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Original Research

Evaluation of microleakage and fracture resistance of various restorative materials in class-1 cavities: An original research

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ABSTRACT:

Background: The intense development of adhesive restorative materials and patients preferences for esthetic restorations prompt clinicians to use alternative restorative materials for molars. Amalgam, however, is the choice of material when it comes to occlusal stress bearing areas, either in primary or permanent molars. To overcome the drawbacks of amalgam and restorative adhesive alternative restorative materials are used and comparison is done between various restorative materials. **Aims**: To evaluate microleakage and fracture resistance of various restorative materials in Class-1 cavities. **Material and Methods**: An in vitro study on 60 caries-free molars were randomly divided into two equal groups for the evaluation of microleakage and fracture resistance. Class I cavities for microleakage and fracture resistance study prepared on 60 samples and randomly divided into three equal groups. Group I received composite resins, Group II received bonded amalgam, and Group III received high copper amalgam. The microleakage was viewed under a stereomicroscope. The fracture resistance was evaluated using a universal testing machine. **Results**: Bonded amalgam exhibited minimum microleakage, when compared to amalgam and composite resin and was found to be statistically insignificant (P = 0.203), while amalgam showed better fracture resistance compared to bonded amalgam and composite resin. It was found to be statistically insignificant (P = 0.144). **Conclusions**: Bonded amalgam appears to be comparable to amalgam when microleakage is considered and to composite resin when fracture resistance is considered; hence, bonded amalgam can also be an alternative material to amalgam in molars.

Keywords: Composite Resins, bonded amalgam, amalgam, microleakage, fracture resistance

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INTRODUCTION

In recent years, resin-based composite materials have been widely used in restorative dentistry. The popularity of these restorations has increased because of a demand for cosmetic, tooth-colored restorations and a decreased acceptance of traditional amalgam by the patients. Although there is an evidence of decrease in the use of amalgam in the dental practice, the cost of amalgam, durability, and ease of manipulation have persuaded many dentists to continue to use it as their first choice for restoring posterior teeth. To overcome the disadvantages of amalgam and reap the benefits of bonding the composite, the concept of bonded amalgam was introduced in 1976 by Zardiackas. This technique involves adhesive systems that reliably bond to enamel and dentin. The new high-copper single composition alloys offered superior properties in terms of high compressive strength, excellent wear resistance, and low technique sensitivity due to reduced or eliminated gamma-2 phase. Resin composites have improved greatly since their introduction and are now the materials of choice for most of the restorations. Despite recent dramatic improvements in the technology of composite resins and their adhesive systems, polymerization shrinkage, which occurs as the material cures, remains a major problem. This shrinkage pulls the restorative material away from the cavity walls, resulting in rupture of the adhesion and the formation of marginal gaps. These gaps cause postoperative sensitivity, discoloration and secondary caries at the restoration interface, and pulpal pathology, eventually leading to failure of the restorations. Composite resins rivalled amalgam because of their esthetic properties and adhesiveness to tooth structure with good wear properties. However, they are highly sensitive to technique resulting in the need to control correct indication and good isolation. The choice of the right composite for each situation, use of a good procedure for bonding to the dental tissue, and proper curing are essential. The major drawbacks of composite resins are polymerization shrinkage and secondary caries that may be difficult to diagnose. Bonded amalgam restorations have the advantages of reduced need for mechanical retention and conserves sound tooth tissues. This procedure helps to restore tooth integrity and assist in the improvement of the marginal seal with potentially less sensitivity. The co-existence of anti-amalgam campaign and the increased demand for tooth-colored restorations in children has influenced the clinicians in their choice of restorative materials in primary molar restorations, instead of the scientific evidence and clinical performance of restorative materials. The aim of this study is to evaluate microleakage and fracture resistance of bonded amalgam, amalgam and composite resins in molars.

MATERIAL AND METHODS

An in vitro study was carried out after obtaining the required ethical clearances from the Institutional Review Board, 60 caries free molars without any developmental defects were selected and stored in saline for a maximum period of one month to conserve the integrity of the surfaces to be bonded. The selected samples were randomly divided into two equal groups for the evaluation of microleakage and fracture resistance.

a) Evaluation of microleakage

In the cervical third on buccal surface of each sample were selected for Class V cavity preparation. The cavity of approximately 4.0 mm × 3.0 mm × 2.5 mm was prepared to standardize the cavity design and randomly divided into three equal groups.

The groups were:

i. Group I: Composite Resins restorations
ii. Group II: High copper amalgam restorations
iii. Group III: Bonded amalgam restorations.

The cavities in Group I were etched using 37% phosphoric acid, then rinsed, and air dried. The bonding agent was applied and restored with posterior hybrid composite material. The restorations were allowed to dry for 5 min before storing them in tap water for 24 h to prevent dehydration. The cavities in Group II received a varnish application and the condensation of high-copper amalgam. The cavities in Group III were etched for 15 s by using 37% phosphoric acid, rinsed, lightly dried to a moist surface followed by the application of PQ1 amalgam adhesive with an applicator tip. The adhesive was rubbed into the dentin for 15 s, air thinned and light cured for 20 s followed by condensation of the high-copper amalgam. After 24 h, the samples were air dried and coated with nail varnish (four to five times) except for an area of 1 mm, surrounding the restored cavities to prevent dye penetration from unnecessary focuses. The samples were immersed in a 2% basic fuchsine solution for 24 h. After the dye penetration, the samples were sectioned longitudinally in a buccolingual direction at the center of the restored cavity and examined under a stereomicroscope, equipped with a 10X objective and 2X zoom lens. Photomicrographs were taken using a Sony digital camera, set to 2X zoom. Photos were analyzed in the Image Pro Express by Media Cybernetics LP, USA, version 4, which is used with Windows software. Calibration and measurement standardization were done. Microleakage in the materials tested are summarized in [Table 1].

	Amalgam	**Bonded Amalgam**	**Composite Resins**
Mean	63.3083	63.6180	106.9033
Maximum	141.36	88.36	280.25
Minimum	28	44.72	64.12
Standard Deviation	42.86	16.50	66.20
Co-Efficient Of Variation	0.67	0.26	0.6

b) Evaluation of fracture resistance

Standardized mesio-occluso-distal (MOD) cavities of 1 mm occlusal isthmus, 2 mm occluso pulpal height of occlusal portion, and 1 mm mesio distal depth of the gingival seat were prepared and were randomly divided into three equal groups.

The groups were:

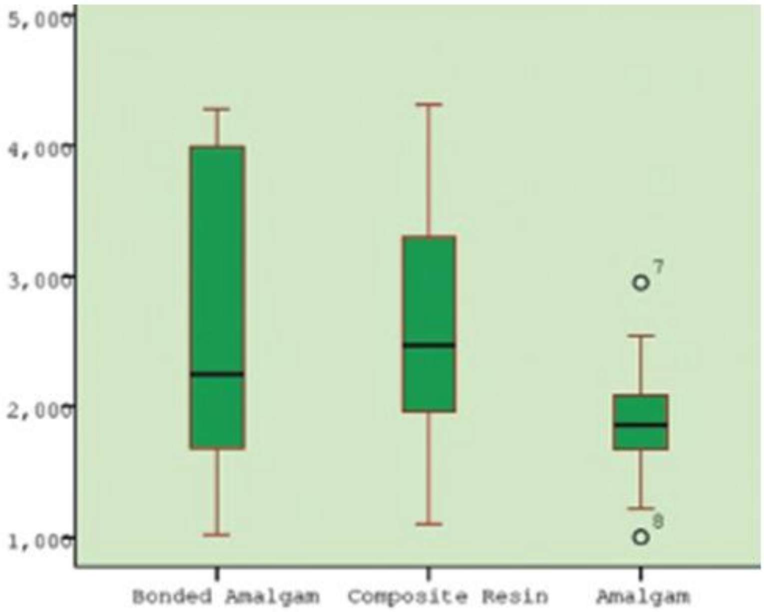
i. Group I: Composite restorations
ii. Group II: Bonded amalgam restorations
iii. Group III: High copper amalgam restorations.

The MOD cavities in Group I were etched by using 37% phosphoric acid, then rinsed, and air dried. The bonding agent was applied and restored with posterior hybrid composite material. The restorations were allowed to dry for 5 min before storing them in tap water for 24 h to prevent dehydration. The MOD cavities in Group II were etched for 15 s by using 37% phosphoric acid, then rinsed, lightly dried to a moist surface followed by the application of PQ1 amalgam adhesive, by using an applicator tip. The adhesive was rubbed into the dentin for 15 s, air thinned, and light cured for 20 s followed by condensation of high-copper amalgam. The MOD cavities in Group III received a varnish and condensation of high-copper amalgam. After 24 h, the samples were removed from the water and air dried, then the samples were subjected to fracture resistance using a universal testing machine. The testing rod touched only the buccal and lingual cusps, not the restoration, until the fracture occurred.

RESULTS

Microleakage was evaluated by measuring the depth of dye penetration in microns. 70% of the samples in the amalgam group exhibited microleakage ranging from 28.0 to 141.36 microns. 60% of the samples in the bonded amalgam group exhibited microleakage ranging from 44.72 to 88.36 microns. 85% of the samples in the composite group exhibited microleakage ranging from 64.12 to 280.25 microns.

The force required to cause the fractures in the restorations was recorded in Newton. It was noticed that fracture resistance in the samples restored with amalgam was more consistent, when compared to the samples restored by using bonded amalgam and composite resin [Graph 1].



Statistical analysis was done by ANOVA test. Bonded amalgam exhibited minimum microleakage compared to amalgam and composite resin and was found to be statistically insignificant (P=0.203). While amalgam showed better fracture resistance compared to bonded amalgam and composite resin that was also found to be statistically insignificant (P=0.144).

	Sum of Squares	DF	Mean Square	F	Significant
Between Groups	9347.204	2	4673.602	1.753	0.203
Within Groups	45,329.483	17	2666.440		
Total	54,676.687	19			

DISCUSSION

Amalgam has remained as the material of choice for direct restorations of posterior teeth, despite facing the controversy. When esthetic concerns are paramount, meticulously placed, tooth-colored materials provide an acceptable alternative. All alternative restorative materials and procedures, however, have certain limitations. The older generation of low-copper amalgams exhibited a limited life span as they contained the gamma-2 phase that caused progressive weakening of the amalgam through corrosion. High-copper amalgams provide satisfactory performance for longer periods and do not appear to require polishing after placement, as was recommended for low-copper amalgams to increase their longevity. High-copper amalgam restorations function satisfactorily over a long period of time by preventing the traditional forms of mechanical failure of the amalgam restorations such as marginal fractures, bulk fractures, and tooth fractures. Amalgam, however, cannot reinforce weak walls because of its low resilience and high modulus of elasticity. These features limit its use in cavities where the enamel is not supported by dentin. In addition, lack of adhesiveness to dental structures requires cavity design with mechanical retention at the expense of healthy tooth structure. Any preparation appears to decrease a tooth's resistance to fracture. Conservative preparation design may affect fracture pattern and enhance options for subsequent restoration. Dentin bonding is now used routinely for both resin-based composite and amalgam restorations and it allows for smaller preparation designs, which make teeth more resistant to fracture. Tooth preparation techniques for both resin-based composite and amalgam have changed from sharp to rounded line angles, which may also help prevent cusp fractures. Bonding enamel and dentin may also increase fracture resistance. The significance of bonding is to prevent the extension of cavity preparation without retentive features in relation to amalgam and still to benefit the advantages of amalgam properties in posterior teeth. Adhesive systems under amalgam restorations were employed to reduce marginal leakage, to improve the capacity of amalgam retention, and preparations of cavities with no mechanical retentions. The promise for reliable bonding of dental amalgam restorations enables a more conservative approach to the restoration of initial carious lesions as well as complex restorations with cuspal reinforcement. The cuspal fracture resistance of hybrid composites, flowable composites, Ormocer, amalgam, and bonded amalgam demonstrated no significant difference in fracture resistance. Studies on cuspal fracture resistance among amalgam, composite, and bonded amalgam showed that bonded amalgam appears to be as effective as bonded composite in supporting undermined enamel in terms of resistance to fracture. Findings from these studies indicate that bonded amalgam can support undermined enamel and reduce the risk of fracture similar to bonded composites. It also indicates that bonded amalgam can be of value in restoring extensively carious posterior teeth. It permits more conservative cavity preparation, because it does not require additional mechanical retention. Sound teeth rarely fracture during normal masticatory stress. Still, cuspal fracture can frequently occur in teeth that have been weakened by caries, large cavity preparations, and reduced dental structure from erosion or abrasion. The fracture resistance of maxillary premolars with MOD Class II cavity preparations restored with silver amalgam and bonded amalgam with Scotch bond Multipurpose and amalgam, Panavia F, and amalgam showed no significant increase in fracture resistance. In the present study, amalgam showed better resistance to fracture when compared to bonded amalgam and composite resins. One very important factor for the success of the restoration is its marginal seal. A good marginal seal prevents pulpal irritation and recurrent caries. This prolongs the life expectancy of the restoration. An adhesive bonding agent is found to affect microleakage only for the short term. In the long-term, however, the effect of the adhesive does not appear to be the dominant factor in reducing microleakage around amalgam restorations. Studies have demonstrated that bonded amalgam restorations provided results similar to conventional amalgam restorations. Bonded amalgam has demonstrated no leakage when compared to amalgam and compomer. As mentioned in the methodology, the adhesive was light cured for 30 s before placing the amalgam. The results of a study by Cobb et al. also indicated that light curing of Scotchbond Multipurpose Plus adhesive system, significantly increases the bond strength of amalgam to dentin. In the present study, bonded amalgam has shown a lower percentage of microleakage when compared to amalgam and composite resins. Bonding in high-copper amalgam (nongamma-2 alloys) can be beneficial, because the corrosion requires a longer period of time to occur or does not take place at all. The ability of the amalgam to resist corrosion can cause microleakage at the tooth restoration interface. Microleakage and subsequent marginal breakdown can result in pulp irritation, tooth discoloration, and secondary caries.

CONCLUSION

The results from the study shows that bonded amalgam restoration allows for less microleakage when compared to amalgam and composite resin restorations. Amalgam restoration shows better resistance to fracture when compared to bonded amalgam and composite resins restorations. Hence, bonded amalgam restoration appears to be comparable to amalgam restorations where microleakage is considered and to composite resin where fracture resistance is considered. This demonstrates that bonded amalgam can also be a better alternative material to amalgam restorations in molars.

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