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The American Academy of Pediatric Dentistry
Volume 8 Number 2

Attachment of anterior tooth fragments

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Abstract

This investigation examined the relationships of tooth preparation and resin material types in repair of fractured anterior teeth by reattachment of fractured tooth fragments. A total of 44 extracted maxillary central incisors were tested. Statistical analysis revealed that no mechanical preparation of the enamel was as retentive as a 45°-circumferential bevel ($p < .01$). In addition, a light-cured resin proved to be as retentive as a chemically cured resin ($p < .01$).

Also examined was the effect of the initial fracture angle on retention of the attached fragment. Teeth fractured with an angle sloping cervically in a lingual-to-facial direction, when viewed proximally, were more retentive than other types of fractures ($p < .05$) when subjected to a lingually directed force from the labial aspect.

Trauma to the anterior teeth is common in the child and adolescent. Fractures often occur and the dentist is faced with choosing a treatment program that will return the tooth to its original condition insofar as possible. While acid-etch resin restorations have been suggested as one of the better choices, this study presents another method to increase the function and esthetics of the tooth. Reattaching the fractured tooth fragment to the tooth remnant enhances the durability of the restoration, since the fragment wears at the same rate as that of the other teeth. Also, the natural enamel translucency and surface finish of the fragment provides the tooth with its original esthetics.

This study investigated the effectiveness of the fragment attachment technique by measuring the force required to cause separation of the fragment. Two different luting agents were compared. The force required to break the attachment with no mechanical preparation of the tooth was compared with that required when the fractured enamel margins were beveled.

Literature Review

In 1978 Tennery[1] reported using the acid-etch technique with a composite resin to bond tooth fragments to the remnant tooth in 5 patients. Tennery's technique involved keeping the fragment moist until bonding. Then, after determining the correct positioning of the remnant tooth, the fragment was pumiced, rinsed, and dried. He used a finishing diamond to taper the enamel slightly on either side of the fracture line. Etching the tooth and the fragment was accomplished before applying the bonding agent to both. Then an excess amount of composite resin was applied to the tooth and the fragment was repositioned and stabilized with finger pressure until the resin cured. Excess flash was removed and the resin finished and polished. Treatment in 4 of his patients was considered successful at the time the article was written, while the fifth patient suffered an additional trauma to the repaired tooth and it was impossible to unite the fragment again.

In 1979 Simonsen[2] gave the following 4 reasons for using a circumferential bevel for reattachments.

1. It removes superficial enamel and fractured enamel prisms.
2. It allows for a resin-enamel lap joint.
3. It forms a finishing line.
4. It presents enamel prisms in "end-on" relation.

He also suggested removing dentin from the fragment to allow room for placement of calcium hydroxide in the exposed dentinal and/or pulpal areas and to increase the amount of internal enamel available on the fragment for etching.

In 1979 Starkey[3] reported reattachment of a tooth fragment in a girl aged 8 years, 6 months who had received an Ellis Class II injury to her mandibular right lateral incisor. Calcium hydroxide was placed over the dentinal tubules of the remnant tooth and fragment during the etching procedure with a solution of 50% phosporic acid. After the $Ca(OH)_2$ was removed, Nuva-Seal® sealant was placed with a brush on the etched enamel of both the remnant and the fragment. The two units of the tooth then were realigned and held in place while the resin sealant was polymerized with UV light.

In 1982 Simonsen[4] again reported reattachment of fractured units but, in this patient he used an external enamel bevel on the lingual aspect of the tooth and fragment and an internal enamel bevel on the facial aspect to increase esthetics. During the 2 years between placement of the restoration and publication, the patient underwent orthodontic treatment requiring bracket bonding to the tooth. The fragment remained attached even after removal of the orthodontic brackets. One concern was the white, chalkish appearance of the fragment compared to the remnant tooth, which the author believed may have been due to the fact that the fragment was allowed to dry for 1 week before reattachment.

McDonald and Avery[5] described reattachment of tooth units following a Class II fracture of the maxillary left central incisor in a 15-year-old boy. No enamel preparation was performed in their technique other than acid etching. The fragment restoration had been retained for more than 2 years at the time of their writing.

Methods and Materials

Extracted incisors were collected from oral surgery offices in the Indianapolis area. These teeth were stored in tap water up to and during the time of the study. The testing procedure consisted of 4 basic steps: (1) fracture of the tooth; (2) tooth preparation and luting of the fractured fragment; (3) thermocycling of the repaired teeth; and (4) conducting the shear test to determine the strength of the repair.

Fracture Procedure

The central incisors were embedded in a 0.5-in diameter cylinder of tray acrylic[a] so that only a mesioincisal or distoincisal angle of each tooth was exposed. The exposed edge of each tooth then was struck with a blunt instrument to produce an Ellis Class II fracture (Fig 1). Only 44 of the original 93 teeth fractured in a desirable manner.

The acrylic surrounding the tooth crown was removed carefully from these specimens so that only the root of each tooth remained embedded in the acrylic. Immediately after fracture, each tooth and its fragment were stored together in water until employed in the study.

Tooth Preparation and Luting

Two different procedures were performed on the same tooth; thus, each tooth served as its own control. In the first test series, the tooth fragment was bonded onto the tooth without mechanical preparation of either the tooth or fragment. The fractured fragment and the enamel of each fractured tooth were etched for 60 sec with 50% phosphoric acid, rinsed with tap water, and dried with compressed air. Twenty-two teeth were repaired by using a light-cured resin bonding agent[b] as the luting agent. An additional 22 teeth were restored using a chemically cured bonding agent[c] for attaching the tooth fragment to the crown. A repaired tooth is shown in Figure 2.

After completion of the thermocycling and shear strength tests on the 44 teeth, a second series of tests

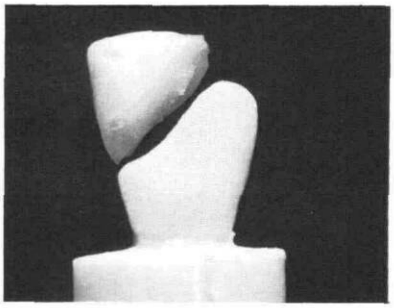

FIG 1. Typical fractured tooth used in the study.

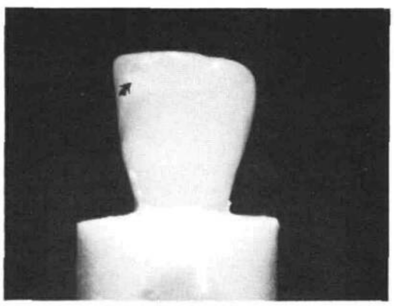

FIG 2. Tooth repaired by reattachment of fractured fragment (arrow indicates fragment bur mark used to standardize point of shear force).

[a] Formatray — Sybron/Kerr: Romulus, MI.

[b] Prisma-Fil Bonding Agent and Composite Resin — LD Caulk Co, Division of Dentsply International: Milford, DE.

[c] Comspan Bonding Agent and Composite Resin — LD Caulk Co, Division of Dentsply International: Milford, DE.

was conducted using these same teeth and the fragments remaining from the first test series.

The teeth and their respective fragments were prepared for the second test series in the following manner. The preparation of each tooth and fragment involved placing a circumferential bevel of ~ 45° to the fractured surface by means of a #169 carbide bur in a high-speed handpiece, using air as the coolant. This preparation also removed any remaining resin material from the first test series. The angle of the bevel preparation was produced as it would be in the clinical setting, simply by estimating the angle of the cut. The prepared enamel was etched for 60 sec with 50% phosphoric acid, rinsed with tap water, and dried with compressed air. The light-cured test group and the chemically cured test group then were restored with their respective resin materials as in the first test series. The composite resins in each test group were used to fill the *V* formed by the bevel preparation.

The curing time for the light-cured restorations was 60 sec for each tooth surface, for a total of 4 min. A 10-min curing time was allowed for the chemically-cured restorations.

Storage and Thermocycling

After restoration, all teeth were stored in tap water at 37°C for 28 days. During the third week of the 4-week storage period, the restored teeth were subjected to thermocycling. They were cycled 2500 times between 2 baths having a temperature differential of 40°C. The cold bath was held at 12°C and the hot bath at 52°C. The dwell time in each bath was 30 sec.

Shear Strength Test

To test the strength of the joint of the fracture repair, the embedded tooth with its luted fragment was inserted and fitted into a stabilizing jig (Fig 3). The tooth was positioned so that the facial plane of the crown was as perpendicular as possible to the applied force. The force was applied to the fragment in a labial-to-lingual direction by means of a small stainless steel ball bearing inserted in the end of a pin which was held in the cross head of a testing machine.[d] The specimens were loaded to failure at a cross-head rate of 0.030 in/min (0.762 mm/min). The force required to detach the fragment was recorded.

Prior to the initial fracture of each repaired tooth, the fragment was marked on the facial surface with a small round bur (Fig 2). This was done to standardize application of the force and all subsequent tests on that tooth, with this point serving as the point of loading. Prior to loading each specimen, the bur mark on the tooth fragment was checked for alignment with the loading pin with articulating paper.

[d] Instron Universal Testing Machine, Model 1123 — Instron Testing Co: Park Ridge, IL.

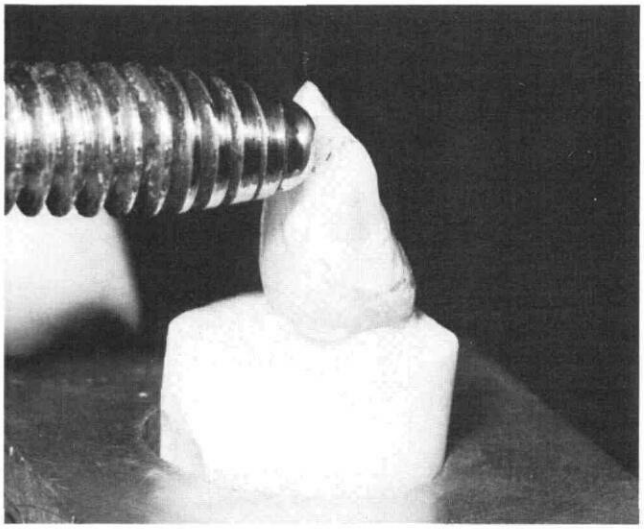

FIG 3. Close-up of shear strength test apparatus.

The data collected were evaluated to determine the retentive capabilities of the no-preparation technique with bonding agent alone as compared with that of the 45° circumferential bevel technique using a combination of bonding agent and composite resin. In addition, a comparison was made of the retentiveness of a light-cured and a chemically cured resin.

A 2-way analysis of variance was used for statistical evaluation. Where appropriate, multiple comparisons were made by subjecting the data to the Neuman Kuels test.

Results

The forces required to fracture each tooth after luting ranged from 1.3 kg to 37.0 kg. The mean force values for teeth repaired with the light-cured resin and the chemically cured resin are shown in Figure 4 and Table 1. Light-cured restorations with no mechanical preparation required 8.51 ± 4.24 kg of force to dissociate the fragment, while the light-cured restorations with a circumferential bevel required 8.92 ± 3.03 kg of force. The chemically cured restorations with no mechanical preparation required 10.36 ± 9.56 kg of force to dissociate the fragment, and the chemically cured restorations with a circumferential bevel required 8.28 ± 4.45 kg of force. These groups were not significantly different from each other at any level of confidence.

The tooth specimens were divided into 3 groups based on the orientation of the fracture plane to the long axis of the tooth. The 3 types of fractures are diagrammed in Figure 5. The fractures were classified as follows: type A fracture — plane of fracture angled cervically in a lingual-to-facial direction when viewed

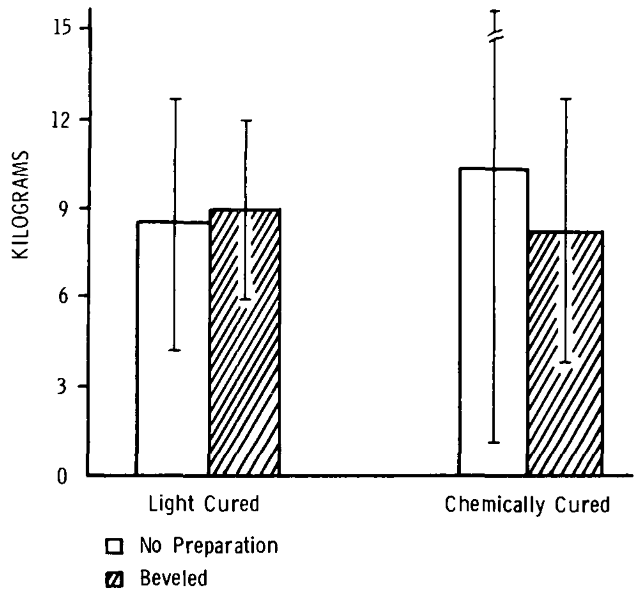

Fig 4. Comparison of mean force required to fracture for the light-cured and chemically cured groups.

Table 1. Mean Force Required To Fracture

	No Preparation	*45° Bevel*
Light-cured	8.51 ± 4.24 kg	8.92 ± 3.03 kg
Chemically cured	10.36 ± 9.56 kg	8.28 ± 4.45 kg

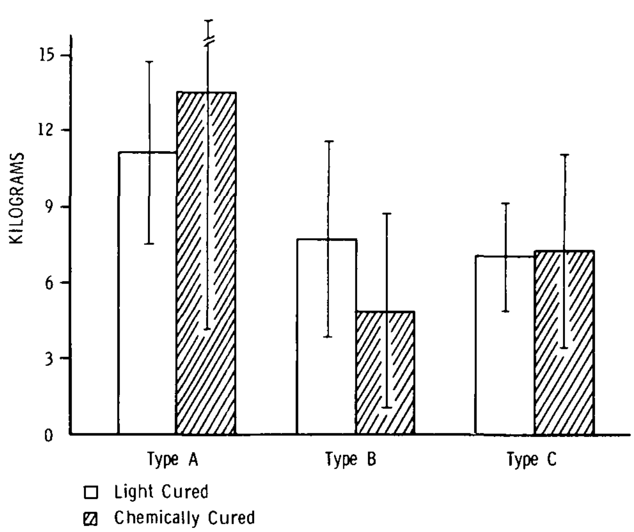

Fig 5. Drawings of type A, B, and C fractures.

proximally; type B fracture — plane of fracture angled cervically in a facial-to-lingual direction when viewed proximally; and type C fracture — plane of fracture approximately perpendicular to the long axis of the tooth.

The results for the 3 fracture types are shown in Figure 6 and Table 2. Statistical analysis of the 3 types of fractures in both the light-cured and chemically cured groups, revealed the following: the type A fracture mean was significantly different from type B and C fracture means ($p < 0.05$); there was no statistical difference between the means for type B and C fractures when compared. This was true for both the light-cured and chemically cured groups.

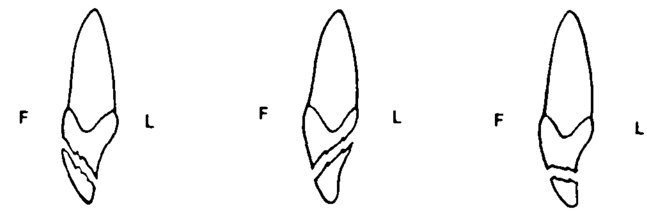

Fig 6. Comparison of mean force required to fracture for types A, B, and C. Type A (left) — fracture plane is angled cervically in a lingual-to-facial direction when viewed proximally. Type B (center) — fracture plane is angled cervically in a facial-to-lingual direction when viewed proximally. Type C (right) — fracture plane is approximately perpendicular to the long axis of the tooth.

Table 2. Fracture Type Means and Standard Deviations

	Light-Cured	*Chemically Cured*
Type A	11.09 ± 3.79 kg	13.56 ± 9.37 kg
Type B	7.79 ± 3.58 kg	4.91 ± 3.50 kg
Type C	7.13 ± 1.90 kg	7.30 ± 3.60 kg

Type A — angled cervically in a lingual-to-facial cross section.
Type B — angled cervically in a facial-to-lingual cross section.
Type C — approximately perpendicular to the long axis of the tooth.

Discussion

This research project was designed to determine: (1) whether external enamel bevels increased the retention for reattachment techniques; (2) whether there is a difference in retention between a representative light-cured and a representative chemically cured resin; and (3) how the initial fracture angle affects the retention of the fragment.

Tooth Preparation

It has been found that to increase the retention for Class IV resin restorations it is necessary to place a 45° bevel circumferentially in the enamel.[5-10] When reattaching a fractured tooth fragment to the original tooth remnant, a 45° circumferential bevel in the enamel of both the tooth fragment and the remnant tooth also has been recommended.[1,2,4] This recommendation for the reattachment technique was made because of studies involving Class IV resin restorations, and not studies concerned with the reattachment of tooth fragments. Starkey[3] and McDonald and Avery[5] have suggested, from case reports, that mechanical preparation in the enamel is not always necessary when reattaching the fractured fragment. The results of this study support this contention, since there was no statistically significant difference in shear bond strength when the tooth fragment was attached using a bevel or when it was attached without preparing either the tooth or fragment.

Hence, these results suggest that placement of a circumferential bevel on the tooth and fragment before luting the restoration is unnecessary, since it does not increase retention. Clinically, this finding is important since the tooth involved undoubtedly has just undergone significant trauma. Ideally, it would seem that the restorative procedure should require minimal tooth preparation in order to decrease manipulative trauma to the tooth and chair time. The no-preparation technique fulfills this requirement, whereas the beveling technique does not.

Resin Material

A light-cured composite resin[b] and a chemically cured composite resin[c] were studied. The shear strength of the 2 resins when used in the reattachment technique was compared. It has been shown previously that light-cured resins have diametral tensile strengths and compressive strengths similar to chemically cured resin systems.[11] However, depth of cure becomes a significant factor in the reattachment technique with light-cured resins, since luting without preparation requires curing through enamel. The results indicate that the 2 resin systems studied here were essentially equal in ability to bond the tooth fragment to the original tooth remnant.

Angle of Fracture

The reattached fragments for the fracture type A incisors withstood fracturing significantly better than the type B and C fractures. This may be explained by considering the amount of lingual support that the tooth provided the fragment when the fracturing force was placed on the facial aspect of the fragment. In type A fractures, the fragment is supported partially by the lingual surface of the tooth. Type B and C fractures do not have this lingual support and, therefore, are less resistant to labial forces. Reattached type B and C fracture fragments were found to withstand fracturing to essentially the same extent. It thus would be expected that fragment restorations in teeth with type A fractures would withstand subsequent labial forces better than either type B or C fractures in vivo.

Conclusions

1. No significant difference was found between the tests on the teeth after luting the fragments with no mechanical preparation and after luting the fragments again, using a 45° circumferential bevel.
2. The light-cured and chemically cured resin materials performed equally well in the attachment technique.
3. Attached tooth fragments, fractured initially with a plane sloping cervically in a lingual-to-facial direction, will be more retentive than other types of fractures when subjected to a dislodgement force directed lingually from the labial.

This article is based on a thesis submitted in partial fulfillment of the requirements for a degree of Master of Science in Dentistry at Indiana University School of Dentistry, Indianapolis.

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