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Comparative evaluation of the fracture resistance of reattached fragments using three different retentive methods: An in vitro study

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ABSTRACT

Background: Traumatic injuries to the anterior teeth are one of the most difficult and perplexing problems faced in the paediatric dentistry. Coronal fracture of the anterior teeth is a common form of dental trauma that mainly affects the maxillary and mandibular incisors. Fragment reattachment has been the preferred technique among clinicians because it has several advantages over the composite restorations such as it is a conservative procedure, maintains original tooth contours, translucence and incisal edge wears at similar rate to adjacent teeth.

Aim: To compare and evaluate the fracture resistance of reattached fragments using three different methods.

Materials and Methods: Forty sound permanent mandibular central and lateral incisor were selected and mounted in self-cure acrylic resin. The teeth were sectioned with a diamond disc 3 mm short of the incisal edge and they were randomly divided into four groups (n=10). Group I – simple reattachment, group II- internal dentinal groove, group III – vertical groove with fiber reinforced post placement, group IV – overcontouring done before the reattachment procedure. The force required to fracture the specimen were recorded using an onscreen calibration tool of the universal testing machine. The results were statistically analyzed.

Results: The results showed that group I, group II and group IV required lesser force to fracture when compared with group III.

Conclusion: The group restored with fiber reinforced post showed the highest value of fracture strength while the simple reattachment had the lowest value.

1. Introduction

Traumatic dental injuries are one of the most perplexing an disruptive problems faced in the paediatric dental practice. Facial trauma that results in fractured, displaced and avulsed teeth can have significant negative functional, esthetic and psychological effects on children.[1] Fractures of coronal portion of anterior teeth are more common form of dental trauma that mainly affects children and adolescents. Coronal fracture of permanent incisors account for 18-22% of all dental trauma.[2]

The treatment of an uncomplicated coronal fracture is a considerable challenge for the dental practitioner because many parameters are implicated in the successful outcome of the restoration – the pattern of fracture, the presence or absence of fractured fragment, restorability of tooth, occlusion, aesthetics, opacity and translucency, the fluorescence and opalescence of original tooth. Hence, the primary goal must be the preservation of dental tissue, re-establishment of the natural aesthetics of traumatized teeth and maintenance of the integrity of the dental arch.[2]

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Various treatment modalities has been employed to treat coronal fractures which include the crowns of pure steel, orthodontic bands, resin held by pins and porcelain crowns. Considering the treatment modalities for crown fracture, reattachment of fractured fragments can offer several advantages comprising of improved esthetics and function, less time consuming, restoration of the surface anatomy with increased wear resistance.

Reis A et al (2001) have advocated the necessity of using additional preparations to augment the retention of the reattached fragment.[3] Several operative procedures have been suggested from no additional tooth preparation to circumferential bevel, internal dentinal groove, external over contouring and superficial over contour of composite on the fracture line.

Hence the aim of this study was to evaluate and compare the fracture strength of reattached fragments using different reattachment techniques – simple reattachment, over contouring, internal dentinal groove and post placement.

2. Materials and Methods

Forty permanent intact human central and lateral mandibular incisors, extracted because of the periodontal reasons, were collected for this study. The teeth were cleaned from debris and calculus with ultrasonic tips; only teeth free from cracks, caries or any other kind of structural defects were selected and stored in normal saline (0.9%) at room temperature till the beginning of the experiment. The teeth were randomly divided into four groups, each consisting of 10 teeth. The teeth were measured on the labial side, from the cervical to the incisal edge, with a digital caliper. This measurement was then divided by three after which the tooth was marked at one-third from the incisal edge. Each tooth was embedded in acrylic resin up to 2 mm above the cemento enamel junction. Specimens were fixed and cut on the mark line, perpendicularly to the long axis of the tooth, with a water-cooled low-speed diamond disk. For each tooth, one fragment was obtained, and specimens were then treated as follows:

2.1. Group I – Simple reattachment

Tooth fragment and remaining tooth structure was etched with 37% phosphoric acid for 15 seconds. Etchant was washed and air dried for 20 seconds. A fifth generation bonding agent was applied and light cured for 20 seconds. Dental composite (Ivoclar vivadent) was applied on the remaining tooth surface and light cured for 20 seconds.

2.2. Group II – Internal dentinal groove

An internal dentinal grove of 1 mm deep and wide was placed within the fragment and remaining teeth by means of no. 2 round carbide bur. Then the areas were etched, rinsed with water and air dried for 20 seconds. A fifth generation bonding agent was applied and light cured for 20 seconds. Dental composite (Ivoclar vivadent) was applied on the remaining tooth surface and light cured for 20 seconds.

2.3. Group III – vertical groove with fiber reinforced composite post technique

In this group, after etching and application of the adhesive system, a small layer of composite was applied to the fractured area of the tooth. Tooth fragment was positioned correctly, excess material was removed from the labial and lingual surfaces, and light curing was done similar to group I.

Single vertical groove 1 mm wide, 4mm in length were laced on the lingual surface perpendicular to the fracture line. Then acid etching of the groove was done and adhesive was applied, fiber reinforced post (no. 1 quartz) of 4mm were made by sectioning the fiber reinforced post with diamond disc. Single post on the lingual surface was placed in the groove. Dental composite (Ivoclar vivadent) was applied on the remaining tooth surface and light cured for 20 seconds was applied to fill the gap between the FRC post.

2.4. Group IV– Over contouring

Following reattachment, the teeth were prepared on the buccal surface by means of cylindrical diamond finishing bur extending 2.5 mm coronally and apically from the fracture line at depth of 0.3 mm. Then the areas were etched, rinsed with water and air dried for 20 seconds. A fifth generation bonding agent was applied and light cured for 20 seconds. Dental composite was applied on the remaining tooth surface and light cured for 20 seconds.

The acrylic blocks containing all specimen were mounted on universal testing machine. The load was applied to each tooth in a labial to lingual direction by means of a reinforced stainless steel wedge at a speed of 1mm / min. The force required to fracture the tooth was calculated and recorded in Kgf.

The data thus compiled was then subjected to statistical analysis for evaluating the fracture resistance of each group.

3. Results

Descriptive and analytical statistics were done. One-way analysis of variance (ANOVA) was used to compare mean fracture resistance of different bands and Inter group comparison was done using Tukey HSD Post hoc test.

All the teeth in Group 1, 2, 4 required lesser force to fracture when compared with the teeth of the Group 3. The force necessary to fracture the teeth in Group 1, Group 2 and group 4 was significantly inferior to the force necessary to fracture the teeth in Group 3 ($P < 0.05$). The statistical analysis showed no significant difference between force needed to fracture the teeth in Group 2 and Group 4.

Table 1: Comparison of mean fracture resistance value and results of one way ANOVA analysis

Groups	Minimum	Maximum	Mean	SD	Anova test	p value
Group 1	12.20	16.40	14.46	1.41		
Group 2	20.40	24.00	22.10	1.16	182.59	<0.01*
Group 3	24.70	29.60	28.04	1.54		
Group 4	21.30	25.40	23.51	1.13		

Table 2: Intergroup comparison of Tukey's Post hoc test of mean fracture resistance of various groups.

Tukey HSD Post-hoc Test...
Group 1 vs Group 2: Diff=7.64, 95%CI=6.05 to 9.23, p=<0.01*
Group 1 vs Group 3: Diff=13.58, 95%CI=11.99 to 15.17, p=0.03*
Group 1 vs Group 4: Diff=9.05, 95%CI=7.46 to 10.64, p=<0.01*
Group 2 vs Group 3: Diff=5.94, 95%CI=4.35 to 7.53, p=<0.01*
Group 2 vs Group 4: Diff=1.41, 95%CI=-0.18 to 3.01, p=0.09
Group 3 vs Group 4: Diff=-4.53, 95%CI=-6.12 to -2.94, p=<0.01*

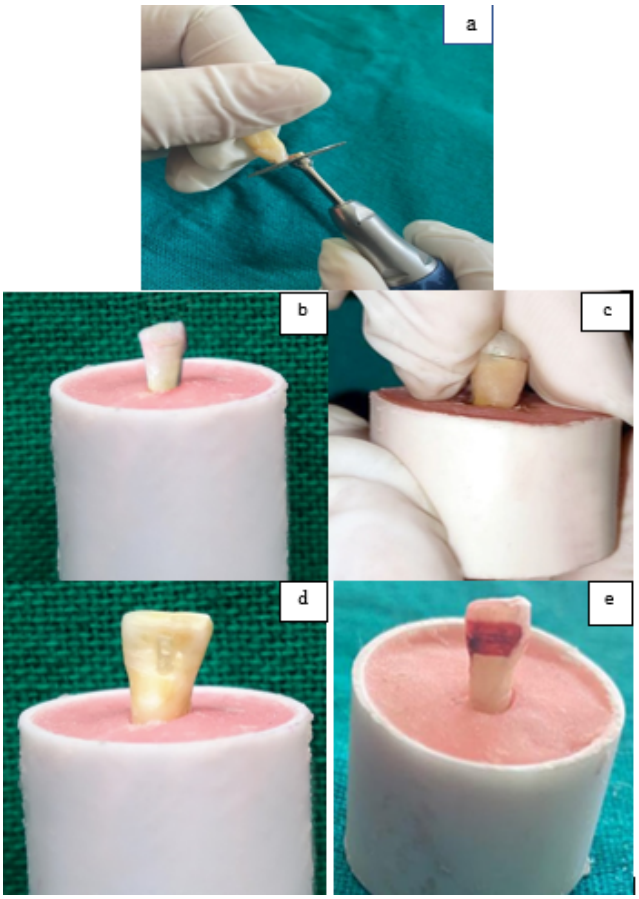

Figure 1: a: Sectioning the fragment – measuring 3mm from the incisal edge; **b:** Simple reattachment; **c:** Internal dentinal groove; **d:** Vertical groove with fiber reinforced post; **e:** Overcontouring

4. Discussion

Dental trauma is a significant public health problem because of its frequency, impact on economic productivity, and quality of life. The incidence of dental trauma have increased in number among children (8-11 years old), and its prevalence ranges from 7.4% to 58%.[4]

The most commonly involved teeth are the maxillary and mandibular incisors, both permanent and deciduous. In the present study, the specimens were sectioned with a diamond disc rather than fractured. Badami et al and Reis et. al (1995 and 2004) have shown that the surface of a sectioned tooth is different from a naturally occurring fractured one, as the fracture produces fragments with a good fitting.[5] A fractured surface tends to run parallel to the main direction of the enamel prisms, whereas the orientation of the sectioned surface is dictated by the alignment of the diamond disk used to section the incisal edge. Therefore, the fitting of the two fractured segments was not perfect and sometimes even presented a gap. Hence, the results obtained in this study should be an underestimation of what could be achieved clinically using these techniques.

Moreover, the teeth used for the experiment were teeth extracted for periodontal reasons, which are usually teeth of older people, whereas trauma happens usually in younger patients. In an attempt to obtain an equal amount of area exposed, all of the teeth were cut at the same distance from the incisor margin (3 mm).[6–8]

Many restorative treatment alternatives have been proposed for the restoration of fractured teeth i.e. resin crowns, stainless steel crowns, orthodontic bands, pin retained resin, porcelain jacket crowns and resin composite restorations. All these procedures are not conservative, have problems in obtaining tooth color, fluorescence, and opalescence and contour to simulate it to the remaining crown portion. These techniques are also time-consuming and high cost. To overcome the disadvantages of the conventional restorative techniques, it was proposed to

restore the uncomplicated crown fractures with the dental fragment.

Reattachment of fractured tooth fragments is one of the treatment options for uncomplicated crown fractures in the permanent dentition. It is considered the most conservative procedure, with maximum aesthetic recovery as the tooth color, contour, surface texture, and translucency are the same as that of the natural tooth.

Different techniques and advancements have been proposed for reattachment of fractured tooth fragments like preparation designs (bevels, chamfers, dentinal grooves); restorative materials and adhesive protocols.[9–11]

In the present study we have evaluated the fracture bond strength of reattached fragments using fifth generation resin by means of 4 different techniques:

1. Simple reattachment.
2. Internal dentinal groove.
3. Vertical groove with fiber reinforced composite post technique.
4. Over contouring.

In group I with simple reattachment, recorded the lowest fracture strength value because of the smaller bonded area, the stress distribution is limited to the fracture line.

In group II, the internal dentinal groove was placed in the tooth, demonstrated higher fracture strength value as compared to the group I because the dentinal bar provides space for resin composite thus reinforcing the bonding. This was in accordance with Kumar S et al (2013) who stated that the greater adhesion area and placement of an internal resin bar which act as an opponent to the compression load applied on buccal surface could be responsible for the better results than the group with the simple reattachment.[12]

Group III with the post placement technique demonstrated the highest fracture resistance as compared to the other three groups because of the reinforcement of adhesion by the placement of fiber reinforced posts in the region of fracture line. This was in accordance with the study done by Karee D et al (2017) who demonstrated that in cases of fragment reattachment with the post placement technique, this group showed highest fracture resistance as compared to the group with internal dentinal groove and circumferential chamfer technique.[3]

In group IV, over contouring technique, higher fracture strength than group I was due to the increased surface area provided by the tooth preparation around the fracture site. The greater the extension of the material on the tooth surface, the better the force distribution over a large enamel area. This result of this study was similar with Abdulkhayum et al. (2014) who stated that the mean fracture strength recovery was more with over contouring technique as compared to simple reattachment because of the better force distribution area.[2]

Similar to the findings of our study, Loguercio et al. (2004) concluded that over contouring and internal dentinal groove technique showed highest fracture strengths as compared to those obtained by bonded, chamfer and resin composite bulid-ups for fractured fragment reattachments.[13]

Another relevant variable, apart from the different techniques is the material used for the reattachment as the strength of the restored teeth also depends upon the adhesive system applied.[14,15]

5. Conclusion

The reattachment of the fractured tooth fragments is an excellent option for restoring the esthetics, contour, surface texture, and translucency of the natural tooth. Vertical grooves with posts have a positive effect on the fracture strength. Among the various techniques and materials used for the study, vertical groove with the fiber reinforced post showed the highest fracture resistance. Therefore, this can be considered as an alternative method for restoring the reattached fragments in dental practice.

6. Source of Funding

None.

7. Conflicts of Interest

None.

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