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Strength of attachment between band and glass ionomer cement

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Aim: To determine the strength of attachment between plain stainless steel band material and glass ionomer cement.
Methods: Seventy-five extracted upper premolars, free of visible structural defects, were used. The teeth were divided randomly into three groups and embedded in acrylic resin blocks. A short length of plain, stainless steel band material with a welded stainless steel standard edgewise 0.022 inch bracket was adapted to the buccal surface of each tooth. The bracket-stainless steel pads were then cemented to the teeth with either Bandtite (Group 1), Granitec (Group 2) or Ariadent (Group 3) glass ionomer cement and stored in an incubator at 37 °C for 30 days. The shear bond strengths of the specimens were measured and compared.
Results: The mean shear bond strengths (SBS) were significantly different: Bandtite 0.7331 ± 0.056 Mpa; Granitec 0.3869 ± 0.047 Mpa; Ariadent 0.2931 ± 0.033 Mpa (ANOVA, $p < 0.001$). Tukey HSD post-hoc tests also showed significant differences between Bandtite and Granitec, Bandtite and Ariadent, and Granitec and Ariadent ($p < 0.001$). All specimens failed at the band-cement interface.
Conclusion: The highest and lowest SBS were related to Bandtite and Ariadent cements, respectively. All cements had bond strengths less than the range of bond strengths considered to be clinically acceptable for bonded orthodontic attachments. Mechanical factors are important for band retention.
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Introduction

Band retention is essential for successful and effective orthodontic treatment.[1,2] Furthermore, plaque retention under loose bands can result in carious lesions in a few weeks.[3] The consensus is that bands cemented with glass ionomer cements are retained longer, and less decalcification occurs under a loose band than under bands cemented with either zinc phosphate or zinc silico-phosphate cements.[4,5–7]

Band retention is improved when the band is well-adapted to the tooth, if it is rigid and if the anatomical surface is roughened. A luting agent should seal the gap between the band and tooth, reduce the risk of caries should the band loosen and be easily removed at the end of treatment. Although one in 10 bands cemented with glass ionomer cements can be expected to fail over the course of orthodontic treatment, glass ionomer cements generally fail at the cement-band interface, leaving a protective layer of cement on the tooth.[4,5,8,9]

Bond strength, which is the load required to dislodge an attachment from the surface of a tooth, is used as a guide to the retention of a band in vivo. A high bond strength is assumed to translate into a high band retention rate. The retention of a band is dependent on the properties of the cement and factors that influence mechanical retention of the band.

In this preliminary in-vitro study, we aim to determine the strength of attachment between a stainless steel pad and glass ionomer cement. We excluded the contributions to band retention made by surface treatment of the anatomical surface of the band material, such as microetching, and mechanical locking of an intact band on the tooth.

Materials and methods

Seventy-five extracted upper premolars were used in this in-vitro study. The teeth were caries-free, had no restorations, no visible dentinal or enamel defects and were not malformed. They were stored in normal saline before the experiment. Soft tissue and blood debris were removed by washing the teeth with water and the crowns were cleaned with a fluoride-free prophylaxis paste and rubber cup. Following cleaning, the teeth were randomly assigned to three groups: Group 1, Bandtite (American Orthodontics, WI, USA) a true glass ionomer cement containing silicon oxide, calcium fluoride, aluminium oxide, barium sulfate, aluminium phosphate, aluminium fluoride, polyacrylic acid and water; Group 2, Granitec (Ortho-Technology, FL, USA) a true glass ionomer cement containing fluoro-alumina-silica glass as a powder and an aqueous solution of polyacrylic acid as the liquid; Group 3, Ariadent (ApadanaTak, Tehran, Iran) a true glass ionomer cement containing fluorosilicate as a powder and an aqueous solution of polyacrylic acid as the liquid.

The teeth were embedded in acrylic resin blocks (Acropars, Tehran, Iran) to within 2 mm of the cemento-enamel junctions, placed in water to dissipate heat from the polymerising resin and then stored in normal saline for 24 hours.

Standard 0.022 inch slot, edgewise brackets (Dentaurum, Ispringen, Germany) were welded to short lengths (5 x 7 mm) of 0.006 inch thick stainless steel band material and adapted to the buccal surface of each tooth. The band material was not microetched. The cements were mixed according to the manufacturers' directions, loaded on the stainless steel pads, pressed on the dry buccal surfaces of the teeth with a burnisher and left undisturbed for 15 minutes. The specimens were transferred to distilled water and stored in an incubator with 100 per cent humidity and a temperature of 37 °C for 30 days.

The teeth were mounted in an Instron Universal Testing Machine (Model 1195, Instron Ltd, High Wycombe, England) with the aid of a purpose-built jig. A shear force was applied to each bracket slot by a length of 0.021 x 0.025 inch wire welded to a 2 x 20 mm wide stainless steel blade at a crosshead speed of 0.5 mm/min. The groups were compared with a one-way analysis of variance and Tukey post-hoc multiple comparison tests.

Results

The observed force at fracture (N) was divided by the mean area of the band material surface (35 mm^2) to obtain the shear bond strength in megapascals (MPa). The results are given in Table I. The SBSs were: Group 1, Bandite, Mean: 0.7331 ± 0.056 MPa, Range: 0.63-0.83 MPa; Group 2, Granitec Mean: 0.3869 ± 0.047 MPa, Range: 0.3-0.47; Group 3, Ariadent Mean: 0.2931 ± 0.033 MPa, Range: 0.23–0.36.

The one-way ANOVA revealed a significant difference in the SBS ($p < 0.001$). Tukey post-hoc tests also showed significant differences between Bandtite and Granitec, Bandtite and Ariadent, and Granitec and Ariadent ($p < 0.001$).

Discussion

We set out to determine the strengths of attachment between the cement, the tooth and a plain stainless steel pad. Previous studies have shown what appears to be a threshold in the shear-peel band strength of microetched orthodontic bands.[10,11] A coarse factory-etched surface aided retention, while a finer in-office pattern reduced the shear-peel band strength to almost half that of the factory-etched band. We aimed to exclude any contribution to retention by either surface treatment of the anatomical surface of a band or by mechanical locking of the band on the tooth. As expected, the bond strengths of all three cements were markedly less than the bond strengths of composite resins used to bond orthodontic attachments to teeth, and the strength of attachment between an intact band and the tooth.[12] We were surprised that the cement remained attached to the plain stainless steel pads for 30 days and at least 0.23 MPa was required to dislodge the pads from the teeth.

Of the cements tested, Bandtite had the highest shear bond strength (approximately 10 per cent of the clinically acceptable range for individual bonded attachments) and Ariadent the lowest bond strength. Following debonding, no remnants of cement remained on the band material and no specimens failed cohesively. We are at a loss to explain the differences between the cements and postulate that the different particle sizes, moisture contamination during storage, the powder/liquid ratio, solvent concentration, mixing procedure and different acidities may have contributed to our findings.[4,8]

Table I. The shear bond strengths of glass ionomer cements.

Group	N	Mean (MPa)	SD	Range	SE	95 per cent CI	
						Upper	Lower
Bandtite	25	0.73 **a,b**	0.05	0.63 – 0.83	0.010	0.75	0.70
Granitec	25	0.38 **a,c**	0.04	0.30 – 0.47	0.009	0.40	0.36
Ariadent	25	0.29 **b,c**	0.03	0.23 – 0.36	0.006	0.30	0.27

ANOVA, $p < 0.001$
Tukey HSD test, groups with the same letters were significantly different from each other at $p < 0.001$

Glass ionomer cements are mixtures of an acid, frequently an aqueous solution of polyacrylic acid, and an acid soluble calcium fluoro-alumina-silica powder. During bonding, polyacrylic acid reacts with the enamel, replacing phosphate and/or calcium ions from the enamel and the cement bonds to the tooth and, in our study, the band material.[13] As a rule glass ionomer cements with higher concentrations of acid and thinner films produce stronger bonds to enamel.[14] As the companies did not provide full information of the composition of their cements, we can only speculate that different concentrations of polyacrylic acid, different solubilities and powder:liquid ratios may be responsible for the different strengths of attachment between the cements and the stainless steel pad.

The ideal luting agent should fill the gap between the band and the tooth for the length of treatment and offer some protection from decay should the band loosen. It could be argued that cohesive failure or failure at the band-glass ionomer cement interface is preferable, as an intact cement film and release of fluoride ions from the cement protect the tooth from decay. The thickness of the cement layer is also an important factor that may compromise the bond strength at the cement-tooth interface. Thick layers of cement are more prone to dissolve in fluids over time and influence the longevity of the bond between the band and the tooth.[2,3] Thin cement films, of the order of 13–19 µm, produce strong bonds.[15,16] Although we did not measure the thickness of the cement layer, we used well-adapted 7 x 5 mm stainless steel pads and held them in place for 15 minutes while the cement set.

The debonding sites for all cements occurred at the band-cement interfaces and intact cement layers remained attached to the teeth. The specimens were stored in distilled water, not saliva, for 30 days and were not subjected to the temperature changes encountered in the mouth. Nor were they subjected to the corrosive effects of some foods and drinks or to physical stress: factors that may promote early loosening and failure at the tooth-cement interface.

Conclusions

The glass ionomer cements failed at the cement-pad interface and all had bond strengths below the value considered to be clinically acceptable for a bonded attachment. The importance of mechanical factors for band retention is stressed.

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References

1. Millett DT, MacCabe JF, Bennett TG, Carter NE, Gordon PH. The effect of sandblasting on the retention of first molar orthodontic bands cemented with glass ionomer cement. Br J Orthod 1995;22:161–9.
2. Fricker JP. A 12-month clinical comparison of resin-modified light-activated adhesives for the cementation of orthodontic molar bands. Am J Orthod Dentofacial Orthop 1997; 112:239–43.
3. Melrose CA, Appleton J, Lovius BB. A scanning electron microscopic study of early enamel caries formed in vivo beneath orthodontic bands. Br J Orthod 1996;23:43–7.

4. Durning P, McCabe JF, Gordon PH. A laboratory investigation into cements used to retain orthodontic bands. Br J Orthod 1994;21:27–32
5. Norris DS, McInnes-Ledoux P, Schwaninger P, Weinberg R. Retention of orthodontic bands with new fluoride–releasing cements. Am J Orthod 1986;89:206–11.
6. Clark RJ, Phillips RW, Norman, RD. An evaluation of silicophosphate as an orthodontic cement. Am J Orthod 1977; 71:190–6.
7. Kvam E, Broch J, Nissen-Meyer IH. Comparison between a zinc phosphate and a glass ionomer for cementation of orthodontic bands. Eur J Orthod 1983;5:307–13.
8. Shaver RL, Siegel IA, Nicholls JI. Effect of ultrasonic ZnPO4 cement removal on band adhesion and cement solubility under orthodontic bands. J Dent Res 1975;54: 206–11.
9. Stirrups DR. A comparative clinical trial of a glass ionomer and a zinc phosphate cement for securing orthodontic bands. Br J Orthod 1991;18:15–20.
10. Grabouski JK, Staley RN, Jakobsen JR. The effect of microetching on the bond strength of metal brackets when bonded to previously bonded teeth: an in vitro study. Am J Orthod Dentofacial Orthop 1998;114:452–60.
11. Aggarwal M, Foley TF, Rix D. A comparison of shear-peel band strength of 5 orthodontic cements. Angle Orthod 2000;70:308–16.
12. Millett DT, Duff S, Morrison L, Cummings A, Gilmour WH. In vitro comparison of orthodontic band cements. Am J Orthod Dentofacial Orthop 2003;123:15–20.
13. Sturdevant CM, Roberson TM, Heymann HO, Sturdevant JR. The Art and Science. 3rd edn. St Louis: Mosby, 1995: 263–7.
14. Bagheri J. Glass ionomer cements. (D. Wilson). 1st edn. Astane Ghods Razavi Publishing Co. 1373:289–310.
15. Craig R, Powers J. Restorative Dental Materials. 11th edn. St. Louis: Mosby, 2002:614–16.
16. Zachrisson BU. Direct bonding in orthodontic treatment and retention: a post-treatment evaluation. Eur J Orthod 2007;29 (suppl.1):128–34.