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Original Article

Fracture resistance of pulpotomized and composite-restored primary molars: Incremental versus bulk-fill techniques

Masoud Fallahinejad Ghajari[1], Amir Ghasemi[2], Arash Yousefi Moradi[3], Khashayar Sanjari[4]

[1]Department of Pediatric Dentistry, Dental Research Center, Research Institute of Dental Science, Dental School, Shahid Beheshti University of Medical Sciences, [2]Department of Restorative Dentistry, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, [3]Department of Pediatric Dentistry, Dental School, Kermanshah University of Medical Sciences, Kermanshah, [4]Department of Pediatric Dentistry, Dental School, Arak University of Medical Sciences, Arak, Iran

ABSTRACT

Background: The aim of this study was to assess the fracture resistance of pulpotomized primary molars restored with incremental and bulk-fill composite application techniques.

Materials and Methods: In this *in-vitro* experimental study, 36 extracted primary molars were nonrandomly (selectively) divided into three groups of 12 each. All teeth underwent conventional pulpotomy treatment, and mesio-occluso-distal cavities were prepared in such a way that the buccolingual width of the preparation was two-thirds of the intercuspal distance, and the depth of the buccal and lingual walls was 4 mm. The teeth were then restored as follows: Group 1 (control) was restored with amalgam, Group 2 was restored with Tetric N-Ceram composite using the incremental technique, and Group 3 was restored with Tetric N-Ceram composite using the bulk-fill technique. The restored teeth were subjected to thermocycling and then underwent fracture resistance testing in a universal testing machine at a crosshead speed of 1 mm/min. Fracture resistance of groups was compared using the one-way ANOVA and Tukey's honestly significant difference test.

Results: The mean fracture resistance was 1291.47 ± 603.88 N in the amalgam, 1283.08 ± 594.57 N in the Tetric N-Ceram incremental, and 1939.06 ± 134.47 N in the Tetric N-Ceram bulk-fill group. The difference in this regard between Group 3 and Groups 1 and 2 was statistically significant ($P = 0.019$ and $P = 0.035$, respectively).

Conclusion: Bulk-fill composite is recommended for reinforcing the remaining tooth structure after the primary molar pulpotomy procedure. Time-saving characteristics of this material are clinically important for reducing appointment time for children.

Key Words: Bulk-fill composite, conventional composite, fracture resistance, primary molar, pulpotomy

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Address for correspondence:
Dr. Khashayar Sanjari, Department of Pediatric Dentistry, Dental School, Arak University of Medical Sciences, Arak, Iran.
E-mail: khashayarsanjari@gmail.com

INTRODUCTION

Dental caries in primary dentition is one of the most common diseases in children worldwide. Pulp therapy is necessary in cases with considerable tooth caries.[1] When primary molars undergo pulpotomy, their fracture resistance minimizes because of extensive loss of tooth structure.[2] Due to the undeniable importance of time required

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for the restoration of primary teeth, materials and techniques enabling a suitable restoration in the shortest time possible are high on demand.[3] When different treatment approaches exist for the restoration of primary teeth, clinicians choose a treatment based on procedures that are cost-effective and evidence-based.[4] Restoration of choice in these teeth is the stainless steel crown because tooth is preserved from fracture, leakage chance decreased, and provided a biological seal.[5] Although amalgam usage in the dental practice is diminished recently, due to its advantages such as low price, high durability, and being user-friendly, most dentists utilize it as their first choice for filling primary molar teeth.[6] Because of improved properties and good appearance, resin-based composites are introduced as a useful restorative material in dental practice.[7] There are some disadvantages in use of conventional composite resins. For example, they have to be used incrementally in 2-mm thick layers. Furthermore, the shrinkage associated with polymerization reaction can accumulate stress in tooth structure and lead to cusp deflection, bond failure, and finally failure of restoration.[8] A new generation in composite resins is presented to decrease the chair time of the conventional restorative procedure.[9] The "bulk-fill" composite introduced to decrease the polymerization shrinkage stress (major disadvantage of composite resin). Hence, this material can be used in a single layer (up to 4 mm), it is an alternative to restorations in the dental practice.[10] When the practitioner inserts this material in a single layer, the time required to accomplish the procedure can be lessened, thus contamination risk alleviated and longevity of restoration enhanced.[11] This study aimed to assess the fracture resistance of pulpotomized primary molars restored with amalgam and composite using the conventional incremental and bulk-fill techniques.

MATERIALS AND METHODS

This *in-vitro*, an experimental study was conducted on 36 extracted human primary second molars with the following inclusion criteria:

- A minimum of one-third of the root remaining and intact furcation
- The width of occlusal caries did not exceed one-third of the intercuspal distance
- Caries depth on the gingival floor at the proximal surfaces had 2-mm distance from the cemento-enamel junction (CEJ).

All teeth were immersed in 1% chloramine-T solution at room temperature after collection until the experiment. The buccal and lingual dimensions of the crown (height and width) were measured by a digital caliper (serial number: 0020536/Mitutoyo, Japan) with 0.01 mm accuracy. To calculate tooth height, the sum of the distance between the palatal cusp tip and the CEJ and the buccal cusp tip and the CEJ was divided by two. Tooth size was calculated by dividing the tooth height by the tooth width. The selected teeth were nonrandomly and selectively divided into three groups of 12 equally based on their sizes. The teeth were prepared using diamond fissure burs with 1-mm diameter and 4-mm height (Jota, Switzerland) and high-speed handpiece underwater and air spray. First, the pulp chamber roof was removed, and then a mesio-occluso-distal cavity was prepared in such a way that the isthmus width of the occlusal cavity was two-thirds of the intercuspal distance, and the gingival floor in mesial and distal cavities was terminated at 1-mm distance from the CEJ. Using a periodontal probe (Hu-Friday, USA), the distance from the cavity preparation margin in the palatal wall and along the mesiopalatal cusp was measured to be 4 mm in such a way that after applying the reinforced zinc oxide cement (Zonalin Kemdent, England) and glass-ionomer cement (GC Fuji II Corporation, Tokyo), minimum thickness of composite in the pulp chamber cavity was 4 mm. Next, Zonalin paste was placed in the pulp chamber floor at 1-mm distance from the marked area for composite. A layer of glass-ionomer cement, mixed according to the manufacturer's instructions, was applied in 1-mm thickness. The cavities were restored as follows:

Group 1: cavities were filled with amalgam after placing a matrix band (Sinalux, Faghihi Co., Iran). Amalgam capsules were mixed in an amalgamator (Ultramat 2, SDI, and Australia) according to the manufacturer's instructions.

Group 2: cavities were etched with 37% phosphoric acid gel (Tetric N-Bond, Ivoclar Vivadent, Schaan, Liechtenstein) for 15 s, rinsed, and two layers of Tetric N-Bond (Ivoclar Vivadent, Schaan, Liechtenstein) was applied, and each layer was cured for 20 s using QTHART-L2 (Bonart Co., Taiwan) light-curing unit with a light intensity of 720 mW/cm^2. Tetric N-Ceram conventional composite (Ivoclar Vivadent, Schaan, Liechtenstein) was applied incrementally. Three triangular-shaped oblique layers were applied in each of the mesial and distal cavities, and two

triangular-shaped oblique layers were applied to the occlusal cavity. The thickness of each layer did not exceed 2 mm, and after applying, each layer was light-cured for 20 s.

Group 3: etching and bonding were performed as in Group 2. Tetris N-Ceram Bulk-Fill composite (Ivoclar Vivadent, Schaan, Liechtenstein) was placed in the cavities as bulk in such a way that the entire cavity was filled with composite and light-cured for 20 s using a quartz–tungsten–halogen light-curing unit.

Next, the specimens were immersed in distilled water for 1 week and were then subjected to thermocycling (1000 thermal cycles between 5°C and 55°C) (Dorsa, Iran). In the next step, the teeth were mounted in autopolymerizing acrylic resin in cylindrical molds measuring 3 cm in diameter and 3.5 cm in height at 2-mm distance from their CEJ. During the polymerization of the acrylic resin, the specimens were immersed in distilled water to decrease the heat generated from the acrylic polymerization and prevent dehydration of specimens. The specimens were then subjected to compressive stress in a universal testing machine (Zwick/Roell, Germany). The load applicator was semicircular with a diameter of 3.7 mm, and the loads were simultaneously applied to the buccal and palatal cusps. The load was applied at a crosshead speed of 1 mm/min vertical to the occlusal surface of teeth and increased until fracture.[10] The mode of failure of specimens was evaluated under a stereomicroscope at × 10. One-way ANOVA was used to compare the fracture resistance of groups. Tukey's honestly significant difference test was used for pair-wise comparison of groups.

RESULTS

Two specimens in the amalgam group were lost during the experiment. Descriptive statistics of the fracture resistance of the groups are shown in Table 1.

Comparison of the fracture resistance values of specimens revealed statistically significant differences among groups (P = 0.012). The mean fracture resistance was 1291.47 ± 603.88 N in the amalgam, 1283.08 ± 594.57 N in the Tetric N-Ceram incremental, and 1939.06 ± 134.47 N in the Tetric N-Ceram Bulk-Fill group. The difference in this regard between Group 3 and Groups 1 and 2 was statistically significant (P = 0.019 and P = 0.035, respectively).

Table 1: Descriptive statistics of the fracture resistance of groups (*n*=34)

Group	*n*	Mean±SD
Amalgam	10	1291.47±603.88
Conventional composite	12	1263.0825±594.57
Bulk-fill composite	12	1939.0426±134.47

The same parameters would be no significant difference. SD: Standard deviation

DISCUSSION

In vital teeth, the failure risk of restoration is less than the restorations which performed in pulpotomized teeth.[12] Resin composites, glass ionomers, or compomers are going to be more favorable than amalgam in operative dentistry of primary teeth.[13] To choose the most suitable material for filling primary pulpotomized molar, there is inadequate strong evidence. Resin composites could be pleasing in the matter of esthetics and also they can make bond to the structure of teeth.[14] Light-cure resin composites reduce the necessity to preparation of additional retention and they could set fast.[15] The depth of polymerization in light-cured resin composites is limited to 2 mm. The incomplete polymerization could cause depletion in mechanical and biological characteristics of composites. Bulk-fill composites are recommended to use in 4- or 5-mm increments. The use of the bulk-fill composites provides an easier restorative procedure and reduces the chair time in teeth with deep and wide cavities.[16] They could make the cusp strain and shrinkage stress lessen and raisen the fracture resistance.[17]

The present study aimed to evaluate the fracture resistance of pulpotomized primary second molars restored with amalgam and conventional incremental and bulk-fill composites. The results obtained in this study presented that within the study conditions; the fracture resistance of bulk-fill composite group was significantly higher than that of conventional composite and amalgam groups. Polymerization shrinkage in bulk-fill composites leads to a strain in tooth structure, which confronts the strain created by the compressive stresses that would result in tooth fracture. This can confer resistance to the remaining tooth structure against compressive stresses.[18,19] On the other hand, different mechanisms prevent premature polymerization in bulk-fill composites such as the presence of stress-decreasing resin or shrinkage stress reliever fillers. Even the activity of

fast initiators may be prevented in these composites resulting in a subsequent reduction in stress in the composite, this decreases the destructive behavior of conventional composites when applied as bulk.[20,21] In a study by Malekafzali *et al*., similar to this study, fracture resistance of teeth restored with bulk-fill composite was increased and this finding has been confirmed in many previous studies.[22] Our findings are in agreement with Cobankara *et al*. who evaluated the fracture resistance of permanent premolars and reported the same results.[23] El-Kalla and García-Godoy, in their study on fracture resistance of pulpotomized primary molars, concluded that in comparison with amalgam, bonded restorations significantly increased the fracture resistance of primary molars.[7] Monga *et al*., in their study on endodontically treated premolars, showed that composite significantly increased the fracture resistance of teeth compared to amalgam; these results are in contrast to our findings.[24] This controversy may be attributed to the type of tooth, type of bonding agent used, type of composite, method of polymerization, the process of tooth restoration, and the remaining tooth structure after cavity preparation. Ehlers *et al*.[25] evaluated the performance of bulk-fill composites in the primary dentition. They declared that it is possible to mention bulk-fill materials as an alternative material in the restoration of primary teeth. Their results are similar to this study. Oter *et al*.[26] evaluated the performance of Class I cavities with bulk-fill composite for 1-year period. They figured out that bulk-fill composites could be performed in primary teeth with high rates of success. This result is in agreement with this study.

Based on the study of Taha *et al*.,[27] the fracture strength of restored teeth by bulk-fill resin composites was significantly higher than other groups and was close to a sound tooth. The result of this study is similar to the present study.

This study is based on extracted teeth and *in-vitro* condition. More clinical studies that specifically focus on fracture resistance of bulk-fill composites are definitely needed to confirm the clinical advantages of bulk-fill composites completely.

CONCLUSION

The use of bulk-fill composite not only saves time but also significantly increases the fracture resistance of pulpotomized primary molars. Considering the above-mentioned advantages, bulk-fill composites are recommended for reinforcing the remaining tooth structure after pulpotomy treatment of primary molars.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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