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Original Research

Comparison of the Fracture Resistance of Pulpotomized Primary Molars Restored with Various Tooth Bonded Restorative Material: An *In Vitro* Study

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Abstract:

Background: This study evaluates the fracture resistance of pulpotomized primary molars restored with Cermet, Resin modified glass-ionomer cement (GIC), and nanocomposites.

Materials and Methods: A total of 60 primary first and second molars were collected for this study. All the teeth were randomly divided into three groups ($N = 20$). Standard pulpotomy cavities were prepared. Teeth were air dried and the canal orifices were capped with a layer of zinc oxide eugenol. A lining of calcium hydroxide was placed over it. Cermet, Resin Modified GIC, and nanocomposite were placed in Groups I, II, and III, respectively. All the samples were then subjected to fracture strength test using the universal testing machine, and the results were statistically analyzed.

Results: All the groups were compared by ANOVA one-way test which indicated that there were statistically significant differences among the three groups with $P < 0.05$.

Conclusion: Nanocomposites can be considered to be a best restorative material in terms of fracture strength among Cermet and Resin modified GIC.

Key Words: Cermet, fracture resistance, nanocomposite, Resin modified glass-ionomer cement, thermocycling unit

Introduction

Dental caries is one of the most prevalent chronic diseases among children. Deep dental caries lead to a severe toothache, periodontal, dentoalveolar abscess, and space infections which may affect the quality of life of the child. Caries prevalence in deciduous teeth is 41-89% out of which 75% of the cases are with pulpal exposure. Extraction of carious teeth leads to a masticatory problem, occlusal discrepancy and loss of interdental space, crowding and ectopic eruption in permanent dentition and should be avoided. When the infection or inflammation is confined to the coronal pulp tissue, then pulpotomy is indicated. It involves the removal of the coronal pulp tissue of a primary tooth without removing the pulp tissue in the root canals. This is followed by applying pulp medicament, the most common formocresol, over radicular pulp tissue. With a final restoration placed on the pulpotomized tooth.[1]

The selection of final restoration materials includes stainless steel crowns, amalgams, intermediate restorative material, glass-ionomer and composite Resin. An acceptable final restoration must allow the tooth to remain functional and without disease.[2] Until date stainless steel crowns and amalgam restoration have been the restoration of choice for the pulpotomized primary teeth.[3] Stainless steel crowns have some disadvantages that require preparation of sound tooth structure not directly involved in the decay process and provide no aesthetic solution to the clinical problem. Until date, the most popular materials used were amalgam and Resin cements in both dentition but amalgam does not bond to tooth structure and requires additional cavity preparation for mechanical retention which leads to weakening of the teeth. Amalgam is not also an aesthetic material due to its silver color. On the other hand, Resin cements come with the concerns of microleakage.

Pediatric dental practice requires restorative materials which adhere to the tooth by minimal intervention, quickly, easily replaced and provide esthetics. Loss of tooth structure leads to increased brittleness of the pulpally treated tooth. Hence, increased fracture toughness of these dental materials is essential.[4] Primary dentition have limited life span and are subjected to lower biting forces when compared to permanent dentition.[5] Glass-ionomer cements (GIC) adhere chemically to tooth structure and is the popularly used restorative material in deciduous teeth.[6] Silver particles were sintered onto the glass to produce optimum mechanical properties for a glass cerment cement.[7]

The use of Resin modified GIC has been a catalyst for a restorative renaissance in pediatric dentistry. Since 1992, these cements have given the dentist a reliable tooth colored alternative to silver amalgam for many types of restorations in children.[8] The restoration of primary anterior teeth presents primary and esthetic problems to the clinician.[9] Nanocomposite Resin have a higher surface hardness when compared to other composite Resins and nanocomposites has esthetic properties required for anterior restorations and mechanical properties required for posterior restorations.[10] It was the objective of this study to evaluate the fracture resistance of pulpotomized primary molars restored with different restorative materials.

Materials and Methods

About 60 primary first and second molars indicated for extraction due to caries, or orthodontic reasons (serial extraction) were collected for this study. The collected teeth were stored in distilled water at room temperature for not more than 3 months. All the teeth were randomly divided into three groups of 20 each. The samples were placed in the rectangular aluminum molds containing a thin mix of acrylic Resin in such a way that the facial and the lingual cusps of the teeth were in the same plane. The acrylic Resin was placed up to 1-2 mm of the tooth surface below the cement-enamel junction to approximate the height of healthy alveolar bone (Figure 1).

Initially, caries was removed with slow speed round bur under water coolant without entering the pulp chamber. The cavity size varied according to the extent of decay. With the completion of the cavity outline, access to the pulp chamber was gained with the high-speed bur. A no. 6 carbide round bur in a slow-speed handpiece completed the final convenience form of the pulp chamber exposing the canal orifices, teeth were air dried, and the canal orifices were capped with a layer of zinc oxide Eugenol. A lining of fast setting $Ca(OH)_2$ was placed over it, and the walls were cleaned of any calcium hydroxide, using a sharp small excavator. The restorative materials were placed in the prepared cavity as follows (Figure 2).

Group I: Cermet (HI Dense – SHOFU)

Three scoops of powder and two drops of liquid were dispensed onto a glass slab. Mixing was done using cement spatula. Mixing time was 30 s. After achieving uniform and heavy consistency, then it was condensed into the prepared cavity. The restoration was then carved to reproduce the proper tooth anatomy.

Group II: Resin-modified GIC (Vitremer) – 3M ESPE

Two scoops of powder and 2 drops of liquid were dispensed and mixed using a cement spatula. Mixing time was 45 s. The primer was applied for 30 s on the cavity and then it was air dried for 15 s and then it was cured for 20 s. Resin modified GIC was placed above it and it was cured for 40 s. Polishing was done after that finishing gloss was applied and cured for 20 s.

Group III: Nanocomposites (Teric N-Ceram)

The prepared pulpotomy cavity was treated with 37% phosphoric acid for 15 s, rinsed with water for 20 s, dried optimally to remove excess water leaving a moist surface. Bonding agent was applied for 30 s and light cured for 20 s. Nanocomposite Resin was placed in the prepared cavity and light cured for 40-60 s. Finishing and polishing was done.

After completion of all the three groups, the samples were stored in artificial saliva at room temperature before being subjected to thermocycling (Figure 3). The teeth were subjected to 1000 thermocycles between 5°C and 55°C with a

Figure 1: Samples mounted in acrylic.

Figure 2: Completed specimens.

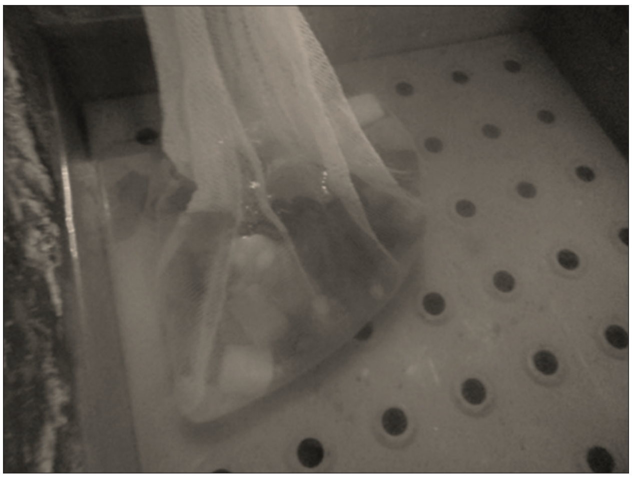


Figure 3: Thermocycling.

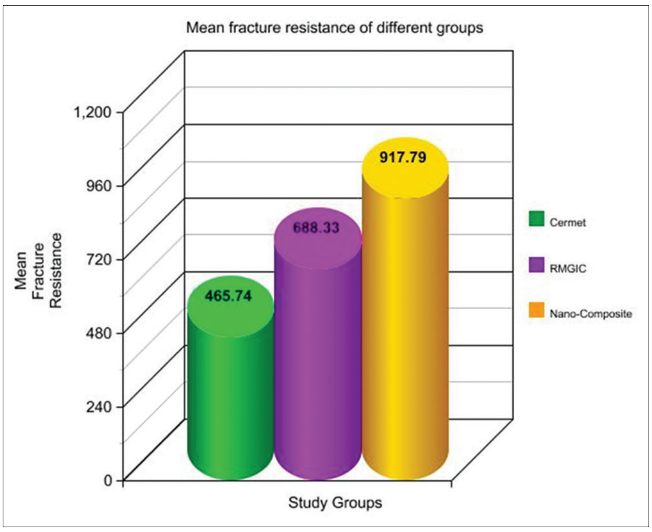
dwell time of 30 s at each temperatures (Figure 4). All the three groups were then subjected to fracture strength test using the universal testing machine. Different sized tapered steel cones with a diameter of 3.5 mm for primary the first molars, 4.5 mm for lower primary second molars and 5.5 mm for primary upper second molars were used. The teeth were tested to compression at a speed of 5.0 mm/min and the breaking load was measured by recording the reading on the display panel of the machine.

Results

The data obtained was tabulated and subjected to descriptive statistical analysis. The mean fracture strengths for the Groups I, II, and III were compared (Table 1 and Graph 1). Group III showed the maximum fracture resistance among the materials tested while Group I exhibited the least. A comparison among the different groups was done using analysis of variance. A significant difference was observed in the fracture strength of the various restorative materials used ($P < 0.05$) (Table 2).

Discussion

Deciduous teeth preservation in primary dentition is important to avoid arch length discrepancies in permanent dentition.[11]



Graph 1: Comparison of means of fracture strength values of different study groups.

Unnecessary loss of tooth structure leads to increased brittleness of the pulpally treated tooth, so increased fracture toughness of these materials is necessary. Increased focus on esthetics and preservation of the tooth structure has led to the development of bonded restorations such as Cermet, Resin modified GIC, and nanocomposites. Bonded restorations preserve the tooth structure and enhance the fracture toughness of the tooth. They also maintain normal contact area, avoid gingival trauma during crown placement, and provide an esthetic restoration. El-Kalla and Garcia-Godoy demonstrated that the bonded Resin based materials increased the fracture resistance of primary teeth restored after pulpotomies.[4]

Previous investigators have shown that preservation of tooth structure is important in order to improve the fracture resistance under occlusal loads and to increase survival rate in restored teeth. They have also demonstrated that the main factor endangering the survival of pulpless teeth is the loss of dentin. According to the findings, thickness of cavity wall had more impact on fracture resistance than the type of cavity (two- or three-surface).

Many factors influence the bite force value, especially in children, including; facial structure, general muscular force, sex

Figure 4: Measuring fracture strength by using universal testing mechine.

Table 1: Mean fracture strength and standard deviation in different groups.

Group	Number of samples	Mean fracture strength (*N*)	Upper value	Lower value	Standard deviation
Group I	20	465.74	1099.5	323.17	230.31
Group II	20	688.33	1013	421	179.09
Group III	20	917.79	1357.5	743.75	169.84

Table 2: ANOVA for fracture strength of different restorative materials used in the study.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	Variance ration *F* value	*P* value
Between groups	2	3,065,474.022	1,532,737.01	40.349	<0.0001*
Within groups	87	3,304,884.944	37,987.19		
Total	89	6,370,358.966			

*Highly significant $P<0.05$. ANOVA: Analysis of variance differences, location of the bite force recording device within the dental arch, mental state during the experiment, state of dentition, malocclusions and temporomandibular dysfunction, the extent of the vertical separation of the teeth and the jaws due to bite fork.[12-14] However, the mean value of maximum bite force has been reported between 151.9 and 374.4 N in different studies. In our study, the mean fracture resistance was 917.79, 688.33 and 465.74 N for nanocomposites, Resin modified GIC and Cermet respectively which were much higher than the maximum bite force values reported in the literatures.[15-17]

Metal-reinforced GIC was introduced because GICs lack toughness and cannot withstand high-stress concentrations that promote crack propagation. GICs can be reinforced by physically incorporating by fusing glass powder to silver particles through sintering referred as Cermet. To improve resistance to abrasion of GIC McClean and Grasser sintered metal alloys with glass and its flexural strength also increased.[18]

Despite all these improvements the two clinical problems of conventional GICs still remained, moisture sensitivity and lack of command curing. To overcome this problems recent advances in dental technology have resulted in the development of Resin modified GICs that demonstrate properties like biocompatibility, coefficient of thermal expansion similar to tooth structure, good compressive strength and fracture resistance, chemical bonding to tooth structure, insolubility in oral fluids, anti-caries activity, ease of placement and manipulation and tooth-colored in multiple shades. With these advantages, along with today's emphasis on conservative cavity preparation Resin modified glass-ionomers have presented clinicians with a renaissance in restorative dentistry for children. The Resin modified glass-ionomer material consists of about 80% glass-ionomer combined with approximately 20% light-cured Resin. It hardens by photopolymerization (lightcuring) as well as chemical curing of the Resin component. The acid/base reaction also hardens the glass-ionomer component. This combination of setting reactions offers complete hardening even with deep cavity preparations into which a light beam may not penetrate.[19]

Daily pediatric practice requires a restorative material that can be quickly and easily placed under less than ideal clinical conditions. The main reasons for preference of GIC as a restorative material over amalgam in primary teeth are chemical adhesion to enamel and dentine, caries inhibiting effect, superior esthetics, and its biocompatibility. RMGIC in addition to this has high bond strength, less sensitive to water and easy to use compared to conventional GIC. The better performance of RMGIC over amalgam is because of its adhesive property and probably by water sorption and expansion of the material during setting. In our study, mean fracture strength of RMGIC is almost similar to that of amalgam. Hence, RMGIC is can be used as an alternative for amalgam in primary molars.[20]

Jagadish and Yogesh (1990) compared the fracture resistance of composite Resin and GIC in Class II cavities and reported that composite Resin possessed greater fracture resistance.[21] The physical properties of composite Resins are determined by the size, shape and amount of filling particles they contain. In one study on this subject Ferracane *et al.* (1988) reported that the fracture resistance of composite Resins depended on the filler composition and that composite Resins containing macro-fill exhibited higher levels of resistance than micro-fill.[22] Owing to the reduced dimension of the particles and to a wide size distribution, an increased filler load can be achieved in nanocomposites, without increasing their viscosity and increasing the mechanical properties such as tensile strength, compressive strength, and other mechanical properties.[23] Composite Resin needs more conservative preparation and adheres to tooth structure due to the application of the adhesive agent prior to it and this will help to preserve the tooth structure.[24]

Nanocomposites are made by dispersing nanofillers. Comparing with conventional composite materials, nanocomposites have numerous advantages such as high mechanical and physical properties, and high reinforcement efficiency. The fracture toughness of nanocomposites increases as the volume fraction increases, and increases as the nanofiller size decreases.[25]

Conclusion

According to this study, nanocomposites showed the highest fracture resistance and can be considered to be a best restorative material in terms of fracture resistance among Cermet and RMGIC. Bonded restorations like nanocomposites not only provide esthetics but also have adequate fracture toughness, they can be used as an alternative to the Amalgam and Stainless steel crown for restoring endodontically treated primary molars.

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