

## Influence of reinforcing techniques on the fracture resistance of reattached teeth

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### Abstract

**Introduction:** Reattachment of fractured tooth fragment is the contemporary minimal intervention concept.

**Aim:** To compare the fracture resistance of three reattachment techniques in fractured endodontically treated incisors.

**Materials and Methods:** Eighty maxillary central incisors were divided into four groups (n=20 each), where group A samples served as control. Remaining (n=60) crowns were sectioned experimentally, and after root canal treatment, in group B reattachment was done by placing palatal grooves and overcontouring. In group C, teeth were reattached by placing glass fiber posts and in group D, titanium posts were used. After thermocycling, fracture resistance evaluation was done by using universal testing machine and mode of failure was analysed under stereomicroscope.

**Statistical Analysis:** The force required to fracture the tooth recorded in newtons was subjected to statistical analysis using one-way ANOVA and Tukey's multiple post-hoc test with a level of significance  $\alpha=0.05$ .

**Results:** Reattachment with titanium post reinforcement has shown higher fracture resistance, whereas palatal grooves with overcontouring has exhibited lowest resistance to fracture ( $p<0.05$ ). Most of the favourable fractures occurred in the fiber post group.

**Conclusion:** Reinforcement with titanium posts can significantly improve the fracture strength of reattached teeth and results in a favourable fracture mode.

**Keywords:** Fiber posts, Reattachment, Super bond C& B, Titanium posts.

### Introduction

Traumatic dental injuries accounts for 18% of the facial injuries, commonly involving anterior teeth and their supporting structures. Most of these injuries occur often in boys than in girls during the first two decades of life.<sup>1</sup> Maxillary central incisors are the commonly involved teeth, because of their anterior and protrusive positions in the dental arch, especially when marked overjet and anterior open-bite are present.<sup>2</sup>

Trauma to the anterior teeth with loss of tooth structure can compromise the emotional state of the affected patient with difficulty in eating, speaking clearly and influences the appearance negatively.<sup>3</sup> Restoration of fractured teeth should reestablish functional and esthetic characteristics including color, shape and occlusal contacts.<sup>4</sup> Thus, correct diagnosis, evaluation and a multidisciplinary approach are most important for successful outcome of the therapy.

The advancements in the field of adhesive dentistry have enabled to provide a predictable long-term reconstruction of fractured teeth with minimally invasive approaches. Several factors may influence the choice of treatment procedure and consequent outcome, such as the extent of periodontal damage, the quality of the remaining tooth structure, availability of fracture fragment and its adaptation to the tooth remnant and the need to perform root canal treatment.<sup>5,6</sup>

The method of tooth fragment reattachment was introduced by Chosack and Eidelman in the year 1964. Since then clinicians have tried different methods seeking one that offers the best adhesion and greatest strength. The primary cause for reattached fragment detachment is a new dental trauma or parafunctional habits causing stress on the restored teeth. The reported survival rate of fragment

reattachment was 25% after 7 years.<sup>7</sup> In complicated crown fractures, where root canal treatment is necessary, the pulp chamber space can be utilized for reinforcement, thus avoiding further tooth preparation.

Studies have reported that, in terms of fracture resistance and biomechanical behavior, reinforcing the fragment by placing fiber posts rather than metal posts will be the best treatment option.<sup>8,9</sup> In contrast, recent *in-vitro* study concluded that the reattached tooth fracture strength was not improved by placing fiber post, but resulted in restorable fracture modes.<sup>10</sup> Further, systematic review and meta-analysis of *in-vitro* and *in-vivo* studies confirmed that rigid posts like cast posts or prefabricated metal posts provide higher fracture strength to endodontically treated teeth and provide better functional longevity when compared to fiber posts.<sup>11,12</sup>

Among the rigid posts, esthetic zirconium or titanium posts are biocompatible, corrosive resistant and exhibit greater flexural strength.<sup>13</sup> Thus, this *in vitro* study was aimed to evaluate the fracture resistance of sectioned fragments that were reattached either with or without root canal posts reinforcement compared to sound teeth. The null hypothesis tested was fracture resistance of reattached tooth was not influenced by the retentive techniques used.

### Materials and Methods

Eighty non-carious maxillary central incisors having similar dimensions and single straight patent root canals were selected. Roots of teeth samples were embedded in acrylic resin blocks after covering with polyvinyl siloxane material (Ad-Sil, Prime Dental Products Pvt. Ltd, India) to mimic the periodontal ligament.

The teeth were randomly divided into 4 groups (n=20 each). Group A was the sound, intact teeth without any treatment that served as control group. Remaining 60 teeth were sectioned to resemble oblique fractures by starting the sectioning on mesio-labial side (6mm above CEJ), running towards the disto-palatal side (3mm above the CEJ) such that pulp chambers of the crowns were exposed.

For all the experimental samples (n=60), access cavity preparations were done and working length was determined. Cleaning and shaping of the root canals was completed using MTwo Ni-Ti files (VDW GMBM, Bayerwald, Germany) and 3% sodium hypochlorite irrigation. After enlarging the root canals upto #40/.06 apical file, canals were obturated with warm lateral compaction, using #40/.06 master gutta percha point and AH plus sealer (DenTsply Mailifer, Germany).

In group B samples, 2 palatal grooves (2mm deep, 2mm wide and 5mm long) were placed both in the fragment and in the remaining tooth with a tapered fissure bur (TF 12, Mani inc, Japan). The fractured surfaces of sectioned fragments and the teeth were acid etched, Adper scotchbond multipurpose adhesive (3M ESPE, MN, USA) was applied and light cured for 10 seconds using Blue Phase C8 LED curing unit (Ivoclar vivadent, USA). A nanohybrid Filtek Z 350 (3M ESPE, MN, USA) composite was used to attach the coronal fragment to the tooth. The palatal surfaces were over contoured by placing a 0.3mm thick composite at the junction of reattached segment and the tooth and light cured for 40 seconds. Finishing and polishing procedures were done using sof-lex disks (3M ESPE, St Paul, USA).

In group C samples, post space preparations were done upto a depth of 8mm, using a calibrated drill to standardize the prepared post space. In coronal fragment, a channel of 2mm depth and 1.3mm diameter was prepared in the pulp chamber. The fit of glass fiber post (Reforpost no:2, Angelus, Londrina PR, Brazil) having 0.70mm apical and 1.3mm coronal diameter with 6% taper was verified and confirmed radiographically. After immersing in 96% ethyl alcohol for 10 minutes, the fiber posts were silanized with a coupling agent (Silano, Angelus, Brazil) and air dried for 60 seconds. The posts were luted with a super-bond C&B self cure adhesive resin cement (Sun Medical co., Ltd,

Moriyama, Japan) and the coronal fragments were reattached to the teeth.

In group D, the fit of titanium posts (Filhol, Dental Southeast Medical Products inc, USA) having a coronal diameter of 1.3mm was verified. The required post length was adjusted by using a plier provided by the manufacturer. Then the posts were surface treated by sandblasting with 50 $\mu$  aluminum oxide particles, luted with self adhesive resin cement and reattachment of the fragment was done using nanohybrid composite resin.

Reattached teeth samples were incubated for one week at 37°C with 100% humidity. Teeth were subjected to thermocycling between 5°C to 55°C for 10,000 cycles and evaluated for fracture resistance. The specimens were attached to a custom made jig and loading test was performed by applying a force at 45° angle on the palatal surface of teeth, 2mm from the incisal margin, using instron testing machine (Autograph, AG-15, shimadzu, USA). The amount of force required to fracture the reattached teeth was recorded in newtons.

The failure mode evaluation was done under stereomicroscope (Prog Res C3, Jenoptik, Germany) having 10X magnification. The mode of failure was noted as “repairable” or favourable if fracture occur above the cemento-enamel junction (CEJ) and “non-repairable” or unfavourable if fracture extends below the CEJ upto the root middle and apical thirds.<sup>14</sup>

Forces at which fracture of teeth occurred, the data in newtons was subjected to statistical analysis by using SPSS/PC version 20.0 software (IBM Corp, Chicago). A one-way analysis of variance (ANOVA) was used to determine the influence of fragment reattachment technique on the fracture resistance. Comparison among the groups was performed by using Tukey’s multiple posthoc test. The mode of failure comparison between the groups was analyzed using the Chi-square test. Statistical analysis was performed at 95% level of confidence.

## Results

The mean force required to fracture the sound vs reattached teeth and the mean percentage values of the fracture strength recovery are shown in table 1.

**Table 1:** Mean, standard deviation of fracture strength measurements (in Newtons) and strength recovery percentage of sound versus restored teeth with different techniques

Groups	Technique	No. of samples	Mean fracture strength	Standard Deviation	% of fracture strength recovery
A	Sound teeth	20	366.58	28.48413	100%
B	Palatal grooves with over contouring	20	155.46	33.26486	42.4%
C	Glass fiber posts	20	182.22	36.40996	49.71%
D	Titanium posts	20	271.49	31.03777	74.06%

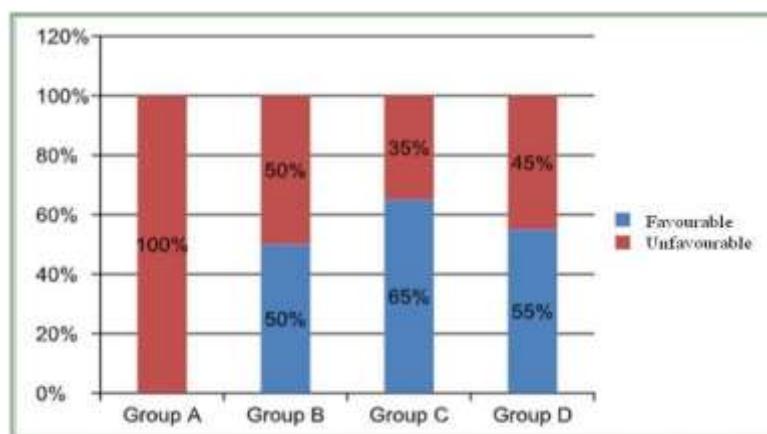


Fig. 1: Bar diagrammatic representation of percentage of mode of failure

Table 2: Pair-wise comparison of fracture mode percentage using chi-square test

	Group A	Group B	Group C	Group D
Group A Sound tooth	-	P = 0.001*	P = 0.001*	P = 0.001*
Group B Palatal grooves with overcontouring	P = 0.001*	-	P = 0.523	P = 1.000
Group C Glass fiber posts	P = 0.001*	P = 0.523	-	P = 0.748
Group D Titanium posts	P = 0.001*	P = 1.000	P = 0.748	-

\* $p \leq 0.05$  is considered statistically significant;  $p > 0.05$  non significant.

Significantly lower fracture resistance was observed for the reattached experimental groups compared to sound teeth ( $P < 0.001$ ). Compared to groups A and D, fracture resistance was least in group B ( $p = .000$ ) and exhibited similar fracture strength of group C ( $P = .052$ ) samples. Reinforcing with fiber posts exhibited lower fracture resistance compared to titanium posts reinforcement ( $p = .000$ ).

Percentage of failure mode for each group was presented in figure 1 and pair-wise comparison between groups was shown in table 2. Sound teeth exhibited non-repairable fractures that were significantly different from experimental groups ( $P = 0.001$ ). The mode of failure was similar for the teeth reinforced with fiber posts and titanium posts ( $p = 0.748$ ).

## Discussion

Reattachment of a tooth fragment procedure is a contemporary minimal intervention concept, as it restores function with cost effectiveness and minimal chair-side time. This technique reduces the quantity of enamel and dentin loss, provides durable resistance, maintains the teeth integrity and esthetics.

The drawback of reattachment procedure is the possible debonding of the reattached fragment either due to progressive degradation of the adhesive interface or a new trauma episode or parafunctional habits involving the restored teeth. Thus, most research work on reattachment

procedures was directed towards the technique that can provide fracture resistance similar to sound intact teeth.

All the reported fragment reattachment techniques have their own advantages and disadvantages. The overall fracture strength recovery reported for simple reattachment procedure was 36.6%, for the internal dentinal grooves was 89.2% and for over contouring was 91.4%. In overcontouring, due to the greater extension of restorative material on the surface, the forces are distributed over a large enamel area. In contrast, a simple reattachment procedure causes the stress concentrations in the fracture line itself. Hence, overcontouring procedure was reported to provide highest fracture resistance followed by internal dentinal groove technique.<sup>15</sup>

In complicated crown fractures, whenever the fractured fragment is available, reattaching the fragment to the tooth using root canal post is the best treatment procedure. By cementing root canal posts with resinous luting agents, retention and resistance of the reattached fragment can be increased. Recent systematic review and meta-analysis of post-retained restorations reported the survival rate of 90% for metal posts reinforced teeth and 83.9% for fiber posts reinforced teeth. The incidence of catastrophic failures were similar for metal and fiber posts.<sup>16</sup> Thus, the titanium post system was selected in the study due to its excellent biocompatibility, color match, high compressive strength and radioopacity.<sup>17</sup>

To obtain coronal fragments, sectioning was done because it is the only way by which we were able to control and standardize fracture line involving the pulp chamber.<sup>18,19</sup> Apart from that, smooth surfaces were resulted by sectioning with a diamond disk, with an advantage of having fewer defects at the interface. Throughout the experimental period, the teeth and the sectioned fragments were stored in saline. Teeth in hydrated state can maintain their original colour with improved bond strength.<sup>20</sup>

After reattachment, teeth were subjected to thermocycling as it was demonstrated that hydrophilic resin monomers absorbs water over a period of time and causes disintegration of resin-dentin interfaces and reduces the bond durability.<sup>15</sup> To simulate the clinical condition, load was applied at 45° angle to the long axis of the tooth on the palatal surface. Specimens submitted to loading at 45° were shown to suffer from the influence of tensile, compression and shear stresses that may damage the restoration.<sup>21</sup>

A significantly higher fracture resistance was exhibited by sound intact teeth in the study compared to reattached teeth. As the type of reinforcing technique affected the fracture strength recovery of reattached teeth, the proposed null hypothesis was rejected. Due to their rigidity reinforcement with titanium posts exhibited highest fracture resistance among the experimental groups. For posterior teeth where the loads tend to be applied longitudinally, a lower modulus posts luted with resin cements seems to be more appropriate. However, for incisors and canines, as these teeth were subjected to oblique loading, stiffer posts appear to be the safest choice.<sup>22</sup> The percentage of fracture strength recovery for titanium post reinforced group was 74.06% of intact teeth. Resistance to fracture was not different between fiber post and over contouring groups showing 49.71% and 42.41% of fracture strength recovery respectively compared to intact teeth.

Corresponding to the previous study results, fiber posts reinforced group exhibited more favorable failures compared to titanium posts group, though it was not statistically significant.<sup>23</sup> Contrary to this finding, other study reported less fracture resistance with more catastrophic root fractures for glass fiber posts compared to zirconium posts.<sup>24</sup>

The amount of load applied using the universal testing machine at a crosshead speed of 1mm/min may not simulate natural traumatic scenario, which was a limitation of the study. Further *in vitro* studies are necessary to determine the technique that can recover the fracture strength of reattached tooth comparable to sound, intact teeth.

## Conclusion

The present *in vitro* study confirm that, reattaching the fractured fragment does not restore tooth original fracture resistance. Inserting a titanium post significantly improves their load bearing capacity, when compared to fiber post insertion or overcontouring with palatal grooves techniques.

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None.

## Conflict of Interest

None.

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