bands.

Miller and Zernik[6] also did a invitro study on bovine maxillary incisors and found that the mean shear strengths was improved on sandblasting with stainless steel discs cemented with glass ionomer cement.

Aggarwal et al[9] compared the shear-peel band strength of 5 orthodontic cements using both factory and in-office micro-etched bands. In this study, the significantly superior band retention of factory-etched bands over the sandblasted bands was found.

Hodges et al[10] Millet et al[11] were also with the opinion that there was improved band retention with sandblasted/ micro-etched bands.

Although this study established greater shear peel band strength with sandblasted band material, in order to come to a decisive conclusion, further research has to be done with greater number of samples. Bands are subjected to stresses like torsion, tensile or shear or a combination of all of these, and it is difficult to precisely measure and quantify these forces. Even there are no validated devices to measure the actual debanding forces in vivo. Moreover the cleaning procedure to remove cement remnant are always accompanied by degree of enamel loss.

CONCLUSION

Current research has shown that sandblasting is a preferred method of surface treatment of metals to improve band strength. The sandblasting process enhances the retentive nature of the stainless steel orthodontic bands by increasing its inner surface area and thinning the oxide layer of the stainless steel band.

The following conclusions can be drawn:

1. The mean retentive force increased to almost three quarter folds on sandblasting the inner surface of the orthodontic bands materials.

2. GC Type-1 demonstrated highly significant (P<0.001) retentive strength ability compared to Keta^{cTM} Cem Radiopaque Glass ionomer cement.

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