

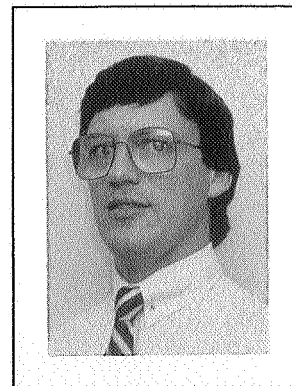
The bond strength of a glass polyalkenoate cement to enamel and stainless steel

John P. Fricker B.D.S.(Syd),M.D.Sc.(Syd),F.R.A.C.D.S.*

Canberra, Australia

Akira Kameda D.D.S.(Tyō),Ph.D.#

Niigata City, Japan



ABSTRACT: An in vitro evaluation of bond strength of a glass polyalkenoate cement to human dental enamel and stainless steel is reported. Shear testing of adhesive strength was measured over time at 23°C following a one minute mixing time.

It was found that there is a significant difference in bond strengths between enamel and stainless steel with strength to enamel the greater. Bond strength increases with time with very low strength measured within 30 minutes from commencement of mixing.

Reference: Aust.Orthod.J.11(3):161-163

MeSH words: dental cements; dental materials; orthodontic appliances; glass ionomer

Key words: bond strength, enamel bond, stainless steel bond

INTRODUCTION

Glass ionomer (polyalkenoate) cements were formulated by Wilson and Kent (1971) as derivatives of dental silicate and zinc polycarboxylate cements. They were further developed by Wilson et al. (1977) as luting agents.

These cements are formed by an acid base reaction between aluminosilicate glass and polyacid. Protons from the acid penetrate the glass powder to release calcium and aluminium ions, initiating a prolonged two phase setting reaction. Calcium ions bind to the acid producing gelation and initial adhesion. Aluminium ions then contribute to the hardening and strengthening as rigid cross-linking occurs over time.

This paper reports an in vitro evaluation of the shear bond strength of a glass polyalkenoate cement to human dental enamel and stainless steel over time. The clinical significance of this is discussed.

MATERIALS AND METHODS

An experimental formulation of glass ionomer cement has been developed for orthodontic purposes. (G.C. Dental Industrial Co Japan).

It has a setting time of seven minutes at 23°C after commencement of mixing and is coloured blue for improved visibility at the time of band removal for prophylaxis.

Mandibular and maxillary premolar teeth extracted for orthodontic reasons were collected and stored in a dilute chlorhexidine solution. From these, teeth without caries or previous restorations were selected for the test sample.

Each tooth was mounted in self-curing acrylic resin to leave only the enamel exposed (Figure 1a).

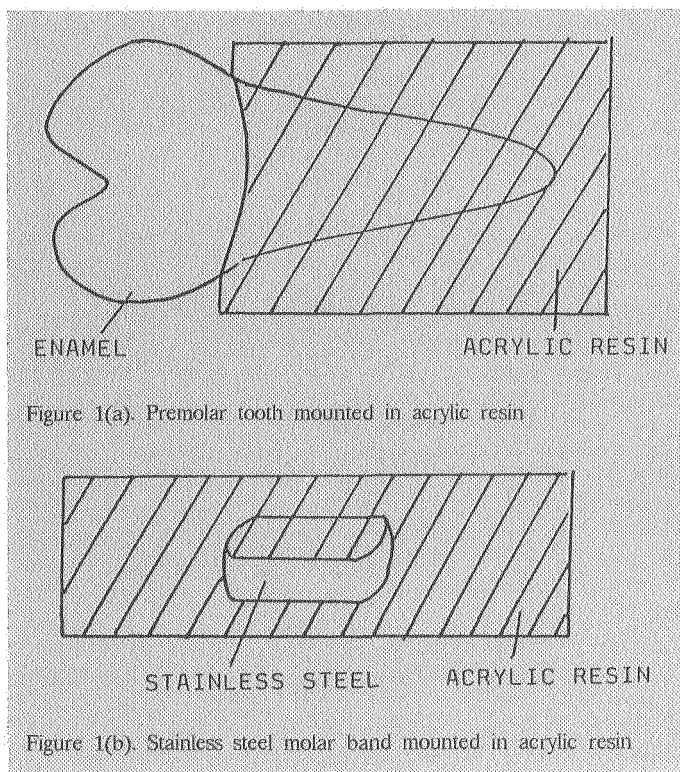


Figure 1(a). Premolar tooth mounted in acrylic resin

Figure 1(b). Stainless steel molar band mounted in acrylic resin

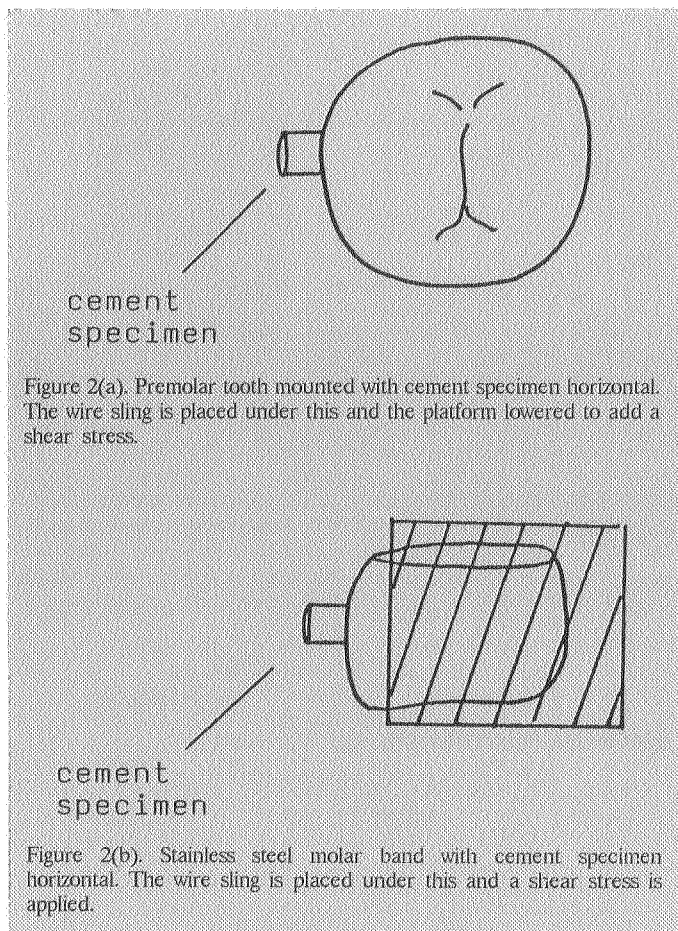
Rocky Mountain universal molar bands were also mounted in self-curing resin exposing a surface as in Figure 1b.

15 specimens of teeth and 15 specimens of molar bands were thus prepared for testing.

Plastic tubing of 4mm diameter was cut into 4mm lengths to house each cement sample and to provide a standard surface area between cement and enamel, and cement and stainless steel.

* Specialist Orthodontist, Private Practice, Canberra, Australia; and Visiting Dental Officer (Specialist), Westmead Dental Clinical School, New South Wales, Australia.

Professor and Chairman, Department of Orthodontics, Niigata Faculty, Nippon Dental College, Niigata City, Japan.



Each sample of cement was mixed on a glass slab at room temperature of 23°C for one minute at manufacturer's recommended proportions, placed in the plastic tubing, then seated on the enamel or stainless surface respectively. The specimen was then supported to maintain the plastic tubing vertically and the cement allowed to set.

Shear strength testing was carried out using a FUDOH KOGYO rheometer model NRM 2010J-cw.

Each specimen was clamped to the platform with the cement projecting horizontally and a vertical wire sling was placed under the cement specimen. *Figure 2(a)(b)*. At time intervals of 7 minutes, 12 minutes, 17 minutes, 27 minutes and 37 minutes shear tests were carried out. Three tests for each time interval were performed and the mean result taken.

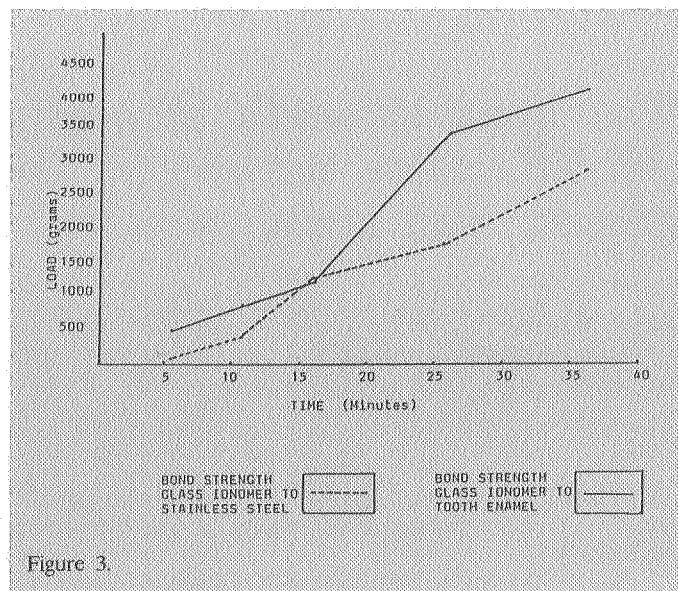
At each allotted time the platform was lowered at 5 cms/min so that the wire sling applied a shear force between the cement specimen and the enamel/stainless steel interface.

The shear strength of each cement specimen at the allotted time interval was taken as the maximum load required to fracture the cement from the test surface and the results were recorded on a RIKADENKI plotter model FR-31.

RESULTS

The average bond strength between glass polyalkenoate cement and tooth enamel were :

7 minutes after mixing -	513 gms
12 " " "	833 "
17 " " "	1166 "
27 " " "	3500 "
37 " " "	4166 "



The average bond strength between glass polyalkenoate cement and stainless steel were :

7 minutes after mixing -	83 gms
12 " " "	483 "
17 " " "	1183 "
27 " " "	1766 "
37 " " "	2800 "

See *Tables 1 and 2*

DISCUSSION

Glass ionomer cements have been shown to be excellent luting agents in orthodontics with superior retention to zinc phosphate cements. (Fricker and McLachlan (1985), Mizrahi (1988), Majier and Smith (1988), Seeholzer and Dasch (1988)).

The setting reaction of these cements is progressive with hardening and strengthening only at the later stages of the set as aluminium ions predominate in the cross linking.

The results indicate a comparatively slow build-up of bond strength at 23°C for both enamel and stainless steel with low strength before twenty seven minutes after commencement of mixing. Bond strength to enamel being 3500 gms and stainless steel 1766 gms.

There is a significant difference in bond strength between enamel and stainless steel and this supports an earlier study comparing retention rates of bands at different powder/liquid ratios (Fricker 1989).

Specimens of the cement were standardised at 4mm by 4mm cylinders for comparative purposes only. In the clinical situation the raw figures may vary due to the increased surface area of the adhesive interface, as well as the storage of teeth in chlorhexidine vs saliva in the mouth.

The rate of increase in strength will also increase at mouth temperature as the setting reaction is significantly more rapid at 37°C (Fricker et al. 1989). One may then assume a shift in the curve of *Figure 3* to the left with a significant increase in the strength levels after 15 minutes.

The clinical significance relates to the interval between cementing of bands and applying the load from archwires and or ties.

Where fixed appliances are placed at a single visit the authors recommend that molar bands are cemented prior to bonding of anterior brackets to maximize the time interval between the setting of glass ionomer cement and the placing of archwires. These cements are sensitive to moisture during the setting reaction and continues beyond the apparent setting time (Walls et al. 1988). It is advised

Table 1.
Bond strength between tooth enamel and polyalkenoic cement over time

Time (min)	Test 1 gm	Test 2 gm	Test 3 gm	Average gms	Average kg/cm ²
7	640	400	300	513	4.08
12	1000	850	650	833	6.62
17	1300	1200	1000	1166	9.27
27	3300	3200	4000	3500	27.84
37	3800	4200	4500	4166	33.14

Table 2.
Bond strength between polyalkenoic cement and stainless steel over time.

Time (min)	Test 1 gm	Test 2 gm	Test 3 gm	Average gms	Average kg/cm ²
7	70	100	80	83	0.66
12	400	500	550	483	3.84
17	1000	1250	1300	1183	9.41
27	2000	1700	1600	1766	14.04
37	2600	2600	3200	2800	22.27

that the bands are protected for as long as possible with a generous coating of vaseline.

In the case of recementation of loose bands it is essential adequate time is given for the cement to achieve its strength prior to repinning. It is always tempting to rush this so that one can cope with the after-school rush!

CONCLUSION

This paper reports the bond strength of a glass polyalkenoate cement over time. There is a significant difference in adhesive strength between enamel and stainless steel with the bond strength to enamel being greater.

The setting reaction of polyalkenoate cements is progressive with slow build-up of strength when measured over the first 37 minutes from commencement of mix.

At mouth temperatures of 37°C this build-up will be more rapid, however when using these cements as orthodontic luting agents it is important to allow sufficient time between cementing the bands and applying a load.

Acknowledgments

This study was supported by a Japan Dental Association, International Research Fellowship for 1989. The authors thank G.C. Dental Industrial Co Japan, for supplying the cement in this study.

REFERENCES

- FRICKER J.P. (1989)
A clinical comparison of different powder liquid powder ratios of two glass ionomer cements in the retention of orthodontic molar bands
Aust.Orthod.J.11(2):89-92
- FRICKER,J.P., HIROTA,K., TAMIYA,Y. (1989)
The effects of temperature on the setting of glass polyalkenoate cements
Aust.Dent.J.(In press)
- FRICKER,J.P. and McLACHLAN,M.D. (1985)
Clinical studies of glass ionomer cements. Part 1. A 12 month clinical study comparing zinc phosphate with glass ionomer.
Aust.Orthod.J.9:179-180

MAJIER,R., and SMITH,D.C. (1988)

A comparison of glass ionomer cement with zinc phosphate cement in orthodontics.

Am.J.Orthod.Dentofac.Orthop.93:273-279

MIZRAHI,E. (1988)

Glass ionomer cements in orthodontics - an update

Am.J.Orthod.Dentofac.Orthop.9:505-507

SEEHOLZER,H.W. and DASCH,W. (1988)

Banding with a Glass Ionomer Cement

J.Clin.Orthod.22 No.3

WALLS,A.W.G, McCABLE,J.F, MURRAY,J.J. (1988)

Factors influencing the setting reaction glass polyalkenoate (ionomer) cements

J.Dent.16:32-35

WILSON,A.D. & KENT,B.E. (1971)

The glass ionomer cement. A new translucent filling material

J.Appl.Chem & Biotechnol.21:p313

WILSON,A.D, CRISP,S., LEWIS,B.G., McLEAN,J.W. (1977)

Experimental luting agents based on Glass Ionomer Cements

Br.Dent.J.142:117-122

Correspondence to:

Dr J.P. Fricker

PO Box 3544

MANUKA CANBERRA

ACT 2603