A Comparison of Resistance to Enamel Demineralization after Banding with Four Orthodontic Cements: An *in vitro* Study

Santosh Kumar Goje, Vijay Kumar Sangolgi, Praveen Neela, CH Lalita

**ABSTRACT**

The use of bands on premolar and molar teeth is quite common due to the fact that cemented bands are stronger than bonded brackets. Enamel demineralization and caries commonly correspond with the use of cemented bands, because of their posterior position in the mouth and difficulty to clean resulting in greater accumulation of plaque. This study aims to compare the *in vitro* resistance to demineralization provided by four orthodontic cements.

**Methodology:** One hundred sound, extracted human premolars were collected, and divided into five groups of 20 each. Four groups were banded with four different cements—zinc phosphate cement, zinc polycarboxylate cement, conventional glass ionomer cement, resin modified glass ionomer cement and the fifth group was not banded which served as the control group. The specimens were stored in deionized water at 37°C for 30 days and thermocycled for 24 hours and debanded with band removal device. The teeth were then stored in artificial demineralization solution for 4 weeks. After which they were subjected to 10% methylene blue dye for 24 hours and buccolingual section of these teeth examined under 4×-magnification stereo zoom microscope.

**Results:** Teeth banded with conventional glass ionomer cement and resin modified glass ionomer cement had the least amount of demineralization followed by zinc polycarboxylate cement and zinc phosphate cement.

**Conclusion:** The teeth banded with the three fluoride releasing cements (conventional GIC, RMGIC, zinc polycarboxylate) demonstrated significantly lesser depth of enamel demineralization as measured by depth of dye penetration than did the zinc phosphate and nonbanded and noncemented control group.

**Keywords:** Banding, Cements, Demineralization.

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**INTRODUCTION**

Orthodontic treatment requires the posterior teeth to act as anchors to hold and guide the other teeth in the arch. This necessitates a firm attachment on the anchor teeth. The orthodontic band cemented on the tooth, is one of the practical means of obtaining such an attachment. The usage of band on the premolars and molars are quite common due to the fact that cemented bands are stronger than bonded brackets.

Enamel decalcification can occur whenever bacterial plaque is retained on the enamel surface for prolonged period. Demineralization which can be seen as white spot lesion is due to the mineral loss at very surface of the enamel. Any covering that provides an area for accumulation of food debris can encourage plaque formation and increase caries hazard.

Furthermore, because of the posterior position in the mouth, banded teeth are more difficult to clean resulting in greater chance of plaque accumulation and food retention. Thereby a cariogenic challenge is created around the orthodontic bands. Other factor is dissolution of cement under the bands due to the influence of oral fluid.

Two favored sites for such accumulation are around the cervical margin of the teeth and under the bands in areas where the cementing medium has been washed out. Thereby use of orthodontic bands commonly results in demineralization of enamel leading to caries.

Orthodontists are becoming increasingly cautious of these problems and have put an effort to reduce the demineralization during orthodontic treatment. Demineralization can be treated but it is always better to prevent it rather than treating it at a later stage, i.e. ‘prevention is always better than cure’. This can be achieved partially by better oral hygiene and the use of topical fluoride applications. Fluorides have shown not only to reduce the demineralization and plaque formation but also help in remineralization of enamel. However, this requires patient compliance which in some cases is difficult to obtain.
Fluoride releasing cements can be used to prevent the demineralization. This can occur only if the cement firmly adheres to the tooth under the bands. Hence, an ideal banding cement should not only release fluorides but also should adhere well to the tooth enamel.

In spite of the wide application of direct bonding procedures in orthodontics, banding of teeth and their cementation with dental cements continue to be practiced by orthodontists.

AIM OF THE STUDY

To evaluate the ability of four orthodontic cements to resist the demineralization of enamel under orthodontic bands.

OBJECTIVES

The objective of this study is to compare the resistance to enamel demineralization after banding with four orthodontic cements namely:

A. Zinc phosphate cement (Harvard cement)
B. Zinc polycarboxylate cement (Poly-F, densply)
C. Conventional glass ionomer cement (GC fuji)
D. Resin modified glass ionomer cement (Relyx Luting 2,3M)

MATERIALS AND METHODS

The study was carried out in the Department of Orthodontics and Dentofacial Orthopedics, Kamineni Institute of Dental Sciences, Narketpally, Nalgonda.

One hundred freshly extracted premolar teeth (Fig. 1) were collected from patients who reported for extraction in the Department of Oral and Maxillofacial Surgery. The teeth collected were caries free and were of normal morphology. After extraction, the teeth were cleaned of any soft tissue debris. Further the teeth were stored in distilled water and then refrigerated. Distilled water was changed frequently to prevent bacterial contamination.

The teeth were divided into five groups as follows:

- **Group A**: Non-banded, Non-cemented teeth (control group)
- **Group B**: Teeth banded with zinc phosphate cement
- **Group C**: Teeth banded with zinc polycarboxylate cement
- **Group D**: Teeth banded with conventional glass ionomer cement
- **Group E**: Teeth banded with resin modified glass ionomer cement

**Banding Procedure for Group B (Zinc Phosphate Cement, Harvard Cement)**

The teeth were cleaned thoroughly, with pumice and water. Excess water was removed using a cotton pellet. The cement was mixed in the powder/liquid ratio of 1.5 gm/1.0 gm on a clean dry glass plate using spatula. The mixing time is 90 seconds. The proper consistency was reached when on lifting the spatula the peak formed slowly falls back into the paste. Once the proper mix was obtained the banding surface of the bands is coated completely with the cement and the bands were seated around the premolars. The bands were tightly fitted to decrease the possibility of cement dissolution. Marginal adaptation was done using a band seater. Excessive cement was removed from occlusal and cervical margins.
Banding Procedure for Group C (Zinc Polycarboxylate Cement, Poly-F Densply)

The teeth were cleaned thoroughly with pumice and water. Excess water was removed using a cotton pellet. The cement dispensed from the cartridge using a dispenser on to the mixing pad. The cement was mixed in the ratio—one measure of powder to 2 to 3 drops of liquid. Using a spatula all the powder was incorporated rapidly into the liquid until creamy consistency was reached. Once the proper mix was obtained, the cement was placed on the internal surface of the bands and the bands were seated around the premolars. The bands were tightly fitted to decrease the possibility of cement dissolution. Marginal adaptation was done using a band seater. Excessive cement was removed from occlusal and cervical margins.

Banding Procedure for Group D and E (Conventional Glass Ionomer Cement and Resin Modified Glass Ionomer Cement)

The teeth were cleaned thoroughly with pumice and water. Excess water was removed using a cotton pellet. The cement was dispensed from the cartridge using a dispenser on to the mixing pad. Using a plastic spatula the cement was mixed thoroughly, with lapping strokes, for 15 to 20 seconds. Once the proper mix was obtained, the cement was placed on the internal surface of the bands and the bands were seated around the premolars. The bands were tightly fitted to decrease the possibility of cement dissolution. Marginal adaptation was done using a band seater. Excessive cement was removed from occlusal and cervical margins.

The cements were allowed to bench set for 2 minutes after which the teeth were transferred to four sealable plastic pouches and immersed in deionised water (Fig. 4). The containers were then incubated for 30 days at room temperature (35°-37°C) to simulate temperature in the oral cavity. After incubation the teeth were thermocycled for 24 hours at 10°C and 50°C with dwell times of 30 seconds to help stimulate the temperature fluctuations in the oral cavity. The bands were then removed using a band removing plier. Each tooth then carefully cleaned with a hand scaler to remove any remaining cement on the surface.

Exposure of the Teeth to the Artificial Demineralizing Solution (Fig. 5)

The teeth were then immersed in an artificial cariogenic solution. The solution was prepared according to a formulation suggested by Silverstone. It consists of 17% gelatin, 1 g/l synthetic hydroxyapatite and 0.1% thymol. The pH of the solution was adjusted to 4.3 by adding lactic acid. The different groups of teeth were kept in this solution in separate glass container for 4 weeks the solution was changed every week to avoid the potential fluoride build up in the solution.

Preparation of the Tooth to check for Amount of Demineralization

The teeth were removed from the demineralizing solution, after 4 weeks and were immersed in deionised water. They were then immersed in a 10% solution of methylene blue for 24 hours at 37°C (Fig. 6). The teeth are removed from the solution, rinsed with deionised water and sectioned with a diamond disk buccolingually through the center of the exposed enamel.
Measurement of the Depth of Dye Penetration

The measurements to check the depth of dye penetration was carried out in the Department of Oral Pathology and Microbiology, Kamineni Institute Of Dental Sciences, Narketpally. The photographs of the each group images taken with digital camera through the Stereo Microscope (Fig. 7) and depth of dye penetration checked by using Image Analysis Software. The degree of demineralization was assessed by the depth of dye penetration into the demineralized area of the tooth which was measured in microns (µ).

RESULTS

The present study was carried out to compare enamel demineralization resistance potential of four commonly used orthodontic cements for banding.

A. Zinc phosphate cement (Harvard cement)
B. Zinc polycarboxylate cement  (Poly-F, Densply)
C. Conventional glass ionomer cement (GC Fuji)
D. Resin modified glass ionomer cement

The mean dye penetration (amount of demineralization) (Graph 1). Mean dye penetration with standard deviation (Table 1). The differences in mean dye penetration groups (Table 2). Fisher test and Turkey HSD were used for statistical analysis.

The stereo microscopic pictures of dye penetration are illustrated in Figures 8 to 12 as follows.

Mean Dye Penetration (Mean Amount of Demineralization) (Table 1)

The results showed that the conventional glass ionomer cement (GC-Fuji) had dye penetration of 6.61 µ, with the standard deviation of 2.11 followed by Resin modified glass ionomer cement with mean dye penetration of 6.90 µ, with standard deviation of 2.92 and zinc polycarboxylate cement (Poly F, densply) with mean dye penetration of 19.20 µ with standard deviation of 5.83 and zinc phosphate (Harvard cement) with mean dye penetration of 55.70 µ with standard deviation of 9.09. The control group had a mean dye penetration of 73.64 µ with standard deviation of 13.80. Fishers test showed a value of 187.97 and 187.10 of conventional GIC and RMGIC respectively which was very highly significant in comparisons with other group.
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Fig. 10: Dye penetration in group C (zinc polycarboxylate cement)

Fig. 11: Dye penetration in group D (GIC)

Fig. 12: Dye penetration in group E (resin modified glass ionomer cement)

Table 1: Summary of mean dye penetration

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>20</td>
<td>73.64</td>
<td>13.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc phosphate</td>
<td>20</td>
<td>55.70</td>
<td>9.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc polycarboxylate</td>
<td>20</td>
<td>19.20</td>
<td>5.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional GIC</td>
<td>20</td>
<td>6.61</td>
<td>2.11</td>
<td>187.97</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td>RMGI</td>
<td>20</td>
<td>6.90</td>
<td>2.92</td>
<td>187.10</td>
<td>0.001 VHS</td>
</tr>
</tbody>
</table>

F: Fisher’s test; VHS: Very highly significant

Table 2: Comparison of mean dye penetration between the groups (dependent variable and dye penetration)

<table>
<thead>
<tr>
<th>Group (I)</th>
<th>Group (J)</th>
<th>Mean difference (I-J)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Zinc phosphate</td>
<td>17.94</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td>Zinc phosphate</td>
<td>Zinc polycarboxylate</td>
<td>54.44</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td></td>
<td>Conventional GIC</td>
<td>67.03</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td></td>
<td>RMGI</td>
<td>66.74</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td>Zinc polycarboxylate</td>
<td>Zinc polycarboxylate</td>
<td>36.50</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td></td>
<td>Conventional GIC</td>
<td>49.09</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td></td>
<td>RMGI</td>
<td>48.80</td>
<td>0.001 VHS</td>
</tr>
<tr>
<td>Zinc polycarboxylate</td>
<td>Conventional GIC</td>
<td>12.59</td>
<td>0.006 HS</td>
</tr>
<tr>
<td></td>
<td>RMGI</td>
<td>12.35</td>
<td>0.006 HS</td>
</tr>
<tr>
<td>RMGI</td>
<td>Conventional GIC</td>
<td>0.29</td>
<td>0.996 HS</td>
</tr>
</tbody>
</table>

Tukey HSD; HS: Highly significant; VHS: Very highly significant

Comparison of Mean Dye Penetration (Mean Amount of Demineralization) (Table 2)

Comparing the mean dye penetration of various groups using the Tukey HSD test it was found that there was very high significant difference (p.001) of dye penetration between zinc phosphate (Harvard cement, 55.70 µ), zinc polycarboxylate (Poly F, densply, 19.20 µ) and conventional glass ionomer (GC-Fuji, 6.61 µ) and resin modified glass ionomer cement (6.90 µ) compared to the control group. Also there was a very high significant difference (p.001) between zinc polycarboxylate (Poly F, Densply, 19.20 µ), conventional glass ionomer (GC-Fuji, 6.61 µ) and resin modified glass ionomer cement (6.90 µ), compared to zinc phosphate cement (Harvard cement, 55.70 µ). Also there was significant difference (p.006) between...
the conventional glass ionomer (GC-Fuji, 6.61 μ) and resin modified glass ionomer cement (6.90 μ) compared to zinc polycarboxylate (Poly F, Densply, 19.2 μ). And there is no significant difference between the conventional glass ionomer (GC-Fuji, 6.61 μ) and resin modified glass ionomer cement (6.90 μ).

DISCUSSION

Bonding in orthodontics is the most commonly employed method of obtaining an attachment on to the tooth. Although the introduction of bonding almost eliminated the banding technique due to its various advantages over the banding, banding of anchor teeth remains popular due to the fact that cemented bands are stronger than the bonded brackets.

The presence of clinically detectable areas of enamel demineralization, often referred to as decalcification, following the removal of orthodontic bands has for many years been accepted as one of the hazards of orthodontic treatment, because of the increased plaque and food accumulation, cement seal breakdown, inadequate band strength and cement dissolution under the bands due to oral fluids. There has been general agreement that the development of white spots seems to be related to (1) the retention of plaque on the gingival side of the brackets or bands, (2) oral hygiene efficiency, and (3) the inherent resistance of the individual. Despite careful patient selection and prophylactic programs, white spot formation during orthodontic treatment with fixed appliances remains a problem.

In agreement with Geiger et al (1988), who reported that the incidence and severity of white spot formation after debonding and debanding was related to treatment time, longer treatment periods resulted in an increase in white spot formation.

In 1978, Zinc phosphate cement was introduced as dental cement. It has become the standard cement used to cement orthodontic bands over the years. There are certain drawbacks inherent in the use of zinc phosphate cement. It is brittle, has a relatively high solubility in the mouth, and it does not adhere to the tooth substance. Zinc phosphate cement relies on the mechanical interlocking for its retentive effect. So decalcification beneath the loose bands remains concern.

Demineralization around the cemented orthodontic bands can be reduced by using fluoride releasing cements which reduces plaque formation and helps to remineralize enamel. Many types of orthodontic cements have been introduced in order to resist demineralization of the enamel by releasing fluoride. One of the first cement zinc polycarboxylate cement introduced by Smith in 1968. The drawbacks of this cement are low viscosity, low compressive strength in comparison with the glass ionomer cement. Later the most popular cement is the glass ionomer cement introduced by Wilson and Kent in 1972. According to Warren Hamula glass ionomer cement release fluoride ions into the adjacent enamel, helping to prevent decalcification of enamel. With glass ionomer, although band fitting and placement are still important for successful performance, decalcification is rare because of the fluoride-releasing property of the cement. Even when an oversize band loosens, the cement maintains its chemical bond to the enamel and forms a protective ring around the tooth. Norris, et al found that glass ionomer offered clinical protection against decalcification of enamel under loose bands. Rezk-Lega et al demonstrated that fluoride released from glass ionomer cements contributes substantially to demineralization reduction.

The aim of this study was to compare the resistance to enamel demineralization provided by four most commonly used cements for the purpose of orthodontic banding which are compared to a nonbanded, noncemented control group. The groups compared being:

- **Group A**: Nonbanded, noncemented control group
- **Group B**: Zinc phosphate cement (Harvard cement)
- **Group C**: Zinc polycarboxylate cement (Poly-F, Densply)
- **Group D**: Conventional glass ionomer cement
- **Group E**: Resin modified glass ionomer cement

The study was conducted on 100 freshly extracted premolar teeth. Teeth were cleaned, dried and divided into five groups of 20 each. Group B, C, D, E were banded with the stainless steel bands using the respective cements. The teeth were then placed in deionized water for 1 month. They were debanded, cleaned and then placed in artificial demineralizing solution for 4 weeks. Later they were cleaned and placed in methylene blue for 24 hours to check the amount of demineralization. Teeth were then sectioned buccolingually and observed under stereo microscope 4X magnification. The depth of demineralization is equal to the depth of dye penetration measured in μ.

The present study showed that Conventional glass ionomer cement and resin modified glass ionomer cement (RMGIC) had the least amount of demineralization compared to the three other groups (control group, zinc phosphate cement and zinc polycarboxylate cement). Similarly conventional glass ionomer cement (6.61 μ) showed almost similar amount of demineralization as resin modified glass ionomer cement (6.90 μ). And zinc polycarboxylate cement (19.20 μ) showed lesser amount of demineralization compared to zinc phosphate cement (55.70 μ) and control group (73.64 μ).

The present study is also supported by the study done by Donly et al in which results demonstrated the exposed carious enamel lesion areas (mm² ± SD) adjacent to orthodontic bands cemented with zinc phosphate and glass ionomer cements (in water, Thoulet’s 1.41 and 1.47 imbibition media respectively) to be: varnished zinc phosphate controls 2.14 ± 0.41, 1.32 ± 0.72, 0.43 ± 0.58; zinc phosphate exposed to external environment 2.23 ± 1.25, 2.89 ± 1.86, 1.73 ± 2.03; varnished glass ionomer controls 2.09 ± 0.36, 1.24 ± 0.51, 0.30 ± 0.43; glass ionomer exposed to external environment 1.37 ± 0.57, 0.43 ± 0.42, 0.10 ± 0.12.

Microfocal radiography study done by SRK Reddy also revealed significant differences in the subsurface area. Enamel under bands cemented with zinc phosphate cements showed deep penetration of acid into the enamel with increased intercrystalline spaces and large radiolucent areas of subsurface
demineralization which resembled a natural carious lesion. Enamel surfaces, under bands cemented with glass ionomer revealed no evidence of subsurface demineralization.

This study shows that RMGIC and glass ionomer cement demonstrated significantly lesser demineralization. This difference might be just not only by the greater amount of fluoride released by glass ionomer cement but also by the greater amount of time the GIC remains in contact with enamel, because GIC is less likely to dissolve in oral fluids or fracture under the shear peel loads compared to other cements.²⁰

The zinc phosphate cement was not significantly different from that of the control group in the depth of dye penetration. This may be due to lack of fluoride in zinc phosphate cement because of which it does not provide any additional protection of the enamel against acid attack by bacteria in oral cavity. In addition, dissolution of zinc phosphate cement in oral cavity overtime might leave a tooth as if no cement were present. This finding also indicated that zinc phosphate cement might act as a suitable control when comparing other banding cements. The mean dye penetration was greater in zinc phosphate compared to RMGIC, conventional glass ionomer and zinc polycarboxylate cement. It is unclear whether this numerical difference is clinically significant. It can be postulated that zinc polycarboxylate, conventional glass ionomer and RMGIC are more effective than zinc phosphate cement in resistance to enamel demineralization when they are used for short term (4 weeks). Hence, it can be expected that there could be lesser enamel demineralization with these three cements over the long course of orthodontic therapy. Considering the shear bond strength, the better handling properties, and the possibility of increased fluoride release, the use of conventional glass ionomer cement and RMGIC over zinc polycarboxylate cement for orthodontic banding might be recommended. However, long term studies are necessary to support this hypothesis.

CONCLUSION

The results obtained from this in vitro study leads to the following conclusions:

The three fluoride releasing cements (conventional GIC, RMGIC, zinc polycarboxylate) demonstrated significantly lesser depth of enamel demineralization as measured by depth of dye penetration than did the zinc phosphate and nonbanded and noncemented control group.

The conventional GIC and RMGIC cements showed significantly lesser amount of demineralization than compared to the zinc polycarboxylate cement group.

The conventional GIC and RMGIC cements showed no significant difference in depth of enamel demineralization.

The zinc phosphate and nonbanded—nonsanded control group demonstrated the greatest depth of enamel demineralization.

The current study does not evaluate the long term effects of the cements and by being an in vitro study the effect may not exactly be as it would be in a real time clinical scenario.

REFERENCES