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Comparison of Bracket Failure with Resin Modified Glass Ionomer Cement and Resin-Based Adhesive

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ABSTRACT

A high strength of bonding materials is needed for orthodontic attachments to sustain therapeutic forces and patients' masticatory habits. **Objectives:** To compare the bond strength of the resin modified glass ionomer cement (RMGIC) and resign based adhesive system which leads to bracket failure in orthodontic treatment (failure to bracket attachment) for the duration of 6 months at the a tertiary care hospital at Hyderabad, Sindh Pakistan. **Methods:** This comparative cross-sectional study involved 30 patients, each with 20 brackets, using non-probability sampling. Participants were between the ages of 13 and 30 with fully erupted permanent teeth and mild skeletal discrepancies. Quadrants were randomized, and 120 attachments were placed in total, split evenly between the two types of materials. The study involved bonding orthodontic brackets using either composite resin or RMGIC. The teeth were prepared and cleansed, and the brackets were bonded following standard procedures. Patients were monitored each month for six months (six visits) to check for any debonded or missing brackets. Chi-Square test was run to compare bracket failure between two groups. **Results:** There were significant differences in bracket failure rates between the composite and RMGIC sides. Composite had a lower failure rate, with 90% of brackets remaining intact compared to 63.3% with RMGIC (p=0.04). Gender comparisons showed both male and female participants experienced more failures with RMGIC than with composite, with p-values of 0.039 and 0.038, respectively. **Conclusions:** RMGIC could not withstand the forces experienced during fixed appliance treatment as effectively as composite resin, resulting in a higher debonding rate.

INTRODUCTION

Orthoodntic brackets are used to achieve tooth movement for correction of malocclusion [1, 2]. Various materials are used for bonding brackets to the enamel surface, with composite being the most commonly used [3]. Although its bonding strength is acceptable for clinical practice, it does not have a fluoride-releasing effect. Orthodontic brackets, along with archwires, create a network that results in plaque retention and white spot lesions. Glass ionomer cement (GIC) was introduced for its fluoride-releasing properties, but it has low strength for orthodontic bonding purposes [4]. This GIC was modified by adding composite to form a hybrid material called resin-modified GIC (RMGIC) [5, 6]. Ideally, the material should provide a constant, low concentration of fluoride in the mouth for continuous protection, reducing reliance on patient compliance [7]. White spot lesions and enamel surface loss due to etching and adhesive removal have become more common after bracket debonding with composite. Glass ionomer cements (GIC) release fluoride, resulting in fewer white spot lesions and easier debonding due to their weak bond strength [8]. Fluoride is known for its anti-cariogenic effect. Resin-modified glass ionomer cements (RMGIC) combine the benefits of conventional GIC and resin properties, offering less moisture sensitivity and higher strength [9]. RMGIC can be a good alternative to composite for orthodontic bonding, as they do not require

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etching or conditioning [10-12]. One study showed that the failure rate with RMGIC and NaOCl as 15%, while with Trans bond XT was 4% [13].

The study aimed to evaluate the failure rate of orthodontic brackets bonded with resin-modified glass ionomer cement (RMGIC) using sodium hypochlorite (NaOCl) enamel conditioning in comparison to brackets bonded with conventional composite resin. The rationale is that while in-vitro comparisons between RMGIC and composite resin exist in the literature, only one study has examined their failure rates in vivo. RMGIC's fluoride release can prevent enamel demineralization and cariogenic activity, especially significant for orthodontic patients who are at risk of food stagnation. The study seeks to provide insight into the clinical performance of RMGIC in preventing demineralization and its impact on bracket failure rates, filling a gap in existing research specific to the study's population. To compare the bond strength of the resin modified glass ionomer cement t(RMGIC) and resign based adhesive system which leads to bracket failure in a orthodontic treatment (failure to bracket attachment) for the duration of 6 months at the a tertiary care hospital at Hyderabad, Sindh Pakistan.

METHODS

This comparative study was conducted in the Orthodontic Department at Liaquat University of Medical & Health Sciences Jamshoro/Hyderabad from November 2020 to October 2021 using a non-probability sampling technique. A total sample size of 120 attachments (with each of the 6 patients having 20 brackets) was calculated using the WHO calculator, based on a failure rate of 15% for RMGIC (P1) and 4% for composite resin (P2). The calculation maintained a 5% level of significance and 80% test power. However, to meet normality assumptions, the study included 30 patients [12]. Ethical approval was obtained from the Ethical Review Committee at LUMHSJamshoro/Hyderabad (LUMHS/ REC 914). Written informed consent was obtained from participants and their parents (for those under 16 years old). The inclusion criteria were both male and female subjects with fully erupted permanent teeth, enamel free from buccal enamel defects, restorations, veneers, or crowns, and normal to mild skeletal discrepancies. The eligible participants must be between the ages of 13 and 30. In contrast, the exclusion criteria disqualify individuals with systemic diseases, trauma, mild to severe skeletal issues, and mental disabilities. Participants with severe periodontal disease, facial and skull abnormalities, or para-functional behaviors are also excluded. Additionally, those requiring surgical correction or growth augmentation are not eligible for the study. Quadrants were randomized using lottery method in each patient and total 120 attachments were placed (60 bonded with each type of materials). Both cements were used to bond the orthodontic brackets to the teeth. Initially, the teeth were cleansed with abrasive slurry for 5 seconds and then etched with 37% phosphoric acid for thirty seconds. After rinsing and air drying the teeth until a frosty enamel surface was visible, the teeth were prepared for composite resin by curing the surface with a curing light. Stainless steel brackets were held with tweezers and a thin layer of composite resin was evenly applied to the mesh surface of the bracket base. The bracket was then placed on the tooth surface in an occluso-gingival, mesio-distal order with proper angulation. The brackets were compressed onto the enamel surface, excess adhesive was removed, and the surface was cured for 20 seconds using a blue spectrum dental curing light on both the distal and mesial sides of the brackets. For bonding RMGIC, the adhesive was hand-mixed. The tooth was etched, washed, and dried using a cotton roll, similar to the composite bonding procedure. A cotton roll was also used to moisten the tooth surfaces after they had dried. Moisture was essential for optimal binding strength. Since the setting period was short, the adhesive was prepared for two brackets at a time. The brackets bonded with RMGIC were allowed to set for 10 minutes. RMGIC brackets were bonded first, followed by composite bonding, to save time and ensure adequate strength. Bracket retention was measured by tallying the number of brackets that had come loose in each group. Patients were monitored for six months, with monthly follow-up visits every 30 days to check for any brackets that had deboned or were missing. The data were analyzed using the computer software "Statistical Package for Social Sciences Version 23.0. Qualitative variables such as gender, occupation, and ethnicity were summarized using frequency and percentage. The mean and standard deviation were computed for quantitative variables like age. Effect modifiers such as gender were controlled through stratification. After stratification, a Chi-Square test ($\chi 2$) was applied with a significance level of <0.05.

RESULTS

The mean age was 19.95 years, with a standard deviation of 4.11 years. The age ranged from a minimum of 13 years to a maximum of 30 years. The frequency of gender and age group in a sample of 30 participants is displayed. The gender distribution was 12 male (40.0%) and 18 female (60.0%). Regarding age groups, 15 participants (51.7%) were aged 13-18 years, 10 participants (33.3%) were aged 18-23 years, and 5 participants (13.7%) were aged 24-30 years (Table 1).

Table 1: Frequency of Gender and Age Group *n(%)

Variables	Characteristic	n= 30
Gender	Male	12 (40.00)
	Female	18 (60.00)
Age group (years)	13-18	15 (51.67)
	18-23	10 (33.33)
	24-30	5 (13.67)

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Table 2 presents the comparison of bracket failure rates for composite and RMGIC sides over a six-month period. Bracket failure was absent in 27 (90%) composite cases and 19 (63.3%) RMGIC cases, with a p-value of 0.04. Bracket failure was present in 3 (10%) composite cases and 11 (36.7%) RMGIC cases. The p-value of 0.04, calculated using Fisher's exact test, indicates a statistically significant difference in bracket failure rates between the two materials.

Table 2: Comparison of Bracket Failure of Composite and RMGIC Side during Six Months

Bracket Failure	Composite, n = 30	RMGIC, n = 30	p-value*
Absent	27 (90%)	19 (63.33%)	0.04
Present	3 (10%)	11 (36.7%)	

*n(%), *Fisher exact test

Table 3 shows the comparison of bracket failure rates for composite and RMGIC sides during a six-month period, categorized by gender. In male participants (n = 12), bracket failure was absent in 11 (91.7%) composite cases and 8 (66.7%) RMGIC cases, with a p-value of 0.039. Failure was present in 2 (9.4%) composite cases and 4 (33.4%) RMGIC cases. In female participants (n = 18), bracket failure was absent in 17 (94.4%) composite cases and 11 (61.1%) RMGIC cases, with a p-value of 0.038. Failure was present in 1 (5.6%) composite case and 7 (38.9%) RMGIC cases. Both male and female groups showed a significant difference in bracket failure rates between the composite and RMGIC sides.

Table 3: Comparison of Bracket Failure of Composite and RMGIC Side during Six Months by Genders

Gender	Bracket Failure	Composite	RMGIC	p-value*
Male (n=12)	Absent	11 (91.6%)	8 (66.66%)	0.039
	Present	2 (9.4%)	4 (33.44%)	
Female (n=18)	Absent	17 (94.44%)	11 (61.11%)	0.038
	Present	1 (5.55%)	7 (38.88%)	

*n(%), *Fisher exact test

DISCUSSION

Our results show a statistically significant difference in bracket failure rates between the composite and RMGIC sides over a six-month period. Bracket failure was more common with RMGIC than composite (p=0.04). When comparing bracket failure rates by gender, the failure rate was higher with RMGIC than with composite in male (p=0.039). Similar results were found in female (p=0.038). This indicates that composite is superior to GIC in both genders over a six-month period. The literature shows that conventional GIC is not suitable for regular orthodontic bonding due to its weak strength and durability. However, RMGIC has higher bonding strength due to the addition of resin, making it a more promising option in orthodontics [14]. Though RMGIC may still have lower bonding strength than resin composite systems, in vitro studies show that current RMGICs perform well for bonding brackets in orthodontics. Studies report that satisfactory adhesion and mechanical stability can be achieved with RMGIC in orthodontic treatments [15-17]. Justus *et al.*, explored whether treating human dental enamel surfaces with 5.25% sodium hypochlorite (NaOCl) before etching would improve orthodontic bracket shear bond strength (SBS) using either a composite resin or a resin-modified glass ionomer cement (RMGIC) [18]. Their in vitro study concluded that NaOCl use resulted in similar bracket bond strength between Fuji Ortho LC and Transbond XT, suggesting that fluoride-releasing RMGICs might be viable for bonding brackets to minimize white spot lesions. In contrast, the present study, which is conducted in vivo, found that conventional composite resin outperformed RMGIC in terms of success rate, particularly in the upper arch. Clinical bond strength values may be influenced by various forces acting on brackets, such as occlusal interferences and masticatory forces. It is important to recognize that the methodology in these studies compares two adhesive systems and may not apply universally to all patients. Therefore, the findings should be approached cautiously and tailored to each patient's individual needs and aesthetic preferences [19, 20].

CONCLUSIONS

Resin-modified glass ionomer cement cannot withstand the typical forces experienced during fixed appliance treatment and has a higher debonding rate compared to composite resin.

Authors Contribution

Conceptualization: AJ, MA
Methodology: SRS
Formal analysis: MSK, JT
Writing, review and editing: AHS

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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