Published online: 2019-09-25

Original Article

Fracture resistance of cementum-extended composite fillings in severely damaged deciduous incisors: An *in vitro* study

Bahman Seraj[1], Sara Ehsani[2], Shirin Taravati[3], Sara Ghadimi[4], Mostafa Fatemi[5], Sahar Safa[6]

[1]Dental Research Center, Department of Pediatric Dentistry
[2]Dental Student's Scientific Research Center, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Pediatric Dentistry, School of Dentistry, Babol University of Medical Sciences, Babol, Iran
[4]Laser Research Center of Dentistry, Department of Pediatric Dentistry
[5]Department of Dental Biomaterials, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[6]Dentist, Tehran, Iran

Correspondence: Dr. Sara Ghadimi
Email: sghadimi@tums.ac.ir

ABSTRACT

Objective: The aim of this study was to comparatively assess the fracture resistance of the cementum-extended and conventional composite fillings with or without intracanal composite posts in severely damaged deciduous incisors. **Materials and Methods:** This *in vitro* study was performed on 60 extracted deciduous maxillary incisors that were randomly divided into four groups: Group 1: Composite filling (CF); Group 2: Composite filling with composite posts (CF + CP); Group 3: Composite filling extended 0.5 mm to cementum (ceCF); Group 4: Composite filling extended 0.5 mm to cementum with composite posts (ceCF + CP). The fracture resistance was assessed by exerting a progressively increasing load with a cross-head speed of 0.5 mm/min in a Universal Testing Machine. **Statistical Analysis:** Data were analyzed by SPSS-18 using one-way analysis of variance at $\alpha < 0.05$. **Results:** The mean fracture resistance (MFR) values of the experimental groups were 410.57 ± 139.44 N, 564.44 ± 92.63 N, 507.5 ± 76.37 N and 601.08 ± 96.04 N. A significant difference was found between the MFR of Groups 1 and 2, Groups 1 and 4 and Groups 3 and 4 ($P < 0.05$). **Conclusion:** A superior outcome was achieved by intracanal composite posts in both conventional and cementum-extended composite fillings.

Key words: Composite resins, deciduous teeth, fracture resistance, post and core technique

INTRODUCTION

Early childhood caries (ECC) is a common infectious disease involving the maxillary anterior primary teeth more frequently. Usually, because of the coronal structure loss, extraction of teeth will be the only option.[1] However, the profound psychological impacts of tooth loss, along with its untoward effects on esthetics, mastication, speech and growth, should not be overlooked.[2,3]

ECC poses a challenge to pediatric dentists, especially when highly mutilated teeth are to be restored by composite resins. In spite of several problems existing naturally in the utility of composite resins, these agents

How to cite this article: Seraj B, Ehsani S, Taravati S, Ghadimi S, Fatemi M, Safa S. Fracture resistance of cementum-extended composite fillings in severely damaged deciduous incisors: An *in vitro* study. Eur J Dent 2014;8:445-9.

 DOI: 10.4103/1305-7456.143614

are suggested as the materials of choice for restoration of anterior teeth because of esthetic demands.[4] On the other hand, small crowns and relatively large pulp chambers of primary teeth leave the dentists with insufficient tooth structure to obtain proper bond and retention.[5]

The post–core method is commonly used to support and strengthen the restoration. To this end, different types of casted or prefabricated post systems have been proposed. In direct restoration of deciduous anterior teeth, tooth-colored posts such as composite posts are preferred.[6]

Additionally, it seems that extension of clinical crown to cementum may increase the longevity of the restoration. This study compared the fracture resistance of conventional and cementum-extended composite restoration with or without intracanal composite posts.

MATERIALS AND METHODS

A total of 60 freshly extracted maxillary primary incisors with similar root length and width were used in this study. The specimens with crack, fracture and root resorption or canal obliteration were discarded. Following the tooth extraction, they were maintained in normal saline to avoid dehydration and were then disinfected in 0.05% chloramine trihydrate solution for 1 week. The teeth were stored in distilled water at 4°C during the study period. The storage medium was replaced every week to minimize contamination.[7,8] All crowns were cut perpendicular to the long axis using a diamond bur in a high-speed hand piece under a water coolant leaving 1 mm above the cemento–enamel junction (CEJ). The width of all teeth was measured using a calliper. The root canals were prepared to size #45 by k-files (Mani Inc., Tochigi, Japan) 1 mm short of the apex. Then, the canals were obturated with Metapex (Meta Biomed Co. Ltd., Republic of Korea) by the same operator, mounted 1.5 mm higher than the acrylic resin surface and divided into four groups of 15 each:
Group 1: The root canals were sealed and the teeth were restored with composite resin (CF)

- Following obturation with Metapex, the root canal orifices were covered with a thin layer of light-curing calcium hydroxide (Lime-Lite, Pulpdent, Watertown, MA, USA) to create a smooth surface for composite placement. Full crown build-up was performed with solid 3M ESPE Filtek Z250 Dental Composite (3M ESPE, St. Paul, MN, USA).

Group 2: Intracanal composite posts were placed and the teeth were restored with composite resin (CF + CP)

- The first 4 mm of the canal fillings was then removed to leave a 3 mm space for composite post placement. Upon etching (Scotchbond™ Etchant, 3M ESPE, St. Paul, MN, USA) and bonding (Single bond, 3M ESPE, St. Paul, MN, USA) with flowable composite (Filtek Z350 × T Flowable, 3M ESPE, St. Paul, MN, USA), intracanal composites were placed and the crown build-up was performed with solid Z250 (3M ESPE, St. Paul, MN, USA) composite.

Group 3: The root canals were sealed and the teeth were restored with composite 0.5 mm extended to the cementum (ceCF)

- Following pulpectomy, the canals were obturated and covered with a thin layer of light-curing calcium hydroxide to create a smooth surface for composite placement. Full crown build-up was performed with solid 3M ESPE Filtek Z250 composite. The composite covered 1 mm of the enamel and 0.5 mm of the cementum.

Group 4: Composite intracanal posts were placed and the teeth were restored with composite resin with 0.5 mm extension to the cementum (ceCF + CP)

- Similar to Group 3, the first 4 mm of the root canal fillings was removed to leave a 3 mm space for composite post placement. Upon etching and bonding with 3M ESPE Z350 XT flowable composite, intracanal composite posts were placed and the crown build-up was performed with solid 3M ESPE Filtek Z250 composite. The composite covered 1 mm of the enamel and 0.5 mm of the cementum.

The composite restoration height in all groups was equal to 4 mm.

To assess the fracture resistance, the teeth were separately mounted into acrylic resin and fixed by a jig. Then, the assembly received a progressively increasing load with a cross-head speed of 0.5 mm/min at 148° to the long axis of the primary incisors on the mid-palatal surface to simulate primary occlusion in a Universal Testing Machine (Zwick, Germany) until the occurrence of the fracture.[5]

The statistical analysis was performed by the one-way analysis of variance (ANOVA) test or its non-parametric

equivalent, the Kruskal–Wallis test (SPSS18). The level of significance was considered at $P < 0.05$.

RESULTS

To assess the possible effect of different mesiodistal widths on the fracture resistance, the one-way ANOVA test was applied; however, no statistically significant difference was found ($P > 0.05$).

The average mesiodistal width of each group of the specimens is presented in Table 1. The highest and the lowest mean fracture resistance (MFR) values were recorded for the ceCF + CF and the ceCF groups, respectively [Table 2, Figure 1].

The MFR in Group 4 was significantly higher than that in Groups 1 and 3, but not Group 2. On the other hand, CF + CP did not show significantly higher MFR compared with CF [Table 3].

The location of the fracture line against CEJ was microscopically examined. A fracture line above the CEJ was recorded for 12 (80%) specimens in the CF group. This value equaled 10 (66.6%) for CF + CP and ceCF + CP and 9 (60%) for ceCF. No statistically significant difference was found between the study groups according to the location of the fracture line against CEJ ($P > 0.05$).

DISCUSSION

Superior outcomes were achieved in terms of the fracture resistance of primary anterior teeth, especially when intracanal composite resin posts were used. Extension of the composite build-up to the cementum was not likely to significantly enhance the longevity of such restorations. However, the application of composite posts with or without the extension of the restoration to the cementum might improve the fracture resistance of the composite restorations of severely damaged anterior primary incisors.

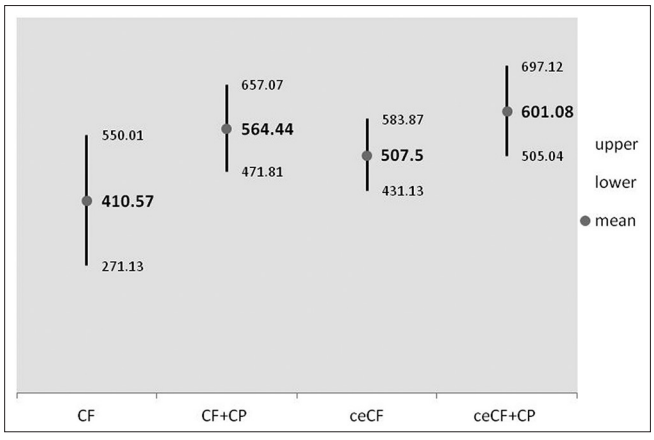

Figure 1: A comparative illustration of the mean fracture resistance (SD) value of each group

Based on the present findings, it could be argued that in cases of general anesthesia, instead of extraction, gingivectomy with laser or electrocautering can be used to expose more cementum to receive a larger composite restoration that will increase the longevity of primary teeth when used with proper intracanal retention.

The mechanical behavior of endodontically treated teeth is strongly influenced by the interface between the applied restorative material, remained dental structure and rigidity of the restorative material.[9] This is even more important when restoring the weakened endodontically treated roots.[10] Despite the proper fit of the cast posts and cores, their application has been limited due to their solely frictional intracanal retention and their relatively high fracture rate as a factor of their stiffness.[11] Therefore, there has been a shift toward application of resin-based posts, which offers a closer

Table 1: The mean mesiodistal width of each group in millimeters

Experimental groups	Mean±SD of mesiodistal width
CF	4.57±0.60
CF+CP	4.60±1.02
ceCF	4.44±0.69
ceCF+CP	4.59±0.81

SD: Standard deviation, CF: Composite filling, CP: Composite posts, ceCF: Cementum extended composite filling

Table 2: The mean fracture resistance (SD) and the range of fracture resistance values

Experimental groups	Mean±SD	Range
CF	410.57±139.44	205.54-678
CF+CP	564.44±92.63	414.52-805.82
ceCF	507.5±76.37	425.27-672
ceCF+CP	601.08±96.04	483.20-840.22

SD: Standard deviation, CF: Composite filling, CP: Composite posts, ceCF: Cementum extended composite filling

Table 3: Statistical differences of the mean fracture resistance between the groups under study (*P* value)*

	Group 1	Group 2	Group 3	Group 4
Group 1	-	0.001‡	0.62	0.001‡
Group 2	0.001‡	-	0.769	0.443
Group 3	0.62	0.769	-	0.001‡
Group 4	0.001‡	0.443	0.001‡	-

*The significance level was considered at $P<0.05$, ‡The significant difference based on one-way ANOVA test or its non-parametric equivalent Kruskal–Wallis test

modulus of elasticity to the root and an adhesive along with mechanical retention, leading to superior stress distribution under functional loads.[12] The flared root in ECC patients lacks sufficient coronal and apical dentin to gain proper fitness for the prefabricated posts. Therefore, these roots are commonly filled with a bulk of luting cements that might jeopardize the longevity of the restoration and the tooth. In order to make amends for the discussed shortcomings, glass–ionomer cements, composite resins and accessory glass fiber posts have been suggested to serve as proper intraradicular fillings.[9,13]

Several tests have been used to assess the effect of masticatory load on the longevity of the restored teeth, including shear bond strength, tensile bond strength and fracture resistance.[14,15] Fracture resistance testing was used in the present study. Because the tooth width is an effective factor in the fracture resistance of the tooth, the groups were matched in this regard. Moreover, the restoration height was standardized in all groups.[9-12,16] The least fracture resistance in the present study was slightly above 410 N. In the study of Rentes *et al*.[17]carried out on 3-5.5 year-old children, the bite force was measured to be 213.17 ± 43.97 N. The mean load values resulting in fracture ranged from 410 N to 601 N in the present study, which was well above the reported maximum bite force for the primary incisors. However, the specimens in the present study did not undergo thermocycling, which might yield lower MFR values, and should be addressed in future studies.[5,18]

Composite resin posts were used in the present study owing to their ease of application, no need for laboratory procedures, lower expenses and superior adaptation.[12,19,20]

The successful application of intracanal posts in endodontically treated teeth is not always a factor of post length. Studies have reported 100% success rates for the teeth restored with composites and reinforced with intracanal posts.[21] It is stated that long posts can adversely affect the underlying development of permanent teeth.[22,23] Therefore, short posts up to the cervical one-third of the roots were applied in the present study. Gurbuz *et al*.[5] studied the effect of application of short posts and their overlying restorations on stress distribution. They concluded that resin-based restorative materials with higher elastic moduli were not as suitable as short post core materials in endodontically treated maxillary deciduous incisors. They argued that the restorative material used should have the similar elasticity as dentin. However, it is assumed that the rigidity of post and core systems has no effect on the fracture behavior of the damaged endodontically treated teeth with limited ferrule.[11,21]

Another crucial factor in the success of post restorations is the ferrule effect.[20] Given the large part of coronal breakdown in ECC, other measures have been sought to achieve the effects of ferrule preparation. For the same reason, to increase the ferrule effect, in the present study a 0.5 mm cement extension of preparation was applied in the ceCF and ceCF + CP groups. Although this extension resulted in higher fracture resistance values compared with the groups where preparation was ended within enamel, the differences were not statistically significant. On the other hand, where composite posts had been used with a preparation extension to the cementum, the fracture resistance values were significantly higher. Authors have argued that the fracture resistance of Parapost prefabricated systems applied with composite cement and core materials is not influenced by ferrule preparation.[22]

Crown lengthening to develop a superior ferrule effect has been recommended for the proper restoration of endodontically treated teeth through the literature.[21,24] There was no consistency between the present findings and those of the *in vitro* study of Meng *et al*.[24] They suggested a significantly increased fracture resistance with increased apical ferrule preparation lengths for simulated forced tooth eruption, but not for simulated crown lengthening. Tang *et al*.[25] suggested that a 1.5-2.0 mm high coronal ferrule would improve the fracture resistance of endodontically restored teeth. However, an apically extended ferrule might decrease the fracture resistance in narrower roots due to the reduced dentin volume and the increased clinical crown/root length ratio.

Restoration of the primary anterior teeth has always posed a challenge to the pediatric clinicians due to the insufficiency of tooth structure, lack of proper bonding of the restorative materials to the primary teeth and the patients' non-cooperation.[26] Because the amount of remained tooth structure to provide enough bond strength is limited in ECC cases, especially in the anterior teeth where the pulp chamber is relatively larger, the need for further retentive measures like intracanal posts has been raised. The results of the present study should be generalized to the clinical situation with caution. The *in vitro* literature on testing the post-endodontic restorations suffers from lack of

methodological standardization due to the significant heterogeneity in test design and parameters. In line with the present study, approximately 60% of the studies performed on the *in vitro* fracture resistance of post-endodontic restorations have used static loading. Only around 15% of similar studies have used thermocycling and mechanical loading. It has been argued that such studies have applied inconsistent numbers of thermo and load cycles and a wide range of cross-head speed of linear loading; thus, further studies under thermocyclic and mechanical loading are recommended to better simulate the clinical situation.[14] This is particularly important because some authors have suggested that the fracture resistance of different posts under thermocycled conditions have not shown any statistical differences.[12] Moreover, the influence of water and NaOCl storage, host-derived matrix metalloproteinases, pH cycling and food-simulating solutions on the degradation of the adhesive interface may project more of a clinically accurate picture.[14,15]

CONCLUSION

The current study showed that the cementum-extended composite fillings with intracanal composite posts could be successful in severely damaged incisors.

ACKNOWLEDGMENT

This project has been supported by the Tehran University of Medical Sciences and Health Services grant number 89-01-69-10260. The authors would like to thank Dr. Shahram Mosharrafian for his consultation.

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Source of Support: Nil.
Conflict of Interest: None declared