

In Vitro Evaluation of the Fracture Resistance of Biodentine Pulpotomized Primary Molars Restored with Different Dental Materials

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ABSTRACT

Aim: Biodentine is a biocompatible, bioactive material with dentin regeneration potential that is known as the future material of choice in primary tooth pulp therapy. Biodentine (BD) is also designed as a dentine substitute in direct posterior restorations. So, the aim of this study is to evaluate the fracture resistance of BD pulpotomized primary molars, restored with different restorative techniques.

Materials and methods: A total of 36 extracted primary second molar teeth were selected. Standardized class I access cavity preparation was done and then the teeth were randomly divided into three experimental groups of 12 in each. Group I ($n = 12$): BD and glass ionomer as liners with composite resin as restoration, group II ($n = 12$): BD as both liner and restoration; and group III ($n = 12$): BD and glass ionomer as liners with amalgam as restoration. After water storage and thermocycling, static fracture resistance was tested. Data (in Newtons) were analyzed using one-way ANOVA ($\alpha = 0.05$).

Results: Statistically significant difference was observed among groups of the study (p value = 0.000). Composite group showed the maximum fracture resistance and amalgam group exhibited the least (2371.67 N vs 1912.17 N). Application of composite and BD respectively led to higher numbers of restorable fractures (75%).

Conclusion: In pulpotomized primary molars using biodentine, composite restoration shows the best fracture resistance followed by BD and amalgam restorations.

Clinical significance: In order to improve the outcome of endodontic treatment in primary molars, biodentine can be used successfully as both pulpotomy and restorative material to achieve less time-consuming treatment in children.

Keywords: Composite resins, Dental amalgam, Fracture strength, Pulpotomy, Tricalcium silicate cement.

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INTRODUCTION

Pediatric dentistry gives special attention to preserving primary teeth and maintaining their developmental, esthetic, and functional capacities.¹ Pulpotomy is one of the most frequent treatments that preserves decayed primary teeth.² In spite of toxicity and mutagenicity of formocresol, it is the most popular medicament in primary teeth pulpotomy due to its ease of handling, bactericidal characteristics and fixative properties.^{2,3}

Various biocompatible materials such as bone morphogenic proteins (BMPs), osteogenic protein-1 (OP-1), demineralized dentin and mineral trioxide aggregate (MTA) have been used as pulpotomy agent and have been studied previously.⁴ Better clinical performance has been shown by MTA compared to formocresol; however MTA has drawbacks such as difficult handling, long setting time and tooth color change.^{5,6} A new biocompatible calcium silicate cement (biodentine), exhibiting properties similar to MTA with improved handling, good physical characteristics and appropriate setting time has been introduced.^{7,8} Researches have shown biodentine as an efficient alternative to MTA, due to its biocompatibility, pulpal response and clinical outcomes.⁹⁻¹¹ Also its adhesion to dentin surface seems to be superior to MTA.⁹ Moreover, biodentine shows improved antibacterial properties compared to MTA, as well as low cytotoxicity.¹² Some studies revealed similar clinical and radiographic outcomes for both biodentine and formocresol.³

After access cavity preparation in cervical pulpotomy technique, the coronal dentin becomes deprived of odontoblastic

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processes and fragile to functional forces. Full coverage by stainless steel crowns (SSCs), providing a leakage-free restoration to prevent cracks,¹³ is the choice method for pulpotomized primary molar teeth restoration.^{14,15} However, SSCs placement requires preparation of sound tooth structure.

Generally, establishing the original strength of a pulpotomized teeth without placement of full coverage restoration could be more beneficial for the patient with respect to periodontal tissue. The most popular dental materials used in restoration of pulpotomized teeth are amalgam and resin composites in both dentitions.¹⁶

Amalgam does not bond to tooth structure, requires additional cavity preparation for mechanical retention that weakens the tooth and is not esthetically acceptable material.^{14,17}

Composite resins are widely used for restoring primary molars in stress-bearing areas requiring minimal tooth preparation in single appointment.^{16,18} However, they are technique sensitive and need more replacement due to recurrent caries as a result of microleakage.¹⁹

Several researches revealed that bonded composite fillings strengthen the tooth structure more than amalgam fillings.¹⁶⁻²⁰

According to manufacturers' claim, biodentine could be considered as an ideal permanent dentin restoration and pulp capping agent.²¹ It is also designed as a dentine substitute in cervical lining and direct posterior restorations.^{22,23}

Recent researches showed that biodentine provides adequate marginal seal at the interface of enamel, dentin and dentin-bonding agent.²²⁻²⁴ This material also has the ability to maintain a successful marginal integrity due to the formation of hydroxyapatite crystals at the surface so enhancing the sealing ability.²⁵

Determining a useful material for improving the survival of the pulp-tomized primary molars is still a challenge. The aim of this study is to evaluate the fracture resistance of primary molars pulp-tomized using biodentine and restored with different restorative materials.

MATERIALS AND METHODS

Following approval of the study protocol by the local ethics committee, 36 mandibular primary second molar teeth extracted due to abscess formation, external or internal root resorption or ectopic eruption of first permanent molars were collected after taking informed consent from the parents of the patients. Teeth with occlusal caries (intact marginal ridges) and approximately similar in buccolingual (BL) and mesiodistal (MD) dimensions were selected. After cleaning, the teeth were stored in 0.5% chloramine solution and then distilled water at 4°C for 1 month. They were covered with a thin layer (0.2–0.3 mm) of wax (the apex of the roots also was sealed using wax) and embedded in a cylinder of self-curing acrylic resin up to 1 mm apical to the cemento-enamel junction (CEJ). After resin setting, the teeth were removed from the resin cylinder, and covering wax was melted by immersion of the samples into boiling water.

The remaining space was filled with polyether impression material, and then samples were reinserted into the cylinders. The resulting layer acts similar to the periodontal ligament. The long axis of the tooth was considered perpendicular to the base of the cylinder.²⁶

Standardized class I access cavities were prepared with rounded line angles, using cylindrical diamond burs (ISO 806314, Hager and Meisinger, GmbH, Neuss, Germany). A digital caliper (Mitutoyo Digimatic; Mitutoyo, Kawasaki, Japan) with 0.1 mm sensitivity was used for accurate standardization of cavity dimensions.

The teeth were dried, and the canal orifices were capped with a 3 mm layer of biodentine (BD) (Septodont, Saint Maur des Faussés, France), which was mixed according to the manufacturer's instruction. BD placement was done using a carrier micro apical placement system (MAP) (Produits Dentaires SA, Vevey, Switzerland), condensed with Schilder pluggers (Dentsply Maillefer, Ballaigues, Switzerland).

A computer program was used to randomly divide the samples into three study groups of 12 teeth each. Twelve minutes after BD

setting, teeth of each group were restored by following techniques and materials mentioned in Table 1.

All specimens were stored for 24 hours and then thermocycled (Vafaie Inc., Tehran, Iran) for 1,000 cycles at 5°C/55°C (dwell time: 15 seconds). The specimens were subjected to a continuous compressive axial loading at a crosshead speed of 0.5 mm/minute using a universal testing machine (Zwick-Roell, Zwick, Ulm, Germany). The force was applied by a 4.8 mm diameter round metal bar positioned parallel to the long axis of the teeth, in contact with the occlusal slopes of the buccal and lingual cusps. Peak load to fracture for each tooth was recorded in Newton (N). Data were analyzed with one-way ANOVA at a significance level of $\alpha = 0.05$, using SPSS 11.5 (SPSS Inc., Chicago, IL). Two independent operators evaluated the fractured teeth to determine the mode of fracture as restorable (fractures ending above the CEJ) or non restorable (fractures ending more than 1 mm below the CEJ).

RESULTS

Mean and standard deviations of fracture resistance of experimental groups are presented in Table 2. One-way ANOVA revealed significant differences among groups ($p = 0.000$). Tukey HSD and Duncan as multiple comparison tests revealed differences between groups of the study (Table 3).

Group I showed the maximum fracture resistance among studied groups and group III exhibited the least (Table 2).

Assessment of fracture pattern revealed that the major fracture mode in composite and biodentine groups was restorable mode; in the amalgam group, no difference was observed (Table 4).

DISCUSSION

Dental caries is one of the most common chronic dental diseases in all countries and all populations.^{17,27}

In pediatric dentistry dental caries that progress beyond dentinoenamel junction or cause the exposure of the pulp tissue, usually are treated with an endodontic treatment like pulpotomy.¹⁷

Formocresol has been the gold standard for the pulpotomy of primary teeth for a long period of time. Recently, regarding to calcium silicate base cements improvements, MTA and BD were introduced as successful pulpotomy agents.^{2,10}

It is shown that, there is no significant difference between clinical outcomes of BD and MTA in pulp-tomized primary teeth.²⁷

BD is a biocompatible, bioactive material with stimulating dentin regeneration potential. It is known as the future material of choice in primary tooth pulp therapy.²⁸

Studies revealed that primary teeth pulp-tomized with BD require less procedural time than formocresol and even BD reduces the risk of recurrent bleeding during pulpotomy.²⁹

Hence, in the current study, BD was used as the pulpotomy agent for primary molars.

Loss of tooth structure during pulpotomy increases brittleness of treated tooth. Thus enhancing the toughness of the pulp-tomized tooth by restorative materials seems necessary.⁸

By this time, stainless steel crowns (SSCs), resin composite and amalgam restorations have been used following pulpotomy treatment in primary dentition. SSCs have disadvantages of removing sound tooth structure during preparation leading to brittleness of the tooth and trauma to gingival tissue during crown placement.¹⁵

Table 1: Restoration techniques of the study groups

Groups	(I) BD + composite	(II) BD + BD	(III) BD + amalgam
Pulpotomy agent	BD (Septodont, Saint Maurdes Faussés, France) mixing 30 seconds with amalgamator (Duomat II, Dental und Goldhalbzeug, 600 Frankfurt, Germany)/4,000 rpm)	BD (Septodont, Saint Maurdes Faussés, France) mixing 30 seconds with amalgamator (Duomat II, Dental und Goldhalbzeug, 600 Frankfurt, Germany)/4,000 rpm)	BD (Septodont, Saint Maurdes Faussés, France) mixing 30 seconds with amalgamator (Duomat II, Dental und Goldhalbzeug, 600 Frankfurt, Germany)/4,000 rpm)
Base	Light-cured GI; Photac-Fil 3M (Espe Premier, GmbH, Seefeld, Germany) (1–2 mm) + lightcuring (20 seconds) (VIP Junior; Bisco, Schaumburg, IL) (intensity: 650 mW/cm ²)	–	Light-cured GI; Photac-Fil 3M (Espe Premier, GmbH, Seefeld, Germany) (1–2 mm) + lightcuring (20 seconds) (VIP Junior; Bisco, Schaumburg, IL) (intensity: 650 mW/cm ²)
Adhesion	Etching (with 37% phosphoric acid gel (Ivoclar, Vivadent, Schaan, Liechtenstein) (15 seconds) + rinsing (20 seconds) and drying + bonding; Adper Single Bond 2 (3MESPE, St.Paul, MN) + lightcuring (20 seconds) (VIP Junior; Bisco, Schaumburg, IL) (intensity: 650 mW/cm ²)	–	Mechanical retention
Final restoration	Composite (Filtek Z250; 3M ESPE; Quadrant LC, Cavex, Haarlem, Netherlands) + light curing (40 seconds) (VIP Junior; Bisco, Schaumburg, IL) (intensity: 650 mW/cm ²) + finishing (Sof-Lex discs (3M E))	BD (Septodont, Saint Maurdes Faussés, France) mixing 30 seconds with amalgamator (Duomat II, Dental und Goldhalbzeug, 600 Frankfurt, Germany)/4,000 rpm)	Admixed amalgam (GS-80, SDI Ltd, Melbourne, Australia) after trituration with amalgamator (Duomat II, Dental und Goldhalbzeug, 600 Frankfurt, Germany) + condensing + carving + burnishing

Table 2: Mean and SD of fracture resistance (N) for 3 groups (n = 12).

Groups	N	Mean ± std. deviation	Minimum	Maximum
I (composite)	12	2371.67 ± 175.243 ^a	1,948	2,600
II (biodentine)	12	2092.17 ± 201.242 ^b	1,892	2,550
III (amalgam)	12	1912.17 ± 153.797 ^c	1,656	2,290
Total	36	2125.44 ± 257.927	1,656	2,600

^{a-c}Statistical significant differences between groups

Table 3: Multiple comparisons of fracture resistance in experimental groups

(I) group	(J) group	p value
I (composite)	Amalgam	0.000
	Biodentine	0.001
II (biodentine)	Composite	0.001
	Amalgam	0.048
III (amalgam)	Composite	0.000
	Biodentine	0.048

Table 4: Distribution of fracture modes among the three groups

Groups	N	Restorable	Nonrestorable
I (composite)	12	9 (75%)	3 (25%)
II (biodentine)	12	7 (58.3%)	5 (41.6%)
III (amalgam)	12	6 (50%)	6 (50%)

On the other hand amalgam does not bond to the tooth structure and requires cavity preparation leading to a fragile tooth.¹⁴

Due to recent attention to esthetics and conservative dentistry, bonded restorations were developed.¹⁷ Bonded restorations such

as composite resins enhance the fracture resistance of the tooth structure, maintain normal contact area and provide an esthetic restoration.³⁰ Although, composite shows following drawbacks: polymerization shrinkage leading to microleakage, secondary carries, and also it is technique sensitive.³¹

Researches have shown the superiority of resistance to fracture in composite restorations in comparison to amalgam in pulpotted primary teeth.^{16,17,30} Our results also revealed that composite resin restorations could be used as an alternative to the amalgam for restoring BD pulpotted primary molars in order to improve the fracture resistance.

Besides the superiority of composite resin from the perspective of fracture resistance, shortcomings such as operator dependence, need for bonding system, necessity of patient's cooperation, need for proper isolation and finally poor biocompatibility limit its use in pediatric dentistry.

According to the manufacturer's claim, BD can be used as a permanent restoration with low marginal leakage, adequate mechanical strength and great microhardness value.^{32,33}

Physical properties of BD such as elastic modulus, flexural strength and Vickers hardness are similar to dentin and it is especially designed as a "dentine replacement" material.²⁴ Due to these favorable properties, we decided to compare BD as final restorative material in pulpotted primary teeth with amalgam and composite regarding the fracture resistance of the teeth.

This study showed teeth restored with biodentine had better fracture resistance values than amalgam, but significantly lower than composite group.

It is demonstrated that in contact surface of BD and dentin, there are tag-like structures resulting in "mineral infiltration zone."³² The mentioned interface could be the explanation of higher fracture resistance of group II (BD + BD) in comparison to group III (BD + amalgam).

Similar to our study Subash and his colleagues showed that composite resin is still the choice material owing to its high fracture resistance and bonding to tooth structure.³⁴

This is noteworthy that one clinical study showed that biodentine is able to restore posterior teeth for up to 6 months. However, when biodentine was used as a dentine substitute combined with direct composite restoration, they found it to have a therapeutic advantage for patients, especially for large cavities where the risk of secondary caries is increased.²³

As the result of this clinical study we concluded if a thick layer of BD is left in place as a dentine substitute and composite resin is added using the sandwich technique the best results are achieved.

Due to the majority of restorable fracture mode in composite and biodentine groups, this approach can help to preserve tooth structure and improve the longevity of the restorations.

Limited clinical and laboratory data about using biodentine as final restoration in teeth with proximal surface caries exist. Collecting extracted second primary molar teeth with intact marginal ridges was time-consuming and limited the sample size of the present study. Further researches on primary teeth with more structural destruction is suggested.

CONCLUSION

In BD-pulpotomized primary molars, composite restorations show the best fracture resistance followed by BD and amalgam restorations.

CLINICAL SIGNIFICANCE

In order to improve the outcome of endodontic treatment in primary molars, biodentine can be used successfully as both pulpotomy and restorative material to achieve less time-consuming treatment in children.

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