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Research Article

The Antibacterial and Shear Peel Bond Strength Properties of Different Dental Luting Cements

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Abstract

Aim: The purpose of this *in vitro* study was to compare the shear peel bond strength of four different kinds of dental luting cements [Conventional Glass Ionomer Cement (CGIC), Resin Modified Glass Ionomer Cement (RMGIC), Glass Carbomer Luting Cement (GCC) and Dual Cure Resin Cement (RC)] and assess the remnant and antibacterial characteristics.

Methods: In the shear peel bond strength test part of the study, stainless steel bands were cemented to 80 extracted permanent molar teeth randomly by using one of four tested cements (20 per group). The force needed for debonding was evaluated by using a universal testing machine. After the debonding test, Adhesive Remnant Index (ARI) was applied. The antibacterial effect of the cements on the selected bacterias (*S. mutans* and *C. albicans*) were tested with agar diffusion test.

Results: RC showed the highest and GCC showed the lowest shear peel bond strength among all luting cements. As for the antibacterial effects, the RMGIC cement group was the only cement which showed antibacterial effect on *C. albicans*. All cements showed some antibacterial effect on *S. mutans*; however, GCC didn't show any antibacterial effect on *S. mutans* and *C. albicans.*

Conclusion: The findings show that different types of luting cements may be preferred according to the characteristics of the individual.

Keywords: Glass Ionomer Cement; Shear Peel Bond Strength; Glass Carbomer; Dual Cure Resin Cement; Adhesive Remnant Index (ARI)

Abbreviations

CGIC: Conventional Glass Ionomer Cement; GCC: Glass Carbomer Cement; RMGIC: Resin Modified Glass Ionomer Cement; RC: Dual Cure Resin Cement

Introduction

Pediatric dentists should manage the developing dentition by preventing space loss in the arches, due largely to the dental caries and early tooth extraction. For this purpose the use of space maintainers (SMs) are essential following premature tooth loss [1]. SMs are most commonly used for maintain the space created by early loss of a first or secondary primary molar and classified as fixed or removable appliances. The band and loop SM is the most common type of SM used in the case of premature unilateral loss of a primary molar [2].

Conventional Glass ionomer cements (CGIC) have become the most commonly used cement for fixed SMs, because of their favorable properties like adhesion to enamel, releasing fluoride ions and showing antibacterial effects. Despite its advantages, CGIC are technically sensitive for moisture contamination during their early setting reaction and they can reach the maximum bond strength after only 24 hours [3,4].

In order to overcome clinical drawbacks of CGIC, different types of luting cements have been recommended to cement bands to teeth. Resin modified glass ionomer cement (RMGIC) and dual cure resin cement (RC) are among the recommended ones, each having particular pros and cons. Recently, a newly developed material named "glass carbomer cement (GCC)" gained popularity in the dental market. This is a new generation of restorative material originating from glass-ionomer cements with the claim of possible gradual mineralization into fluorapatite. The material is in the form of luting agent, restorative and sealant [5].

Among the variety of several luting materials, the clinician should evaluate the potential need for antibacterial activity over retention or vice-versa. Thus, every material would serve for specific purpose on selected cases. To date, there is no documented comparative evaluation of shear peel bond strength of GIC, GCC, RMGIC and RC.

Aim of the Study

The aims of the present study were to compare; four different type of luting cements' shear peel bond strength and evaluate the amount of cement remaining after debanding and compare antibacterial effects on *C. albicans* and *S. mutans.*

Materials and Methods

This study was approved by Baskent University Institutional Review Board and Ethics Committee (Project no: D-KA16/02) and supported by Baskent University Research Fund. Shear peel bond strength was tested on molar bands, which were luted on 80 extracted human third molars free of hypoplastic enamel, cracks, caries or restoration. The teeth used in the present study was extracted for orthodontic reasons and the patients gave consent to use their teeth for research purposes. The teeth were stored in distilled water until the tests and were randomly assigned to receive a molar band luted with one of the cements as follows:

- Group 1: Conventional Glass Ionomer Cement (Ketac-Cem, 3M ESPE, St. Paul, USA)
- Group 2: Resin Modified Glass Ionomer Cement (Unitek Multicure Glass Ionomer Orthodontic band cement, 3M Unitek, Monrovia, USA)
- Group 3: Glass Carbomer Luting Cement (Glass Carbomer Products, Leiden, Netherlands)
- Group 4: Dual Cure Resin Cement (Rely X, 3M ESPE, USA)

Teeth were embedded in acrylic resin blocks. The same operator selected molar bands for each tooth. A 0.9 mm (0.036 inch) stainless steel wire was attached to the mid-buccal and mid-lingual side to the molar bands. The modified bands were adapted and cemented with adhesive cements according to manufacturer's instructions. CGIC group was allowed to set for 10 minutes. The GCC group was cured by Led Heat Cure Lamp (GCP dental carbo led CL-01, product no. 108.001, GCP Dental b.v. The Netherlands) for 60 seconds with 60 degree. RMGIC group was cured with a quartz tungsten photopolymerization device (Optilux 501, Kerr; Danbury, CT, USA). RC group was cured with a Elipar S10 photopolymerization device (3M Espe, Seefeld, Germany).

The specimens were then transferred to store at 37°C in 100% humidity for 24h, and they were subsequently tested for shear peel bond strength.

Shear-Peel Bond Strength Test

The teeth with the molar bands cemented were subjected to the shear peel bond strength test using a universal testing machine (Figure1) (UTM 8874) with a load cell of 200 kgf and a crosshead speed of 0.5 mm/min at Baskent University Faculty of Engineering Laboratories. The load required to dislodge the molar bands was recorded and converted to MPa/mm^2.

Figure 1: A specimen set-up in the Instron testing machine for a shear-peel bond strength test.

Adhesive Remnant Index Scores

After the debanding procedure, samples were visually assessed under 4X magnification by one investigator and were classified with a modification of the Adhesive Remnant Index (ARI) established by Artun and Bergland [6]. The scoring was as follows: $^{(0)}$ no cement remains on the tooth surface; $^{(1)}$ less than half the crown surface under the band is covered by cement; $^{(2)}$ more than half the crown surface under the band is covered by cement; $^{(3)}$ the entire crown surface under the band is covered by cement.

Agar Diffusion Test

Microbiologic evaluation was performed at Başkent University Microbiology Laboratories. *Streptococcus mutans* (ATCC 35668) and *Candida albicans* (ATCC 10231) strains were cultured in brain-heart infusion broth (BHIB) (BHI™- Difco Laboratories, Detroit, MI, USA) for 24 hours. The bacterial colonies were taken from the broth cultures and adjusted to 0.5 McFarland standard. Brain heart infusion agar was used for diffusion test. About 15 ml of Brain heart infusion agar was spread evenly to a thickness of 5 mm in petri dish and after solidification it was swabbed with the bacteria suspension. 5 mm diameter and 2 mm depth wells were made in agar plate with agar punchers. Four different materials were tested at separate plates for each microorganism and in each plate required distances from the edge of the plate and between each other were kept. These wells were filled with the test medicaments or sterile distilled water (as negative control), and incubated at 37°C for one week. Zones of inhibition were measured across the diameter with a transparent ruler and recorded at 1st, 3th and 7th days. The tests were repeated five times for all strains.

All the procedures were carried out under aseptic conditions in a laminar airflow chamber.

Statistical analysis

Data analysis was performed by using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, United States). Normality in distributions of continuous variables were determined by Kolmogorov Smirnov test. Homogeneity of variances were tested with Levene test. The continuous variables were shown as mean ± SD or median (IQR), otherwise, number of cases and percentages were used for categorical data.

The mean differences among groups were compared by One-Way ANOVA. Kruskal Wallis test was applied for comparisons of the medians. When the p value from One-Way ANOVA or Kruskal Wallis test statistics are statistically significant post hoc Tukey HSD or Conover's non-parametric multiple comparison test were used to determine which group differ from which others. Categorical data were analyzed by Pearson's Chi-square or Fisher's exact test, where applicable.

Regarding the Agar diffusion test, the possible differences among 1st, 3rd and 7th day diameter measurements were evaluated by Repeated Measurements of ANOVA. When the p-value Wilks Lambda test are statistically significant, Bonferroni Adjusted multiple comparison test was utilized to know which measurement time differ from which others.

Results

The descriptive and comparative statistics of shear peel bond strength for the tested luting cements are presented in table 1. The highest bond strength value was recorded for the RC (Rely X; 1.837MPa) (p = 0,002), whereas the lowest bond strength value was recorded for the GCC (0,972 MPa) (p = 0,042). There was no statistically difference between CGIC and RMGIC (p > 0,05).

Cement	N	Mean (MPa)	Std. Dev.	Median	Int. Range	Min	Max
Ketac-Cem	20	1,20340(a)*	,363194	1,19050	,518	,453	1,752
Unitek Multicure Glass Ionomer	20	1,19230(a)	,329026	1,17550	,407	,677	1,971
Glass Carbomer	20	,97275(b)	,423358	,94450	,518	,251	2,096
Rely X	20	1,83785(c)	,666419	1,65300	1,153	,828	3,252

Table 1: Shear Peel Bond Strength values for tested materials.

*Different letters indicate significant difference (P < 0.05). Lower-case letters indicate differences in vertical directions

The group cemented with CGIC showed a higher prevalence of ARI score ''1'', whereas, the groups cemented with RMGIC, GCC and RC showed a higher prevalence of ARI score ''0''.

The results of the microbiological analysis are presented in table 2. On the 1st, 3rd and 7th day; CGIC, RMGIC and dual cure resin cement's antimicrobial effect on streptococcus mutans was statistically higher than glass carbomer cement's group.

Cement	Time	n	Mean (mm)	Std. Deviation	Std. Error	95 % Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Ketac-Cem	1st day	5	14,6 a	2,966	1,326	10,9	18,28	10	18
	3rd day	5	19,6 a	6,767	3,026	11,19	28	10	25
	7th day	5	19,6a	6,767	3,026	11,19	28	10	25
Unitek Multicure Glass Ionomer	1st day	5	23b	2,345	1,048	20,08	25,91	21	27
	3rd day	5	32 b	3,701	1,655	27,6	36,79	26	35
	7th day	5	33,2 b	4,711	2,107	27,34	39,05	25	37
Rely X	1st day	5	16,8 a	4,604	2,059	11,08	22,51	14	25
	3rd day	5	20 a	8,185	3,660	9,83	30,16	13	32
	7th day	5	20,2 a	11,432	5,112	6,004	34,39	10	38
Glass Carbomer	1st day	5	0 c	0	0	0	0	0	0
	3rd day	5	0 c	0	0	0	0	0	0
	7th day	5	0 c	0	0	0	0	0	0

Table 2: The mean values of the inhibition zones of the tested materials in mm on S. mutans.

*Different letters indicate significant difference (P < 0,001). Lower-case letters indicate differences in vertical directions

The only antibacterial effect for *C. albicans* was showed by RMGIC group (Table 3).

Time	N	Mean (mm)	Std. Deviation
1st Day	5	26,0000 (a)*	2,34521
3rd Day	5	18,2000 (a)	4,91935
7th Day	5	13,4000 (b)	2,07364

Table 3: Inhibition zones (in mm) of Resin Modified Glass Ionomer Cement on *C. albicans* for different times .
*Different letters indicate significant difference (P < .05). Lower-case letters indicate differences in vertical directions

Discussion

Conventional glass ionomer cement is most widely accepted cement material for molar band cementation due to its advantages such as adhesion to both enamel and metal as well as fluoride uptake and release. Despite these advantages, it is clinically sensitive to moisture and this disadvantage makes CGIC more fragile under occlusal loads [7,8]. Additionally, an ideal cement should provide a reliable bond between different subtracts and compressive and tensile fracture strengths during clinical use [9].

Literature provides data regarding the shear peel bond strength of CGIC in comparison with some other cements excluding GCC [7,8,10,11]. Previous studies that evaluated the shear peel bond strength between CGIC and RMGIC showed that RMGIC has higher physical and mechanical properties than CGIC [12,13]. In the current study, the results of shear peel bond strength test show contrast to the previous studies as there was no statistical difference between RMGIC and CGIC, as shown in Cantekin., *et al*'s study [14].

Glass carbomer cement is a new material in dentistry. In previous studies GCC, as a restorative, showed high shear peel bond strength to enamel [15], low microleakage [16,17], and biocompatible properties [18]. In the present study glass carbomer luting cement was tested and the material demonstrated lowest shear peel bond strength compared to RMGIC, CGIC and RC. This result likely occurred because the mechanical properties differ between glass carbomer luting cement and glass carbomer restorative material. On the other hand, the results obtained herein are not sufficient to dispute the literature due to the scarcity of data regarding this material. Additional studies are needed concerning the modes of action of this new luting cement.

In this study, Rely X cement was used as a resin cement. Lara Orsi., *et al.* [19] compared four different types of luting cements: Rely X, Panavia F, Zinc Phosphate and CGIC. The shear peel bond strength of Rely X obtained in the present study was 1.837 MPa/mm^2, which is very similar with previous results.

Although laboratory studies are required for testing physical and mechanical properties, they still have several limitations. Ideal study designs to test a material include mechanical, thermal, chemical and microbiological factors at the same time in order to mimic intraoral conditions. This was not possible in the present study. Microbial test was conducted only on two selected bacteria, which is not the case in the mouth. In addition, literature supports that there might be nonhomogeneous forces with shear peel bond strength tests which lead to cohesive fractures in cement material itself [20]. Thus, the findings can be analyzed incorrect and may lead to lower results than expected [21].

In previous studies, the site of cement failure was shown to occur at the band cement interface with CGIC and the enamel cement interface with RMGIC [22]. These findings are consistent with the results obtained herein. In the present study, the bands cemented with CGIC mostly had an ARI score of "1" indicating that bond failure mostly occurred at the band-cement interface. Most of the bands cemented with RMGIC, Rely X, GCC, had an ARI score of "0" which means that bond failure occurred predominantly at the enamel-cement interface. This situation indicates that glass ionomer cements which includes resin bond to the enamel with lower chemical adhesion than conventional glass ionomer cement when enamel pretreatment is not performed. Thus, one can hypothesize that lower chemical bonding can allow more microleakage and white spot lesions. However, in previous studies no significant differences were shown between CGIC and RMGIC regarding white spot lesions occurrence [23].

Maintaining hygiene around the SM during treatment is important, due to the difficulty in preventing plaque accumulation around the bands [24]. Additionally, unfavorable chemical properties of luting materials that have been used for band cementation such as high solubility in oral fluids and low bond strengths, may contribute to demineralization beneath the bands [25,26]. At this point, antimicrobial properties of luting cements come into question.

In the present study, the antibacterial effects of GIC, RMGIC, Rely X and GCC were tested on two microorganisms: *S. mutans* and *C. albicans*. CGIC, Rely X and RMGIC showed antibacterial effect on S. mutans. RMGIC was the only luting cement that showed antibacterial effect on *C. albicans*. On the contrary, GCC didn't show any antibacterial effect on any of the bacteria.

When bonding performance is considered, Rely X cement showed higher retention strength than other cement types. On the other hand, the material is lacking any antibacterial effect on *C. albicans*. RMGIC showed lower retention than Rely X cement but showed higher retention than GCC. At the same time, the material was the only cement type that showed antibacterial effect on *C. albicans* and *S. mutans* both. The research shows that RMGIC is more suitable for patients with high caries risk.

Further studies would provide additional data for the clinicians to make an appropriate luting material selection for specific cases. Clearly, a prospective clinical trial is ideal for comparing cements. *In vitro* studies such as the present one could offer high retention rates with resin cements; however, the needs of patients with higher caries risk are different from the ones under going orthodontic treatment and with a good oral hygiene [27,28].

Conclusion

1. Rely X cement showed statistically significant higher shear peel bond strength than RMGIC, GCC, CGIC.
2. GCC showed lowest shear peel bond strength and also, didn't show any antibacterial effect on *S. mutans* and *C. albicans*.
3. RMGIC showed highest antimicrobial effect on *S. mutans* and was the only cement type which showed antibacterial effect on *C. albicans*.

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