RESEARCH ARTICLE

Comparative assessment of resistance to enamel demineralization after orthodontic banding with three different cements- An in vitro study

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ABSTRACT

Objectives: This in vitro study aimed to compare the resistance to enamel demineralization after banding with three orthodontic cements, namely Zinc Phosphate, Zinc Polycarboxylate and Resin Modified Glass Ionomer Cement [RMGI] (Fuji Ortho Band Pak, GC).

Materials and Methods: 80 premolars were selected, cleaned, dried and divided into four groups. Group A was a Control group. Group B, C and D were banded with the stainless steel bands using the respective cements. The teeth were then placed in deionized water for one month. They were debanded, cleaned and placed in artificial demineralizing solution for four weeks. Afterwards, they were cleaned and placed in methylene blue for 24 hours to check the amount of demineralization. The teeth were cut buccolingually and observed under the Motic Image Digital microscope. For analysis, the depth of dye penetration was measured in µm, which was considered as the depth of sub superficial demineralization.

Results: RMGI cement showed significantly lower amount of demineralization (6.68 ±3.02µm) compared to the Zinc Polycarboxylate cement group (18.08± 5.83µm). The Zinc Phosphate cement group(55.36±8.67µm) and the Control group(76.72±18.83µm) demonstrated the greatest depth of enamel demineralization. Overall comparison showed a statistically significant difference ($F=187.97$, $p<0.001$).

Conclusions: RMGI used for banding achieves the greatest resistance against enamel demineralization in comparison with zinc phosphate and zinc polycarboxylate cements.

Keywords: Banding, cements, resin modified glass ionomer, enamel demineralization, zinc polycarboxylate, zinc phosphate, orthodontic cement, plaque.

INTRODUCTION

Orthodontic treatment requires the posterior teeth to act as anchors to hold and guide the other teeth in the arch. The usage of bands on premolars and molars are quite common due to the fact that cemented bands are stronger than bonded brackets and also because they provide firm attachment. Enamel demineralization adjacent to bands and brackets is a great shortcoming in the patients of fixed orthodontic treatment especially those with poor oral hygiene.[1-2] A vital requisite of a cemented orthodontic band is the protection of the tooth from demineralization and carious attack. Demineralization, which can be seen as white spot lesions,[3-4] is due to the mineral loss at the surface of the enamel. Any

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defect that provides a sheltered area for accumulation of food debris can encourage plaque formation. Due to their posterior position in the mouth, banded teeth are more difficult to clean resulting in propensity for plaque accumulation and food retention; thereby an increased cariogenic challenge is created around the orthodontic bands. Other factors that contribute are cement seal breakdown, inadequate band strength and cement dissolution under the bands due to the water sorption and solubility.[3] So, the use of orthodontic bands commonly results in the demineralization of enamel leading to caries.[4-5]

In the early stages, demineralization can be prevented, but in the advanced stages it has to be treated. Prevention can be achieved partially by improving the patient oral hygiene and use of topical fluoride applications. Fluorides have shown not only to reduce demineralization[6-7] and plaque formation, but also help in remineralization of enamel[8-9]. However, these preventive strategies need patient compliance[10-11] and hence, are not much reliable. [12–13] Therefore, preventive strategies, which do not need the patient's compliance, might be more effective in preventing or reducing demineralization.[14-18] Fluoride releasing cements can be used to prevent demineralization. This can occur only if the cement firmly adheres to the tooth under the bands. Hence, ideal banding cement should not only release fluorides but should also adhere well to the enamel. This study was designed to evaluate the ability of three commonly used orthodontic cements to resist to the demineralization of enamel under orthodontic bands. The null hypothesis of the study was that there is no difference in the ability of any of the three orthodontic cements to resist the demineralization of enamel under orthodontics bands.

MATERIALS AND METHODS

Eighty extracted premolars were collected from patients who reported for extractions in the Department of Oral and Maxillofacial Surgery, A. B. Shetty Memorial Institute of Dental Sciences, Mangalore. Only the teeth free of caries and other lesions were used. The teeth were divided into four groups as follows:

Group A - Non-Banded, Teeth (Control Group)

Group B - Teeth Banded with Zinc Phosphate Cement (ZnPH) [Harvard cement by Harvard Dental- Hoppegarten ,Germany].

Group C - Teeth Banded with Zinc Polycarboxylate Cement (ZnPC, Densply) [Poly-F by Densply-Konstanz, Germany].

Group D - Teeth Banded with Resin Modified Glass Ionomer Cement (RMGI) [Fuji Ortho Band Paste Pak, GC, Tokyo, Japan].

Manipulation procedure for the cements:

ZnPH: The cement was mixed in the powder /liquid ratio of 1.5g/1.0g on a clean, dry glass plate using a spatula. The mixing time was 90 seconds. The proper consistency was reached when on lifting the spatula the peak formed slowly falls back into the paste.

ZnPC: The cement was mixed in the ratio - one measure of powder to 2-3 drops of liquid. Using a spatula all the powder was incorporated rapidly into the liquid until creamy consistency was reached.

RMGI: 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 15-20 seconds.

Procedure

Teeth belonging to the Control group (n=20) were not cemented and banded, while for the other groups, the buccal surface of each tooth were cleaned with pumice slurry, washed in distilled water and air dried. Stainless steel custom-made orthodontic bands with no attachments were contoured and seated around the teeth by using marginal adaptation with a band seater. Bands were tightly adapted to decrease the possibility of cement dissolution. The bands were seated with the respective cements after manipulation according to the manufacturer's instructions. The cements were allowed to bench set and then the teeth were transferred to sealable plastic pouches and immersed in deionised water. The teeth were then stored for 30 days (for cement dissolution) at room temperature. After storage, the teeth were thermocycled for 24 hours at 10^0C and 50^0C with dwell times of 30 seconds to help simulate the temperature fluctuations in the oral cavity.[23] The bands were removed and each tooth was carefully cleaned with a hand scaler to remove any remaining cement on the surface. The teeth were then immersed in an artificial cariogenic solution. The solution was prepared according to a formulation suggested by Silverstone.[22] It consisted of 17% acidified gelatin, 1 g/L synthetic hydroxyapatite, and 0.1% thymol. The pH of the solution was adjusted to 4.3 by adding 1mol lactic acid. The different groups of teeth were kept in this solution in separate glass containers for four weeks. The solution was changed every week to avoid the fluoride saturation in the solution. The teeth were removed from the demineralizing solution after four weeks, and immersed in deionised water. Later the teeth were immersed in a 10% solution of methylene blue for 24 hours at 37^0C. They were then removed from the solution, rinsed with deionised water and sectioned with a diamond blade bucco-lingually through the centre of the exposed enamel. The depth of dye penetration into the demineralized area of the tooth was measured in µm, which was considered as equal to the depth of demineralization.

The measurements were done on a Motic Image Digital microscope (4X magnification), which was connected to a computer imaging system. The software used was Motic Image Plus 2.

The numerical data was subjected to descriptive and inferential analysis. Fishers F test and Tukey HSD (for multiple comparisons) were used for statistical analysis. The level of significance was fixed at 5%.

RESULTS

The results revealed that the teeth banded with RMGI had dye penetration of 6.68 ±3.02µm, while 18.08± 5.83µm was recorded with Zinc Polycarboxylate, 55.36±8.67µm with Zinc Phosphate and 76.72± 18.83µm for the Control group. Overall, comparison showed a statistically significant difference (F=187.97, $p<0.001$). This data is presented in Table 1. RMGI showed the highest resistance to demineralization followed by Zinc Polycarboxylate, Zinc Phosphate and the control group.

Table 2 shows multiple comparisons between the groups. It was found that there was a highly significant difference ($p<0.001$) of dye penetration between Zinc Phosphate, Zinc Polycarboxylate and

Table 1. Mean and standard deviation values of the different groups.

	N	Mean±Sd	F value
Control	20	76.72 ± 18.83	187.97 ($p<0.001$)
Zinc phosphate	20	55.36 ± 8.68	
Zinc polycarboxylate	20	18.04 ± 5.83	
RMGI	20	6.68 ± 3.02	

F = Fishers Test

Table 2. Comparison of Mean Dye Penetration values between the groups using Tukey HSD test.

(I) Group	(J) Group	Mean Difference (I-J)	p
Control	Zinc phosphate	21.36	P<0.001
	Zinc polycarboxylate	58.68	P<0.001
	RMGI	70.04	P<0.001
Zinc phosphate	Zinc polycarboxylate	37.32	P<0.001
	RMGI	48.68	P<0.001
Zinc polycarboxylate	RMGI	11.36	P<0.006

RMGI cement groups when compared to the Control group. A highly significant difference (p<0.001) between Zinc Polycarboxylate and RMGI cement when compared to the Zinc Phosphate group was observed. Comparison between Zinc Polycarboxylate and RMGI groups also showed a highly significant difference (p<0.006).

DISCUSSION

Although the introduction of bonding almost completely eliminated the banding technique due to its various advantages, banding, especially in the anchor teeth remains popular due to the fact that cemented bands are stronger than bonded brackets. Demineralization around the bands can be reduced by using fluoride releasing cements,[6-7] which reduces plaque formation and helps to remineralize enamel.[8-9] The cement acts as an additional local source of fluoride near the appliances, whereas the amount of release depends on the substance group present in the respective cement material.[1, 21]

Even though zinc phosphate cement is currently not used for orthodontic treatment, it has a long history of clinical use for band cementation and is considered as a standard.[10] Hence, for comparison, this cement has been included in the present study.

The most popular cement at present is the glass ionomer cement, which was introduced by Wilson and Kent in 1972. According to Warren Hamula[14] glass ionomer cements release fluoride ions into the adjacent enamel helping to prevent decalcification. Norris et al.[15] found that glass ionomer offered clinical protection against decalcification under loose bands. Rezk-Legaet al.[16] demonstrated that fluoride released from glass ionomer cements contributed substantially to demineralization reduction. RMGIs, developed in the late 1980s, are more recent entrants into the dental cement arena, having been first introduced commercially as a luting cement in 1994. This class of cements is less technique-sensitive than the conventional glass ionomer materials and possesses some very favorable physicomechanical properties compared with conventional glass ionomer cement, yet releases similar levels of fluoride.

In the present study, RMGI had the least amount of demineralization compared to the other groups. Both Zinc Polycarboxylate (18.38µm) and RMGI (6.68µm) demonstrated significantly lower mean dye penetration than Zinc Phosphate (58.68µm) and the Control groups (75.59µm). This was similar to the results obtained by Foley et al[10] (Control group - 301µm, Zinc Phosphate - 296µm, Zinc Polycarboxylate - 230µm, RMGI - 196µm). However, higher amount of dye penetration has been observed in their study. Probably, the different study designs might have laid to the difference in the penetration.

The present study results are also in consensus with those of Donly et al,[8] which showed that RMGI and Zinc Polycarboxylate demonstrated significantly lower demineralization. It can be remarked that RMGI has an added advantage, i.e., it not only releases greater amount of fluoride but remains in contact with the enamel for longer period of time.[24-25] This is because RMGI is less likely to dissolve in oral fluids or fracture under the shear peel loads as compared to Zinc Polycarboxylate.[17]

Difference in the enamel demineralization can also be attributed to the inherent nature of the material present in the cement. The liquid used for Zinc Phosphate cement is phosphoric acid which causes greater depth of demineralization as compared to polyacrylic acid.[26]

The mean dye penetration of Zinc Phosphate (58.68µm) was not significantly different from that of the Control group (75.59µm). The higher dye penetration in Control group may be attributed to the direct contact with cariogenic solution.[20] Similar is the case with Zinc Phosphate cements, which can leave the tooth as vulnerable as there is no cement present at all. This finding indicates that Zinc Phosphate cement might act as a suitable control when comparing with other banding cements. Additionally, Zinc phosphate cement contains no fluoride, and hence it does not provide any additional protection for the enamel against acid attack by bacteria in oral cavity.

It can be suggested that Zinc Polycarboxylate and RMGI cements are more effective than Zinc Phosphate cement in resistance to enamel demineralization when used for a short term (four weeks). Hence, it can be expected that there could be lower enamel demineralization with these two cements over the long course of orthodontic therapy. Considering the increased shear band strength,[14,17] the better handling properties, and the possibility of increased fluoride release, the use of RMGI over Zinc Polycarboxylate as a preventive orthodontic banding cement might be recommended.

CONCLUSION

Within the limitations of the study, it can be concluded that:

1. The two fluoride releasing cement groups (RMGI and Zinc Polycarboxylate) demonstrated significantly lower depth of demineralization than did the Zinc Phosphate and the Control groups.

2. The RMGI can be safely considered for banding as it showed the least amount of demineralization.

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