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Techniques In Tooth Fragment Reattachment

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Abstract:
Aim: The aim of this in-vitro study was to compare and evaluate the fracture resistance of sound maxillary incisor teeth reattached using different tooth preparation techniques, namely, circumferential chamfer, vertical groove with fibre reinforced composite (FRC) post and internal dentin groove.
Materials and Methods: Sixty sound permanent maxillary incisors were mounted in acrylic blocks and divided randomly into four groups (n = 15). In-group A, 15 teeth were retained as positive control in normal saline. The remaining three groups where fragment was to be reattached, a standardized section was made through the middle third of crown, perpendicular to long axis of tooth with a water-cooled low speed diamond disc to simulate Ellis and Davey Class II fracture. In Group B, following reattachment with composite, a 1 mm deep circumferential chamfer was prepared on the fracture line using a diamond bur and filled with composite. In Group C, two vertical grooves 1 mm deep, 1 mm wide, and 4 mm in length were placed on the labial surface perpendicular to the fracture line. Two fibre-reinforced composite (FRC) posts were placed in the grooves and restored with composite. In Group D, dentin was removed from the fractured fragment, filled with composite and reattached. An onscreen calibration tool of the universal testing machine was used to record the force required to fracture the reattached teeth using and the fractured specimens were examined under stereomicroscope.
Results: Teeth in Groups B, C, and D required lesser force to fracture when compared to the teeth in Group A.
Conclusion: The reattachment techniques used in this study resulted in fracture resistance lower to that of intact teeth; vertical grooves with fibre reinforced composite (FRC) post showed superior result compared to the other techniques.
Clinical Significance: In today's era of evident-based minimally invasive dentistry, reattachment of the fractured crown fragment of a traumatized anterior tooth has become the most desirable treatment option. Fragment reattachment is a procedure that offers benefits, such as preservation of dental structure and maintenance of colour, shape and translucency of the original tooth. The aim of this study was to analyse the reattachment techniques used to restore anterior teeth fractured by trauma. The restoration of an anterior tooth by reattaching the original fragment seems to be the most conservative treatment approach for uncomplicated crown fracture cases. When compared with other restorative techniques, such as direct composite restorations, laminate veneers, intra radicular retainers, etc., reattaching the fragment itself can offer several advantages including improved aesthetics and function, and restoration of the surface anatomy with increased wear resistance.
Key words: *Dental trauma; fibre-reinforced composite post; fragment reattachment; permanent tooth.*

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I. Introduction:

The prevalence of maxillary central incisor teeth being injured in any trauma to the facial region is 37%, attributable to their anterior placement in the arch and protrusive eruptive pattern, followed by maxillary lateral incisors (16%) and mandibular central incisors.[1] Most common form of traumatic dental injuries are the crown fractures of permanent dentition. Aesthetic rehabilitation of fractured anterior teeth is one of the greatest challenges to a dentist.[2]

Following trauma immediate replacement of lost tooth structure is desired and reattachment of fractured teeth segments is one such treatment option. Improvement in adhesive techniques and restorative materials has made reattachment of dental fragment possible.[3] Reattachment procedures have better prognosis with promising long-term consequences due to the current notions of dentine hybridization. Incisal function, natural translucency and surface texture are reinstated by reattachment. It also provides superior aesthetics, favourable emotional and social response and is relatively simple, atraumatic, and inexpensive procedure.[4]

Fragment reattachment is a provisional recuperative technique with a durability of 2-7 years as stated by the IADT guidelines (2020).[5] The preparation method and the material used for bonding have substantial effects on the strength of such refurbished teeth.[6]

The aim of this in-vitro study was to evaluate and compare the fracture resistance of reattached incisal fragments of sound maxillary incisor teeth using three different tooth preparation designs: circumferential chamfer, vertical grooves with fibre reinforced composite (FRC) posts and internal dentin groove.

II. Materials and Methods:

Ethical approval for this study (Protocol No. YEC2/196) was provided by the Yenepoya Ethics Committee 2, Yenepoya (Deemed to be University), Mangalore on 18 November 2019.

Sixty human non-carious freshly extracted permanent maxillary incisors, extracted for periodontal reasons were collected. Sample size was calculated considering a margin of error of 5% and a confidence level of 95%. The teeth were thoroughly cleaned free of debris and calculus using scalers and stored in normal saline at room temperature.

The samples were randomly divided into four groups (n=15) and embedded in standardized jigs using self-cure acrylic till the level of cementoenamel junction parallel to long axis of the jig.

Sample Preparation:

15 teeth were kept as positive control group (Group A) in normal saline. For the three groups in which fragments were reattached, a water-cooled low speed diamond disc was used to simulate the Ellis and Davey Class II fracture, cutting through the middle third of the crown perpendicular to the long axis of the tooth. (Fig.1 A)

Sample Restoration:

Group A: This was the positive control group. The intact teeth were not sectioned.

Group B: Single Bond Universal adhesive (3M ESPE, St. Paul, MN, USA) was applied on the remaining tooth structure and light cured for 10s. Filtek Z350 XT Universal Restorative body shade (3M ESPE, St. Paul, MN, USA) was applied to the fractured surfaces and the fragment was positioned fittingly and cured in stages.
In the next step, a 1mm deep circumferential chamfer was placed on the fracture line using a diamond bur with a depth marker, and the chamfer was restored with the same composite. (Fig.1 B)

Group C: After reattachment, two vertical grooves, 1mm deep,1mm wide and 4mm in length were placed on the labial surface perpendicular to fracture line using high speed depth orientation diamond bur. After applying the adhesive and sectioning a longer FRC post, two 4 mm length posts were placed in the grooves. Composite material was applied to fill the space between the FRC post and surface of the tooth, and it was light-cured. (Fig.1 C)

Group D: A high-speed airotor diamond bur was used to remove the entire dentin portion of the fragment. After the adhesive was applied, the area where the dentin was removed was filled with dental composite, reattached, and cured. (Fig.1 D)

Evaluation:

The specimens were mounted in the universal testing machine (Tecsol-TSI-BDS) (Fig.2 A) at 45° to the horizontal plane, and the load was applied in the labial to lingual direction at 1mm/min in the centre of the restoration using a reinforced stainless-steel wedge (Fig.2 B). The force required to fracture the tooth was recorded using an onscreen calibration tool (Fig.2 C).

Stereomicroscopic evaluation for mode of fracture

The samples were analysed for mode of fracture under stereomicroscope (Stemi DV4: Carl Zeiss, Gottingen, Germany) at 3.5x magnification and was categorized as one of the two characteristic failure modes: adhesive fracture at tooth–restoration interface and cohesive breakage of the remaining part of the tooth (Fig.3).

III. Results:

The data were collected, tabulated, and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 23 (IBM, Chicago, US). One-way ANOVA was used for comparison of three groups (p value <0.05 is considered significant). Continuous variable were described in terms of mean and standard deviation. For the multiple comparison of groups, Tukey's Post Hoc test was used (p value <0.05 is considered significant).

When compared to group A, all the teeth in Groups B, C, and D required lesser force to fracture as shown in Table 1.

Table 2 gives the intergroup comparison which revealed that the force needed to fracture the teeth in Group B and Group D was significantly lesser to the force required to fracture the teeth in Group A ($P < 0.05$), but not when compared with Group C ($P = 0.945$).

The most common type of fracture mode was adhesive fracture at tooth–restoration interface and cohesive breakage of the remaining part of the tooth as observed in stereomicroscopic evaluation. (Table 3)

IV. Discussion:

Uncomplicated crown fractures involving only enamel and dentin represent about 28%-44% of traumatized teeth in children.[7] Rehabilitation of such fracture usually ranges from a composite resin restoration to dental fragment reattachment.[8] The later technique helps attain restorations that totally restore patient's aesthetics, surface texture, occlusal alignment, contour, colour and natural shape and is the most favourable treatment option.[9]

Additional preparation of the fragment or tooth shows a better performance for resistance to fracture as concluded by many studies. Preparation techniques such as enamel bevelling of the fragment and remaining crown, internal dentin groove, external chamfer, and the over contour technique are some of them. It has turned out to be apparent that the preparation technique and material used to join fractured fragments have notable impact on the fracture strength of restored teeth.[10]

A study conducted by Reis et al. concluded that a simple reattachment without any preparation of the fragment or tooth could recover 37.1% of the intact tooth's fracture resistance. Buccal chamfer recovered 60.6% and an over contour and placement of an internal groove recovered of 97.2 and 90.5% fracture strength respectively.[11]

Other studies have also shown that a preparation post reattachment, such as a bevel or a chamfer, has a positive effect on fracture resistance.[12] In a recent study by Stellini et al., fractured cattle incisors were repaired with different preparations post reattachment. He concluded that overcontouring or the combination of vestibular and lingual chamfer gave the tooth a fracture resistance 50% superior to that of an intact tooth.[13]

Another factor influencing the strength is maintaining adequate hydration or rehydration of a dehydrated tooth fragment before the restorative procedure[14]. In a study on bovine teeth, Poubel et al. stated that the fracture strength following reattachment of a dehydrated fragment was inferior to that of a tooth kept hydrated or rehydrated for 15 minutes.[15]

A study conducted by Badami et al. showed that neither the bevel nor the material that was used restore the original fracture resistance of the tooth. The resistance of the fracture segment was shown to be directly proportional to the surface area of adhesion.[16] In order to reduce operative error, the amount of dentin removed in the circumferential chamfer and internal dentin groove groups were standardized using a diamond disk bur of 4 mm diameter.

New trauma or excessive masticatory forces primarily cause the reattached tooth fragment to fail, which explains why many previous attempts have been directed at improving the fracture strength of the rebonded fragment.[17] Despite the ever-increasing popularity of self-etching bonding agents, adhesive systems that utilize phosphoric acid as a separate conditioner remain the gold standard of enamel bonding reliability and durability. The bond strength of self-etching adhesives can be as good as or better than that of etch-and-rinse adhesives.[18]

In the present study, the reattachment done with vertical grooves with fibre reinforced composite (FRC) posts showed good fracture resistance when compared to circumferential chamfer and internal dentin groove. The fibre-reinforced post positioned in the region of the fracture line has led to reinforcement of adhesion. A more conservative preparation of the coronal buccal surface was achieved using this method and the value of resistance against fracture was almost as high as that of the control group.

Most frequently, failures involved an adhesive type fracture at the resin enamel interface and a cohesive type fracture within the resin body. Even though high amount of force was exerted, it caused the fracture of reattached fragment leaving the posts intact.

Although this is an in-vitro study, the actual presentation of a patient with a fractured tooth presents a challenge to clinicians. Nevertheless, since the bond strength and fracture resistance recovery are superior, vertical grooves with fibre reinforced composite (FRC) posts may be adopted to improve the longevity of reattached teeth. From a clinical standpoint, the use of this fragment reattachment technique is in accordance with the minimal intervention concept. It reduces the quantity of enamel and dentin lost and guarantees a complete restoration of the tooth.

V. Conclusion:

The reattachment of fractured tooth fragments offers an excellent restorative option for clinicians and patients because it restores tooth function, aesthetics, requires less time in the dental office, and represents a cost-effective approach. Among the various techniques and materials used for the fragment reattachment, this study which included vertical grooves with FRC posts shows the highest fracture resistance. This can be considered as an alternate method of reattachment when the fragment is intact, with adequate size and appropriately preserved margins.

VI. Clinical significance:

Recent developments in restorative materials, adhesive protocols and preparation designs have allowed clinicians to predictably reinstate fractured teeth. With the advent of adhesive dentistry, reattachment using the patient's own tooth fragment has become a simplified and more reliable treatment option. Fragment reattachment is a procedure that offers benefits, such as preservation of dental structure and maintenance of colour, shape and translucency of the original tooth. The aim of this study was to analyse the reattachment techniques used to restore anterior teeth fractured by trauma. The restoration of an anterior tooth by reattaching the original fragment seems to be the most conservative treatment approach for uncomplicated crown fracture cases. When compared with other restorative techniques, such as direct composite restorations, laminate veneers, intra radicular retainers, etc., reattaching the fragment itself can offer several advantages including improved aesthetics and function, and restoration of the surface anatomy with increased wear resistance.

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Tables and Figure legends:

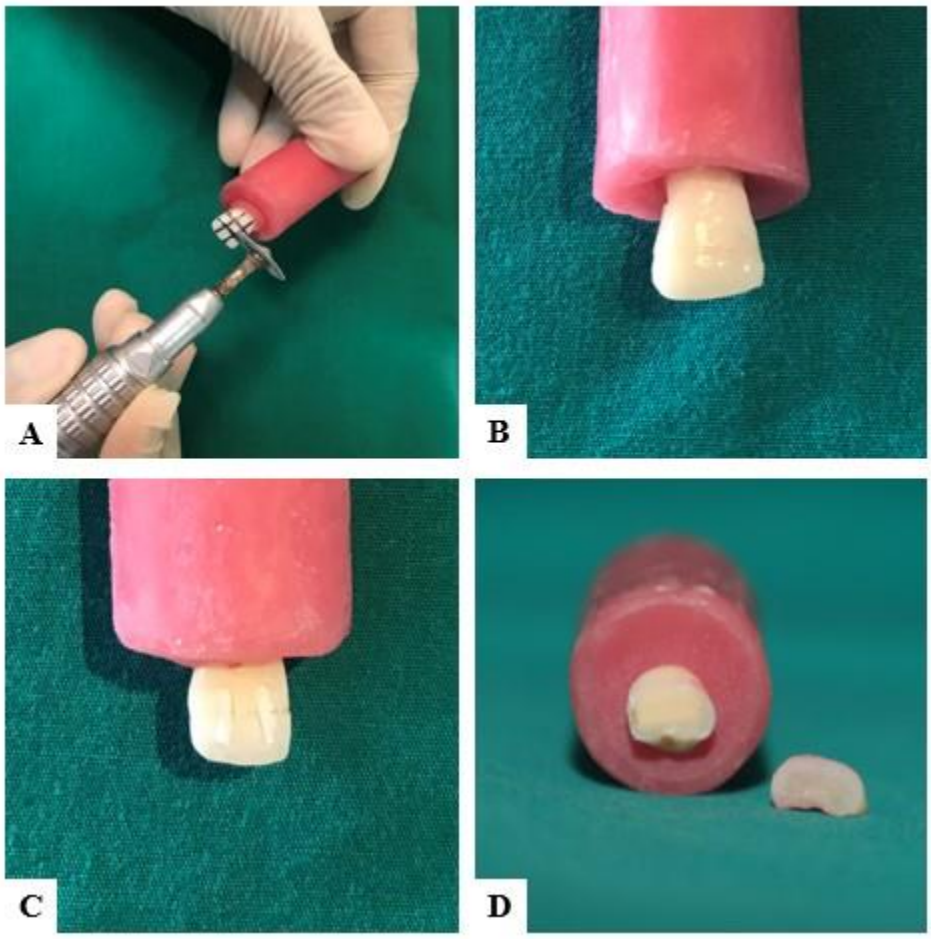

Fig 1 Methodology A) Sectioning the sample, B) Circumferential Chamfer Technique, C) Vertical Grooves with Fiber Reinforced Composite Post Technique, D) Internal Dentin Groove Technique.

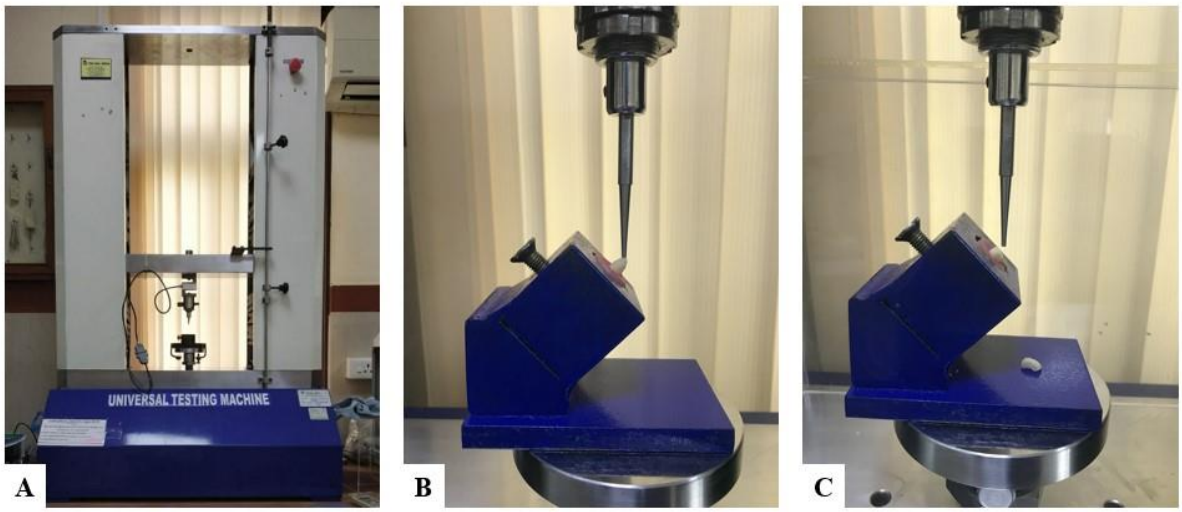

Fig 2 Evaluation A) Universal Testing Machine, B) Load applied on the mounted sample, C) Fractured sample.

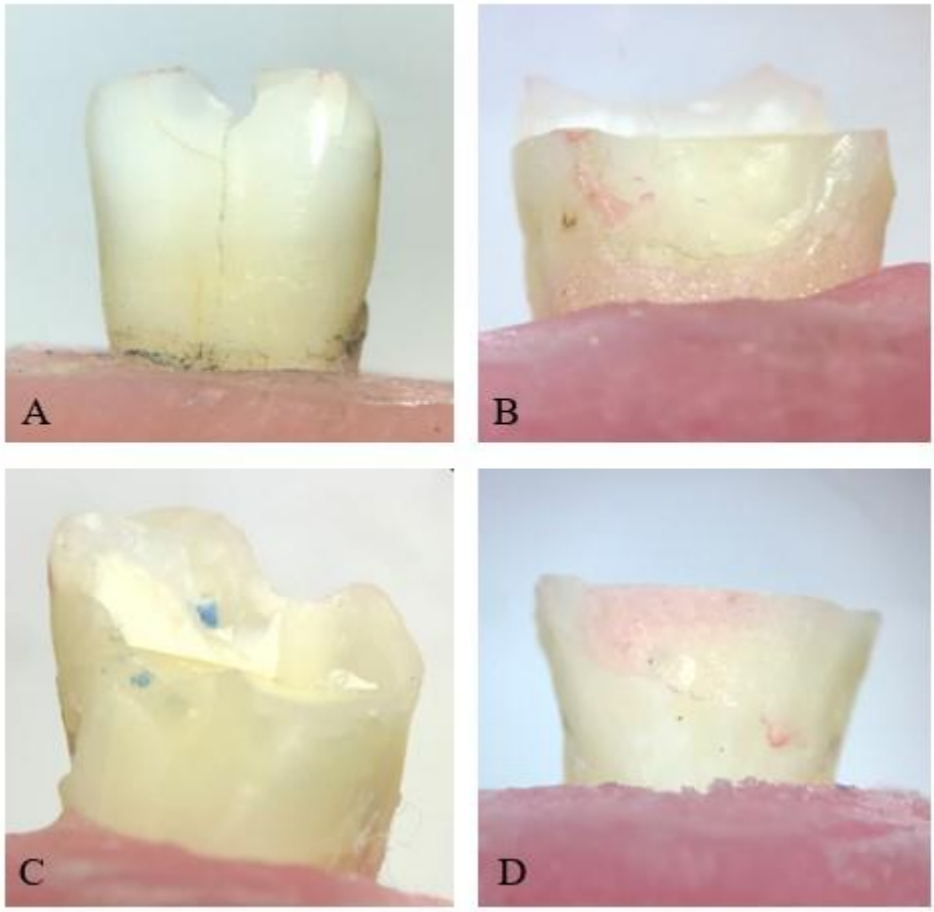

Fig 3 Stereomicroscopic evaluation for mode of fracture A) Intact, B) Circumferential Chamfer, C) Vertical Grooves With FRC Posts and D) Internal Dentin Groove.

Tables:

Groups	M (SD)	F	p value	95% CI
Intact	41.20 (9.20)	56.0	0.00	36.11 to 46.30
Circumferential Chamfer	28.48 (10.15)			22.86 to 34.11
Vertical Grooves With FRC Posts	39.70 (4.47)			37.22 to 42.18
Internal Dentin Groove	10.17 (3.43)			8.27 to 12.07

Table 1 Comparison of shear bond strength for the four groups

Groups		P value	95% CI
Intact	Circumferential Chamfer	0.000	5.55 to 19.88
	Vertical Grooves With FRC Posts	0.945	-5.66 to 8.66
	Internal Dentin Groove	0.000	23.86 to 38.19
Circumferential Chamfer	Vertical Grooves With FRC Posts	0.001	-18.38 to -4.05
	Internal Dentin Groove	0.000	11.14 to 25.48
Vertical Grooves With FRC Posts	Internal Dentin Groove	0.000	22.36 to 36.69

Table 2 Multiple comparison using Tukey post hoc test.

Groups	Adhesive fracture at tooth–restoration interface.	Cohesive breakage of the remaining part of the tooth.
Circumferential Chamfer	8	7
Vertical Grooves With FRC Posts	11	4
Internal Dentin Groove	13	2

Table 3 Evaluation of mode of fracture among the prepared groups.