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Research Article

Fracture Resistance of Puplotomized Primary Molars Restored with Various Restorative Materials

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Abstract

Background: Occlusal preparation for pulpotomy is one of the causative factors of tooth weakening which increase the susceptibility of the tooth to fracture.

Aim: To evaluate fracture resistance of resin-modified glass-ionomer cement, nanocomposite and compomer versus amalgam restoration for restoring pulpotomized primary molars.

Methodology: Pulpotomy with class II cavity preparation was performed in 120 extracted second primary molars with class II cavity preparation. Teeth were randomly divided into two equal main groups (60 each), Group (A) with cusp reduction and group (B) without cusp reduction. Each group is further subdivided into four subgroups (15 each) according to the type of restorative materials. Functional cusps were reduced in group (A) by connecting two guide grooves of 1.5mm depth. Teeth were restored with four different types of restorative materials, amalgam, glass ionomer, composite and compomer. All restored teeth were thermo-cycled then mounted in blocks of self–curing acrylic resin. Fracture resistance was measured using universal testing machine. Fracture of tooth structure was examined and categorized either favorable fracture (if the fracture line is above the CEJ) or unfavorable fracture (if the fracture line is below the CEJ extending to the radicular portion). Data were statistically analyzed using ANOVA and post hoctucky test.

Results: In both (A) and (B) groups, the highest resistance to fracture was recorded in composite subgroups (823.02 ± 267.49 & 807.87 ± 257.51) while compomer was the restorative material that yielded the lowest fracture resistance in both groups (404.78 ± 170.00 & 397.47 ± 131.35). A highly significant statistically difference (0.001) was revealed when both groups (A, B) were compared regarding the type of fracture in different subgroups. Favorable fractures were observed higher in prepared cavities with cusp reduction, while unfavorable fractures were significantly higher in prepared with no cusp reduction.

Conclusion: Fracture resistance was higher in pulpotomized teeth restored with composite in comparison with RMGIC, amalgam and comopmer in both groups (A, B). Teeth with cusp coverage restorations recorded higher numbers of favorable type of fracture.

Keywords: Cusp Reduction; Restorative Material; Fracture Resistance

Introduction

Dental caries is the most common chronic disease among children. Pulpotomy is used to maintain primary molars with carious involvement, symptomless or with reversible pulpitis which on the other hand would be extracted. Its objective is to preserve radicular pulp, avoid pain, inflammation and maintain the tooth [1].

Restorative materials in pediatric dentistry requires sufficient retention and strength to maintain the remaining tooth structure and protect the teeth against masticatory force [2]. Different types of materials can be selected as final restoration in pulpotomized primary molars which include amalgam, composite resin, glass-ionomer cement, compomer and stainless steel crown (SSC) to maintain teeth without disease and restore the function [3].

Amalgam is used to restore posterior teeth as it can resist masticatory force but it lack bond to tooth structure and require mechanical retention by additional preparation of the cavity which leads to tooth weakening [4]. The adhesive restorative materials used for restoring pulpotomized teeth, possess high esthetic property and mechanical strength and excellent adhesion to dental hard tissues less damage to sound structure as no need for mechanical undercut for retention. Therefore it reduce damage to pulpal tissue [5].

Dental fracture in restored posterior teeth represents a common clinical problem. Fracture resistance is the ability of material to resist fracture through achievement of good adhesion between restoration and tooth structure [6]. Fracture resistance of tooth depends on tooth anatomy, type of restorative material, dimension of cavity preparation, isthmus width and position of tooth in dental arch [7]. When there is no dentin support underneath cusp tip, onlay restoration can be done. The working cusp should be covered to increase bond strength and distribution of force on this cusp [8]. The stress value is influenced mainly by cavity design and type of restorative materials. In cusp coverage treatment the cusp height should be reduced to decrease the stress value on teeth. However direct restoration with cusp coverage increases fracture resistance against compressive forces [9].

Therefore there was a need for this study to evaluate the fracture resistance of pulpotomized teeth restored with or without cusp reduction by various types of restorative materials**.**

Methodology

Teeth selection and specimens

One hundred and twenty second primary molars were collected, according to the following inclusion criteria

1. Without previous restorations
2. Caries depth should not exceed the level of CEJ (Cemento-enamel junction)
3. Remaining roots have at least one third of their length.

All teeth were cleaned of tissue remnants, debris and stored in screw-top containers containing 0.5% chloramine T solution at room temperature for 24hours. Then transferred to distilled water until the preparation of samples and conduction of tests [10].

Teeth were randomly divided into two equal main groups (60 each), regarding cusp reduction preparation. Group (A) with cusp reduction and group (B) without cusp reduction. Each group was further subdivided into four subgroups (15 teeth each) according to the type of restorative materials**.**

Cavity preparation and cusp reduction:

- Class II cavity was prepared by removing all carious teeth structure and undermined enamel using fissure bur by high speed hand piece with water coolant.
- Standardized access cavities for pulpotomy were prepared in all teeth by using large round bur on high speed. Access cavities were filled with zinc phosphate cement layer to the level of gingival seat [6].
- After access cavitities were prepared, the functional cusps of teeth in group (A) were reduced 1.5mm, approximately, occlusally by using fissure bur of 1.0 mm diameter in accordance with the cuspal inclination. Periodontal probe was used as a guide for the depth of cusp reduction. Two 1.5 mm guide grooves were placed and then the cusps were reduced by connecting these grooves [11].

Teeth restoration in both groups

In subgroup I, teeth were restored with Amalgam using universal metal matrix band in Tofflemire matrix retainer according to standard cavity restoration for pulpotomy through restoring tooth anatomy.

Teeth in Subgroup II were restored with resin modified GI filing material Photac fill quick aplicap (3M ESPE, USA) according to manufacturer instructions. Restorations were carved according to tooth anatomy then finished and polished well.

Subgroup III teeth Teeth were restored with composite (Tetric N- Ceram Bulk Fil) Ivoclar vivadent. Self–etch adhesive (Tetric N –bond universal) was applied with disposable brush and light cured for 10 seconds according to manufacturer instructions. Nano composite resin was applied in increments of maximum 4mm and adapted to the cavity walls with a plastic instrument. Light Cured for (20 sec) then finished and polished.

Teeth for Subgroup VI were restored with (Compoglass F) Ivoclar vivadent. Self – etch adhesiv. Compoglass F was inserted in Compule Dispenser Gun, applied in layers of maximum 2-3mm and adapted with the plastic instruments. Restoration was light cured for 20 seconds and finished with finishing bur.

All restored teeth were subjected to 500 thermocycling rounds between 5C and 55C with dwell time of thirty seconds at each temperature. Then teeth were mounted in self –curing acrylic resin cylinders 3 cm in diameter with the cusp tips aligned in the same plane to ensure a more equal distribution of the load during testing. The acrylic resin was placed up to a point approximately 2mm below cement enamel junction to approximate the height of healthy alveolar bone.

Evaluation of fracture

Load of fracture all the samples were then subjected to fracture strength test using universal testing machine with a ball ended cylindrical tip to distribute load. The tip was placed at the triangular ridge on the occlusal surface of the restoration parallel to the vertical axis of the tooth. A load force was applied with a cross-head speed of 0.5 mm/s until the fracture occurred. The breaking load was measured through recording the reading on the display panel of the machine [12].

Results

Data were analyzed with SPSS version 21. The normality of data was first tested with Shapiro test.

Continuous variables were presented as mean ± SD (standard deviation). ANOVA test was used to compare more than 2 groups and post hoc tucky test was used for intra group comparisons.

Table 1 Shows comparison of fracture resistance between all subgroups. The highest main value was observed in composite subgroup (823.02 ± 267.49), followed by RMGIC subgroup (600.64 ± 420.67), Amalgam subgroup (553.00 ± 180.56), and Compomer subgroup (404.78 ± 170.00). There was a statistically significant difference between composite and all other subgroups; (p=0.002).

	Amalgam(A1)	RMGIC(A2)	Composite(A3)	Compomer(A4)
With cusp reduction	553.00 ± 180.56^{a}	600.64 ± 420.67^{b}	823.02 ± 267.49^{abc}	404.78 ± 170.00^{c}
ANOVA test	5.804			
p-value	0.002*			

Table 1: Fracture resistance between different sub groups with cusp reduction.

* indicate a significant difference between subgroups

The same letter in two subgroups indicates a significant difference between them

Table 2 showed fracture resistance between different subgroups without cusp reduction. Composite subgroup showed the highest resistance against fracture (807.87 ± 257.51) followed by Amalgam subgroup (552.98 ± 180.56), RMGIC subgroup (529.05 ± 130.73) and Compomer (397.47 ± 131.35). Intra group comparison showed higher significant difference between composite subgroup and all other subgroups (amalgam, RMGI and compomer) (p<0.001). Also significant difference was recorded between amalgam and compomer subgroups (p<0.001). No significant difference was found either between amalgam and RMGI or between RMGI and compomer subgroups.

Items	Amalgam(B1)	RMGIC(B2)	Composite(B3)	Compomer(B4)
Without cusp reduction	552.98 ± 180.56^{ad}	529.05 ± 130.^{7}3b	807.87 ± 257.51^{abc}	397.47 ± 131.35^{cd}
ANOVA test	12.84			
p-value	<0.001**			

Table 2: Fracture resistances between different sub groups without cusp reduction.

**highly significant p >0.001, the same letter in two subgroups indicates a significant difference between them.

Table 3 showed comparison between the two main groups regarding tooth fracture. Results revealed that, a statistically significant difference was found by comparing favorable and unfavorable fracture type. Number of specimens with favorable fractures were significantly higher in prepared cavities with cusp reduction (0.001), while number of specimens with unfavorable fractures were significantly higher in teeth prepared with no cusp reduction (0.001).

Type of Failure	With Cusp reduction	Without Cusp reduction	P-value
Favorable all 4 subgroups materials	49 (81.7%)	18 (30%)	χ^2=42.47
Un Favorable all 4 subgroups materials	11 (18.3%)	42 (70%)	P=<0.001**

Table 3: Type of fracture in cusp reduction and without cusp reduction group.

Discussion

Preservation of primary teeth is an essential target for the management of the developing dentition that creates a positive attitude in children toward dental health. Early loss of primary teeth leads to drifting, tilting and malposition of the adjacent teeth [13].

In pulpotomized primary molars the main problem is the depth of the cavity resulting in long unsupported cusps [14]. These cusps may need to be reduced to increase fracture resistance of the tooth and restoration. Focusing on esthetics and preservation of the tooth structure has led to the development of bonded restorations. They hold the unsupported cusps to restorative material, preventing their separation with subsequent fracture.

The restorative materials in the oral cavity are subjected to excessive forces, biting on a hard object and uncontrolled contact between opposing teeth. These restorative materials should have the ability to withstand these forces and fracture, especially in stress bearing area.

This is an *in vitro* study in which the fracture resistance and fracture pattern of pulpotomized primary molars restored with different restorative materials have been evaluated. The primary second molars were selected in this study according to Ajami., *et al.* [15] Who reported that the fracture resistance affects with several factors as, the size of teeth, isthmus width and extent of carious lesion. Class II cavities were prepared in this study to simulate a situation that is often found clinically.

Resin modified GIC, Tetric N Ceram, and Compoglass F. were used in this study in respect of the conservative approach to preserve tooth structure and the increased esthetic demands. Also, they were compared with amalgam because it is the most popular restorative materials for primary posterior teeth.

In this study the applied loads had constant speed and direction and constantly increased until fracture has occurred. A high stress was concentrated on the triangular ridges of the lingual and facial cusp rather than the entire occlusal surface. While masticatory forces have relatively constant magnitude and cause different fracture modes due to variable speeds, different directions and longer periods of time [16].

Cusp reduction was performed by reducing cusp height 1.5mm to reduce stress value on restorative material and remaining tooth structure. Functional cusp was selected to be reduced as the applied force during centric and eccentric jaw movement mainly occurred on this cusp. Meanwhile, no forces were applied on non-functional cusp during lateral jaw movement [8]. The reduced cusps were covered when more than two thirds of the tooth are missing, cavity width exceeds half the distance between the two cusp tips and extensive caries.

This study showed that composite group with cusp reduction had the higher fracture resistance in comparison with other subgroups, in agreement with Torabzadeh., *et al* [17]. They concluded that, direct composite with cusp coverage was a desirable treatment of weakened teeth. Also agreement with Panahandeh., *et al.* [18] reported that the compressive strength of teeth with 1.5mm cusp coverage is equal to that of sound teeth. Mincik., *et al.* [19] concluded that composite restoration with cusp coverage is the most ideal non-prosthetic solution for endodontically treated teeth.

On the other hand, this result disagrees with Veerapravati., *et al.* [20] they reported that cuspal coverage bonded amalgam provided higher fracture resistance than cuspal coverage resin composite this difference may attributed to the use of different teeth and different cavity preparation. Also, the results of this study disagree with Malekafzali., *et al.* [10] who concluded that composite restoration without cusp reduction showed higher fracture resistance than composite and amalgam with cusp reduction.

This study demonstrated that, composite group without cusp reduction showed the highest resistance against fracture with significant difference when compared with other subgroups. This result was also in agreement with El-kalla and Godoy [14] who reported, that the fracture resistance of composite resin is higher than amalgam when used in pulpotomized primary molars. Also Mohammed., *et al.* [21] supported our study as they concluded that, nanocomposite is considered to be the best restorative material in terms of fracture strength among cermet and RMGIC. Our study was in a line with Sangwan., *et al.* [22] who concluded that, composite showed more fracture resistance followed by silver amalgam in endodontically treated teeth.

However this result disagrees with Joynt., *et al* [23,24]. They reported that, the use of composite in weakened permanent teeth did not improve cuspal stiffness. Also disagreement with Vanishree., *et al.* [25] they concluded that, amalgam restoration showed better fracture resistance than bonded amalgam and composite resin in primary molars the different due to used high copper amalgam preventing forms of mechanical failure such as tooth fracture.

These findings may be due to the ability of adhesive composite resin to transmit and distribute functional stresses through restorative material-tooth interface due to mechanical interlocking of resin with peritubular/intertubular dentin and hybrid layer formation, with the potential to reinforce the weakened tooth structure [26].

Pattern of fracture line is divided in two types favorable fracture line above CEJ where unfavorable fracture line below CEJ. On comparing fracture type between cusp reduction and without cusp reduction groups

The result of this study is in agreement with Yamada., *et al.* [27] where 60% of the fractures occurred in cusp coverage restorations of upper premolars were restorable. In agreement with Veerapravati., *et al.* [20] when cuspal coverage restoration failed, the fracture usually within the restorative material itself.

Malekafzali., *et al.* [10] reported that, fracture of cusp reduction group occurred at suitable location above CEJ when compared without cusp reduction group. Also, the study agreed with Ibraheem., *et al.* [28] who suggested that, the fracture of cusp covered with composite often occurred in the restorations themselves, which allowed the fracture to be repaired. On the other hand the restorations without cuspal coverage not only provided low fracture resistance but also their fracture pattern usually involved tooth structures which made the failure difficult to be repaired or eventually led to tooth loss.

Conclusions

From the results of this study we can conclude that Composite restoration showed higher fracture resistance than RMGIC, compomer and amalgam in either with or without cusp reduction groups. Favorable fractures (above CEJ) were mainly observed in teeth with cusp reduction.

Clinical Relevance and Importance

According to our knowledge, this was the first study in which fracture resistance, of restorative materials and teeth, was measured regarding cusp reduction to withstand teeth weakened by access cavity preparation for pulpotomy**.**

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