Comparison of Retention and Demineralization Inhibition Potential of Adhesive Banding Cements in Primary Teeth

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ABSTRACT

Purpose: The purpose of this study was to evaluate the efficacy of banding cements in terms of retentive capability and demineralization inhibition potential.
Methods: We included 48 non-carious primary mandibular second molar teeth. Preformed stainless steel bands were adapted onto the teeth. All teeth were randomly assigned to four groups: Group I (Adaptation of bands without cementation), Group II (Cementation of bands using conventional Glass Ionomer Cement), Group III (Cementation of bands using Resin-modified Glass Ionomer Cement), Group IV (Cementation of bands using Resin cement), and placed in artificial saliva. Each day, specimens were taken from artificial saliva and suspended in an artificial caries solution for 35 minutes, every 8 hours. At the end of 3 months, retention of bands was estimated using an Instron Universal Testing Machine. The mode of failure was recorded and specimens were sectioned and examined under polarized microscope for demineralized lesions.
Results: The mean retention value was highest with resin cement, followed by RMGIC, GIC, and Control group respectively. The RMGIC group showed more favorable modes of failures. All the experimental groups showed significant demineralization inhibition potential.
Conclusion: RMGIC is the preferable banding cement and can be used effectively to cement bands in primary dentition.
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The prime concern of dentists for the developing occlusion should be the conservation of every millimeter of space in every child's original dental arch. Preservation of the space can often eliminate or reduce the need for prolonged orthodontic treatment. Although steel-band-supported space maintainers are the most commonly used, they do have some limitations. Enamel demineralization and caries are commonly associated with the use of cemented bands. Inadequate bonding strength, seal breakdown, space maintainers, the solubility of cements, and poor oral hygiene can contribute to the initiation of decalcification.[1] Thus, an ideal banding cement should be retentive, release fluoride, and adhere strongly to enamel.

In the past 2 decades, glass ionomer cements (**GICs**) have become popular for band cementation. This is by the virtue of their coefficient of thermal expansion being similar to the natural tooth structure, the physicochemical bonding to enamel and dentin. A much desired propensity to release fluoride, many confer a caries inhibition potential to the adjacent tooth structures.[2] Resin-modified glass ionomers (**RMGICs**) combine the properties of glass ionomers with the additional strength of a polymerizing resin component. Their favorable properties include low solubility and ability to chelate via acid-base reaction to enamel and metal. In addition, RMGICs release fluoride into enamel without losing

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cement strength.[2] These cements are self-adherent, moisture tolerant, easy to work with, and have good tensile and compressive strength. The only limitation of this cement is its questionable fluoride release.[3]

Many studies have been conducted to compare the retention, mode of failure or demineralization inhibition potential of different cements in permanent dentition. To date, however, no study has evaluated all of these parameters simultaneously in primary teeth. Comparisons of the composition and morphology in primary and permanent teeth show some differences. Primary tooth enamel has a much higher organic content, with a concomitant lower mineral composition, than that of permanent tooth enamel. Primary tooth enamel is quite thin, and demineralization may progress through the dentinoenamel junction into dentin more rapidly than with permanent teeth. In addition, it is also known that the primary teeth have more hypocalcified and hypomineralized areas due to in-utero disturbances in amelogenesis.[4]

Therefore, the purpose of this study was to compare 3 adhesive banding cements for the retention, mode of failure and demineralization inhibition potential in primary teeth.

METHODS

We collected 48 noncaries primary mandibular second molars (therapeutically extracted in cases of serial extraction, pre-shedding mobility, and retained teeth). After the debridement of remaining soft tissue with a periodontal scaler, teeth were placed in distilled water and stored in a refrigerator for a period of 4 weeks, as advised by the International Organization for Standardization (1994).[5,6] Teeth were polished with the mixture of nonfluoridated pumice and water. Teeth with no caries or cracks and with intact crown enamel were selected using a stereo-microscope. Each tooth was mounted up to the cervical line in the block of self-curing acrylic.[1] Optimally sized, clinically adapted stainless steel preformed bands (Libral Traders Pvt Ltd, New Delhi, India) were selected and fitted according to tooth size and morphology. Two opposing orthodontic Begg brackets were spot-welded on to the buccal and lingual surfaces of preformed bands and then adapted onto the teeth.[1]

Subsequently, the 48 teeth were randomly assigned to 4 groups of 12 each: group 1 (control group), in which stainless steel bands were adapted without cementation; group 2, in which stainless steel bands were cemented via conventional GIC (Ketac Cem Easymix, 3M ESPE, St. Paul, Minn); group 3, in which stainless steel bands were cemented using RMGIC (Rely X Luting, 3M ESPE); and group 4, in which stainless steel bands were cemented using resin cement (Rely X ARC, 3M ESPE).

All the experimental teeth were cemented according to the manufacturer's instructions and placed in 4 separate plastic containers containing nonfluoridated artificial saliva. All the containers were maintained at room temperature. The teeth were taken from the artificial saliva (20 mm $NaHCO_3$, 3 mm NaH_2PO_4, 1 mm $CaCl_2$ at neutral Ph) and suspended into an artificial caries solution (2.2 mm Ca+, 2.2 mm PO_4^{-3}, and 50 mm acetic acid at Ph 4.5) for 35 minutes, every 8 hours.[7] The teeth of each group were brushed twice daily for 2 minutes with a normal toothbrush and water to exclusively evaluate the demineralization inhibition efficacy of banding cements.[8] This procedure was followed for a period of 90 days. After 90 days, all the specimens were removed from the solution. Each specimen was then mounted in a debond assembly and tested in an Instron Universal Testing Machine (Hounsfield, UK.) at a crosshead speed of 0.5 mm/minute in tensile mode.[9] The debond assembly consisted of a specially designed apparatus with stainless steel wire loops (0.7-mm thick and 14-inch long),[10] which engaged the prewelded Begg brackets on the buccal and lingual sides of the band and exerted the tensile stress at the band/cement/enamel interface, attached as the superior vise grip to remove the cemented bands. Each mounted tooth was clamped in a specially designed jig as the inferior vise grip of the instrument.[11]

Cement retention was measured as the force, in kilograms, required to fracture the band cement. Following the band removal, an assessment of the failure as cohesive or adhesive was made under the stereo-microscope. After each cemented band failed, the location of the failure was recorded and the failure site was graded as follows[3]:

- grade 0 = between the cement and enamel (adhesive failure);
- grade 1 = within the body of the cement (cohesive failure); and
- grade 2 = between the cement and stainless steel band (adhesive failure).

Once the tooth had been removed from the jig, the loop was removed from the band, and the band was cut and opened out to a flat tape.[11] A calibrated metallic scale was used to assess the length and breadth of the band, and the surface area of each band was calculated. The cements were carefully cleaned off the teeth, and each tooth was sectioned using a hard tissue microtome and examined under polarized light microscope to evaluate the depth and area of demineralized lesion. The extent of demineralization was numerically scored (0-4) using the histological scoring criteria proposed by Kidd et al.[12] as such:

- score 0 = no enamel demineralization or a narrow surface zone of opacity (edge phenomenon);
- score 1 = enamel demineralization limited to the outer 50% of the enamel;
- score 2 = demineralization involving the inner 50% of the enamel, up to the enamel-dentin junction;
- score 3 = demineralization involving the outer 50% of the dentin; and

score 4= demineralization involving the inner 50% of the dentin.

STATISTICAL ANALYSIS

Results were expressed as mean±standard deviation, range, and percentages. Kruskal-Wallis analysis of variance (**ANOVA**) was used for multiple group comparisons, followed by the Wilcoxon's rank sum test (Mann-Whitney test) for groupwise comparisons of the retention of adhesive banding cements. Categorical data was analyzed via the chi-square and Fisher's exact tests. For all tests, a *P*-value of .05 or less was considered statistically significant.

RESULTS

All groups, when compared with each other, showed statistically significant differences in retention values. The retention value of resin cement was the highest, followed by RMGIC, GIC, and group 1 (Table 1). Most of the experimental groups showed adhesive failure at the cement/band interface. Statistically significant differences were observed between the RMGIC and the resin groups, as none of the samples showed adhesive failure between teeth and cement in the RMGIC group, whereas 25% of samples showed adhesive failure between teeth and cement in the resin group (Table 2). Significant differences were noted in demineralization inhibition potential when groups 2 through 4 were compared to group 1. Two samples had enamel be chipped off during band removal and, consequently, were not included in the evaluation of the demineralization inhibition potential (Table 3).

DISCUSSION

The findings of the present study clearly show that resin cement has better retentive strength than RMGIC, followed by GIC and group 1. The results are comparable to previous studies.[1,13-15] This supports the notion that resin cement retention is superior to other adhesive banding cements and that RMGIC has a retentive strength superior to the conventional GIC and group 1, in which no

Table 1. Descriptive Statistics Showing the Means and Standard Deviations for Retention Values (kg/cm²) among the Various Experimental and Control Groups*

Group	No. of samples	Retention (kg/cm²)		Difference between groups†		
		Range	Mean±(SD)	Groups compared	Mean difference	*P*-value
1 (control)	12	0.14-1.02	0.38±0.24	1-2	4.21	<.01
2 (glass ionomer cement)	12	3.28-6.48	4.59±1.21	1-3	9.58	<.01
3 (resin-modified glass ionomer cement)	12	8.04-13.42	9.96±1.58	1-4	17.50	<.01
4 (resin cement)	12	12.55-21.22	17.88±2.36	2-3	5.37	<.01
				2-4	13.29	<.01
				3-4	7.92	<.01

* Kruskal Wallis analysis of variance, chi–square=43.9, P<.01; all the groups showed significantly different retention values in the decreasing order: Group 4>Group 3>Group 2>Group 1.

† Wilcoxon's Rank sum test (Mann–Whitney test).

Table 2. Descriptive Statistics Showing the Means and Standard Deviations for the Mode of Failure among the Various Experimental Groups

Group*	No. of samples	Failure mode		
		Adhesive (grade 1) N (%)	Cohesive (grade 2) N (%)	Adhesive (grade 3) N (%)
1 (control)	12	-	-	-
2 (glass ionomer cement)	12	2 (17)	3 (25)	7 (58)
3 (resin-modified glass ionomer cement)	12	0 (0)	5 (42)	7 (58)
4 (resin cement)	12	3 (25)	1 (8)	8 (67)

* Group 1 chi–square=5.56, P=.24; group 2 vs 3 chi–square=2.50, P=.29; group 2 vs 4 chi–square=1.27, P=.53; group 3 vs 4 chi–square=5.73, P=.05.

cement was used for banding. It also confirmed the finding that cementation is necessary for achieving adequate banding strength.

It is evident that the factor responsible for the greater retention shown by resin cement was the hybrid layer produced during impregnation, diffusion, and monomer polymerization into enamel previously etched by acid conditioners. RMGICs are notably superior to conventional GICs in mechanical properties. This is likely to be attributed to the ability of 2-HEMA to quickly balance the network flexibility after the curing of methacrylate groups bonded to polycarboxylate chains. According to Burgess JO, Barghi N, Chan DC, Hummert,[16] this is apparently due to the steric hindrance phenomenon that provides the stability and also can restrict the torsional bond angles.[16]

Table 3. Descriptive Statistics Showing Means and standard deviations for the Demineralization Inhibition Potential among the Various Control and Experimental Groups

Groups*	Demineralization observed		Total	Demineralization scores				
	Yes (%)	No (%)		0	1	2	3	4
1	7 (58)	5 (42)	12	5 (42)	6 (50)	1 (8)	-	-
2	2 (17)	10 (83)	12	10 (83)	2 (17)	-	-	-
3	2 (17)	10 (83)	12	10 (83)	2 (17)	-	-	-
4	1 (10)	9 (90)	12†	9 (90)	1 (10)	-	-	-

** Fisher's exact test: P>.04 for group 1 vs 2 and group 1 vs 3; P>.01 for group 1 vs 4; P=.10 for group 2 vs 3; and P=.60 for group 2 vs 4 and for group 3 vs 4.*

† Two samples were rejected due to enamel being chipped off during band removal.

In our study, most of the experimental group specimens showed adhesive failures between the cement and band interface, followed by the cohesive failures, and few specimens have shown the adhesive failure at the tooth/cement interface. Most authors believed that the adhesive fracture between the cement and the band is the most frequent yet favorable one,[3,11] because it leaves the cement on the tooth surface, which shows good adhesive bonding between the cement and the tooth. If this failure mode is seen in fluoride-releasing cements that leave cement in contact with enamel, it would offer the most protection against enamel decalcification.[3,17]

In our study, the second frequent type of failure seen in the GIC and RMGIC groups was cohesive failure. In a study by Norevall et al., it was reported that cohesive failure within the cement is an acceptable mode of failure.[18] In the present study, 2 group 2 specimens and 3 group 3 specimens showed adhesive failures between the teeth and cement, which is an unfavorable mode of failure. Three group 4 specimens showed adhesive failures between the teeth and cement, and 2 of these indicated enamel chipping. This could be attributed to the micromechanical retention followed by acid etching procedure done before cementation.[18] No group 3 samples showed this mode of failure, which shows a good adhesive bond between 2 surfaces.

Groups 2 and 3 showed significant demineralization inhibition potential owing to comparable fluoride release.[2,3,14,15,19-23] GICs can have a "burst effect," releasing more fluoride in vitro soon after their placement into the oral cavity.[7,23,25] Forsten[26] in 1991 proposed the concept that GICs can act as rechargeable fluoride release devices. Wood et al[27] compared zinc polycarboxylate and RMGIC in terms of demineralization inhibition potential. They found that, although both cements release fluoride into enamel, RMGIC shows less demineralization. This might be justified not only by the greater amount of fluoride released by RMGIC, but also by the amount of time each cement was in contact with enamel. RMGIC remains in contact with the enamel surface for a longer time because of its low dissolution properties or greater fracture resistance.[27] A few studies[28,29] have reported that RMGICs are potentially more cariopreventive than nonfluoride-releasing resin cements.

This study's results also confirm that resin cement showed significant demineralization inhibition potential comparable to GIC and RMGIC. Similar findings were reported by Moura et al.[30] This might be attributed to its excellent mechanical bonding to the tooth enamel and less microleakage.[31] Yet, it did show erosion of the enamel surface in some specimens in the present study during the debonding procedure, which is undesirable for banding in space maintainer therapy. There are studies, however, that suggest less demineralization inhibition property of resin cement vs GIC and RMGIC.[19,32]

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Resin-modified glass ionomer cement (RMGIC) cement is the best adhesive cement when compared to glass ionomer cement (GIC) and resin cement for banding space maintainers. This conclusion is drawn from the fact that the RMGIC group had shown significantly high bond strength, more favorable modes of failure, and good demineralization inhibition potential.
2. The resin cement group showed the highest bond strength, followed by the RMGIC, GIC, and control groups, respectively. Although the resin cement group showed the highest bond strength, it also showed the chipping of the enamel from some specimens during the debonding procedure, which was its main drawback as a luting cement for space maintainers.

3. The conventional GIC and RMGIC groups had shown adequate demineralization inhibition potential, but the retentive bond strength of conventional GIC was comparatively less than that of RMGIC.

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