Original Article

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EVALUATION OF TOOTH FRAGMENT REATTACHMENT FRACTURE RESISTANCE USING THREE DIFFERENT TECHNIQUES & MATERIALS : AN IN VITRO STUDY

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ABSTRACT:

Aim: To evaluate the effect of various materials and reattachment techniques on impact strength of human extracted incisors using universal testing machine.
Methodology: 160 permanent anterior teeth were included and randomly distributed into 4 groups, 1 control group and 3 experimental groups. Intact teeth composed the control group. In Group 1, fragments were reattached without any preparation. In Group 2 after reattachment, a 1mm-depth circumferential chamfer was placed and filled with composite. In Group 3, internal dentinal groove was prepared in the fragment and reattached. Group 1& 2 were further divided into group a & group b based on the use of composite. They are further divided into subgroups based on the bonding agents used. Group 3 was divided into subgroups based on bonding agents that were used in the study.
Results: The force necessary to fracture the teeth in simple reattachment was significantly inferior to the force necessary to fracture the teeth in control group. However the force necessary to fracture the teeth in chamfer and internal groove technique were very much close to that of the control group. Groups bonded with composite showed higher fracture resistance than groups bonded without composite.
Conclusion: No technique or material, when individually considered, was capable of achieving the mechanical strength of the sound teeth; however, the association of reattachment technique i.e., circumferential chamfer bonding with total etch bonding system could approximate the impact strength of the restored teeth to that observed in the sound teeth.

Keywords: Reattachment; Bonding agents; Impact strength; Dental trauma; Tooth fragment; Anterior tooth fracture.

INTRODUCTION:

"Our objective should be the perpetual preservation of what remains than the meticulous restoration of what is missing"
-M.M.DEVAN

Traumatic fracture of anterior teeth is the most frequent type of injury in the permanent dentition, especially among children from 9 to 11 years old. [1,2,3] They are more common in boys than in girls because of their active involvement in extracurricular activities. Prevalence of trauma to maxillary incisors accounts for about 37%; this is because of their anterior positioning and protrusion caused by the eruptive pattern.[3,4] A

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dental trauma with the resulting fracture of the anterior teeth is an agonizing experience for a young individual who requires immediate attention, not only because of the physical impairment but also because of the psychological impact on the patient.

Several techniques have been proposed for restoring fractured crowns, including stainless steel crowns, orthodontic bands, pin retained resin restorations, composite resins with acid etch adhesives techniques, porcelain veneers and jacket crowns, each of which show diverse degrees of success.[1] Although these alternatives recover the mechanical strength of fractured teeth,[1] these techniques are not conservative and require wear of sound dental structure and have some technical difficulties to obtain perfect tooth contour, color and translucence to match it to the remaining crown portion. Besides they are time consuming and expensive.

The development of composite materials has also made possible the use of many adhesive materials and techniques, therefore the reattachment of fractured tooth fragments would appear to be a further application of such materials. It also seems prudent to advise and educate patients to keep tooth fragments following trauma, so that reattachment may be attempted.

Chosack and Eidelman in 1964 have proposed the restoration of fractured crowns using the dental fragment. At present, reattachment of fractured tooth fragments should be the first choice to restore fractured teeth.[5] Fragment bonding has several advantages over other techniques which include: a) superior natural appearance as no composite resin appears as natural and translucent as the patient's own incisor enamel; b) harmonious wear, as most composite restorations wear out faster than the enamel while the patient's own incisor edge wears harmoniously; c) preservation of the pulp vitality; and finally, d) economical and less time consuming reconstruction of the contour and morphology of the crown.[6] The success of reattachment depends on certain factors like the site of fracture, size of fractured remnants, periodontal status, pulpal involvement, maturity of the root formation, biological width invasion, occlusion, time, material used for reattachment, use of post, and prognosis.

Another main issue which has to be considered in fragment reattachment is the longevity. Due to new traumas and un-physiologic use of the restored teeth, 50% of reattached fragments were de-bonded in 2.5 years. [7] Thus, the relative low lifespan of the teeth submitted to fragment reattachment justifies the search for new materials and techniques that could improve durability of this kind of restoration.

MATERIALS AND METHODS:

This study was undertaken in the Department of Conservative Dentistry &

Endodontics, Panineeya institute of dental sciences & research centre, Hyderabad. The purpose of the study was to evaluate the effect of various materials and reattachment techniques on impact strength of human extracted incisors. After preparation of samples, impact strength was evaluated using Universal Strength Testing Machine at Micro, Small and Medium Enterprises [MSME] Sanathnagar.

Specimen preparation:

This study utilized freshly extracted human incisors (n=150) and they were cleaned from adherent tissue using a sickle scaler. Teeth were stored in (0.9%) normal saline solution at room temperature till the beginning of experiment. Each specimen was then embedded in an acrylic block such that the long axis of tooth was aligned with the central axis of the block. To obtain standardized fragments, the crowns of 150 experimental teeth were sectioned using diamond disc. The section was perpendicular to the long axis of the teeth and parallel to the incisal edge. The length of each sectioned fragment was 3mm. Fragments broken in more than one piece were discarded and teeth with intact fragment were only included in the study.

Reattachment procedures:

Simple reattachment (n=60) (Fig 1): Fragments were restored without any additional preparation and fractured teeth were randomly assigned into six subgroups (n=10). In the first three subgroups fragments were reattached using bonding agents only (Prime & bond NT - DENTSPLY/DeTrey Konstanz, Germany, Adper single - 3M/ESPE, St. Paul, MN, USA & G bond - GC com, Tokyo, Japan) in the remaining three subgroups, the same adhesives were used in conjunction with a thin layer of hybrid resin composite (Z-250 - 3M/ESPE, St. Paul, MN, USA) .

Chamfer preparation (n=60) (Fig 2): The teeth were first sub-grouped, in the first three subgroups only bonding agents were used. In the next three subgroups, bonding agents + Z250 composite was used restored as with simple reattachment procedure. There-after, 0.3mm deep preparation was made on buccal surface using water cooled high speed cylindrical diamond burs. In each subgroup, the same adhesive used for fragment reattachment was applied on buccal cavity and light cured. Z250 resin composite was used to restore the buccal preparation. Following light curing of the composite, finishing and polishing procedures were made with Soflex discs (3M ESPE, St. Paul, MN USA).

Internal dentinal groove (n=30) (Fig 3): Before re-attachment, an internal groove (1-mm deep and 1-mm wide) was prepared within the fragment and the remaining tooth structure using water cooled, high speed carbide bur. Bonding agents were applied to both the surfaces, followed by placement of the Z250 composite within the grooves. The fragment was carefully reattached under pressure, the excess composite was removed, and each tooth surface was light cured for 60 seconds.

Measuring impact strength resistance

The reattached teeth were subjected to thermo-cycling. The acrylic blocks containing the specimen were mounted in universal testing machine (Instron) (Fig 4). 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 recorded in Newton's using an onscreen calibration tool. The results were tabulated in Microsoft excel sheet and subjected to statistical analysis [SPSS].

RESULT:

Data was analysed using One way Anova and Tukeys multiple post hoc statistical tests. It was observed that average fracture resistance among groups attached with composite were high when compared to those groups attached without composite (Table 1). There was significant difference in the mean fracture resistance between Group 1a and group 1b (P value: 0.015), Group 1a and 2a (P value: 0.0001), Group 1a and 3(P value: 0.0001). There was no significant difference was observed in the mean fracture resistance of group 1b with 2b (P value: 1.00). Among the subgroups, total etch bonding agents showed higher fracture resistance values, when compared to self-etch groups (Table 2, Graph 1).

Among the different techniques, the fracture resistance among groups attached with chamfer showed higher values followed by the internal groove and least by the simple reattachment groups (Table 3, Graph 2). There was significant difference in the mean fracture resistance between chamfer re-attachment and simple re-attachment (P=0.007), no significant difference between chamfer preparation and internal groove technique (P=0.277), significant difference between internal groove technique and simple reattachment (P=0.0001).

DISCUSSION:

The possibility of occurrence of oro-facial trauma in the child and teenage population is high and is considered a serious dental public health problem. Of these traumas, dental crown fractures play a major role, comprising an estimated 70% of all orofacial traumas. Uncomplicated crown fractures are frequent dental injuries, especially in young patients**.** [8]

The present study was designed to determine fracture strength of anterior crown fragment reattached using simple reattachment, over-contouring with chamfer and internal dentinal groove techniques. Anterior teeth were selected for the study because of the high frequency of trauma in this region. [2,3] Impact strength evaluation of reattached teeth is highly relevant because most of the reattachment failures occur due to new trauma.[4] So by increasing impact strength of reattached teeth by using different methods we could increase the longevity of the tooth.

Although it has been argued that the results of in vitro studies cannot be extrapolated to the in vivo condition, it has been claimed that they may help to predict the outcome of clinical applications. Therefore, it was important that this study has both a clinical and a laboratory-based component to examine the overall clinical outcome after fragment reattachment, particularly with respect to the survival of the restored teeth.

In the current study, the teeth were sectioned in a standardized manner with a mounted disc, as the aim was to compare reattachment techniques. The sectioning was made in the incisal third of the crown so as to enable better handling of the tooth fragment during reattachment. Using a disc results in smooth surfaces, which is an advantage as the number of defects in the adhesive interface is reduced and it allows to standardize the mode of 'fracture' that would have been otherwise random.[9] Therefore, the approximation in this study, between the tooth and the fragment, 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. The test specimens were sectioned and reattached but not naturally fractured.

Impact strengths of reattached teeth specimen were evaluated in this study. In order to evaluate the impact, a crosshead speed of 5mm/min was selected and the compressive load was applied in the incisal third of teeth specimen at 45 degrees using Universal strength testing machine to simulate impact from a fall. In this way the effects of various determining factors like type of reattachment technique, type of adhesive system, and intermediate material on impact strength were determined. From the study it was observed that reattachment technique plays a major role in determining impact strength; type of adhesive system shows a secondary, but significant influence; and intermediate material has also influence on impact strength of restored teeth.

Impact strength mean values of all experimental groups (Table 2) shows that overcontouring with chamfer technique is more effective than the direct bonding technique. In over-contouring with chamfer (group 2), the highest impact strength values could be attributed to enlarged area of adhesion provided by tooth preparation around the fracture site. Due to greater extension of the material on the surface, the better force distribution is seen over a large enamel area, contrary to what occurred in simple reattachment (group 1), where the stress concentration is in the fracture line. However, this greater exposure of resin composite may diminish the long term aesthetics due to the process of abrasion and discoloration that occurs due to the composites with time.[10] Polishing at recall appointments may solve this problem.

Placement of internal dentinal groove (group 3) may provide excellent fracture strength and good esthetic durability almost next to group 2. It is likely that the greater adhesion area and permeability of an internal resin bar which acts as an opponent to compression load applied on the buccal surface could be responsible for the good results obtained in this group.

Another observation made in the study is that, the groups bonded with composite (Group 1a & Group 2a) had higher fracture resistance than the groups bonded without the composite (Group 1b & Group 2b). An in-vitro study also concluded that the worst fracture resistance and the lowest failure load were obtained from the bonded specimens with adhesive only. [10]

Among the different adhesive systems used in the present study, the total etch systems (Subgroups 1, 2, 4, 5) have shown higher fracture resistance when compared to groups where, self-etch systems (Subgroups 3, 6) were used.

Despite of the ever-increasing popularity of self-etching bonding agents, adhesive systems that employ phosphoric acid as a separate conditioner still represent the gold standard of reliable and strong enamel bonding. [11,12] Enamel etching with phosphoric acid provides selective dissolution of prisms, increasing porosity and surface energy, allowing better surface wetting by the adhesive and better interlocking between adhesive and substrate.

Therefore, when individually considered, none of the factors (reattachment technique, adhesive system and luting agent) were capable to restore the original strength of the teeth, regardless of the other factors. However, an appropriate association between reattachment technique and adhesive system can completely rehabilitate the reattached teeth, providing impact strength similar to sound teeth. In this study, the appropriate association was found between over-contouring with chamfer technique and total-etch adhesive system.

The recovery of the impact strength of the restored teeth is the main goal of fragment reattachment. Based on the results of this study, it was observed that the reattachment technique and proper selection of materials are the main factors that, determines the impact strength of fragment reattached teeth. However, the bonding procedure is also important and should be carried out carefully, because flaws during the bonding procedure could reduce the bond strength of the segments. In this way, the results of this study provide information about impact strength of restored teeth.

CONCLUSION:

According to the methodology used within the parameters of this in vitro study, the following conclusions can be drawn:

1. Fragment re-attachment with additional preparation is a realistic alternative for restoring esthetics and

function to the traumatized teeth.

2. Of the preparations techniques employed in the present study, group 2 (chamfer technique) showed highest fracture resistance nearing to control group, when compared to group 1(simple reattachment technique) and group 3(internal dentinal groove technique).

3. The groups bonded with composite showed highest fracture resistance than the groups bonded with only adhesives & without composite.

4. Among the various adhesive systems used, total etch system showed highest fracture resistance when compared to self-etch system.

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FIGURES:

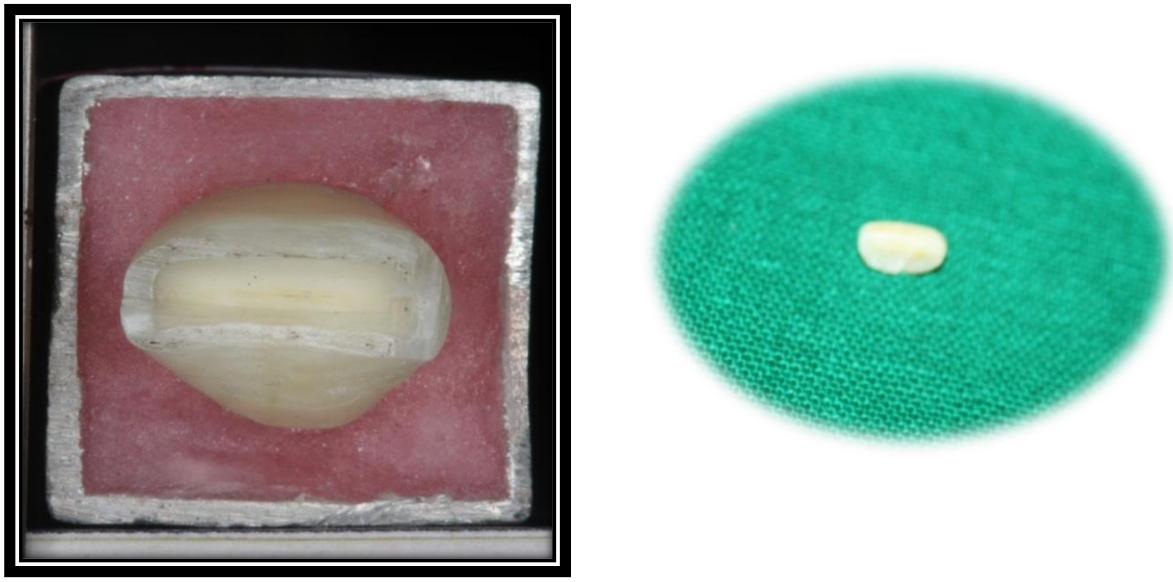


FIG 1: Simple reattachment technique

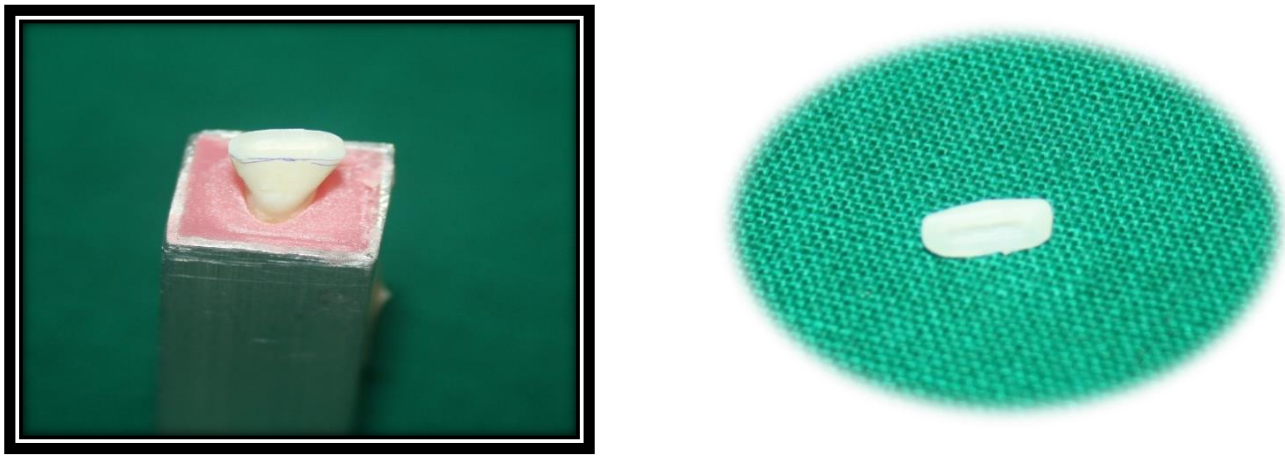


FIG 2: Teeth with internal dentinal groove

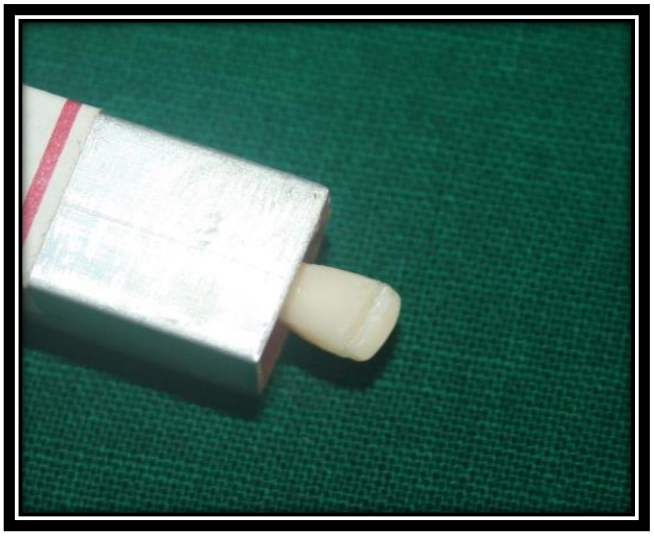


FIG 3: Placement of circumferential chamfer

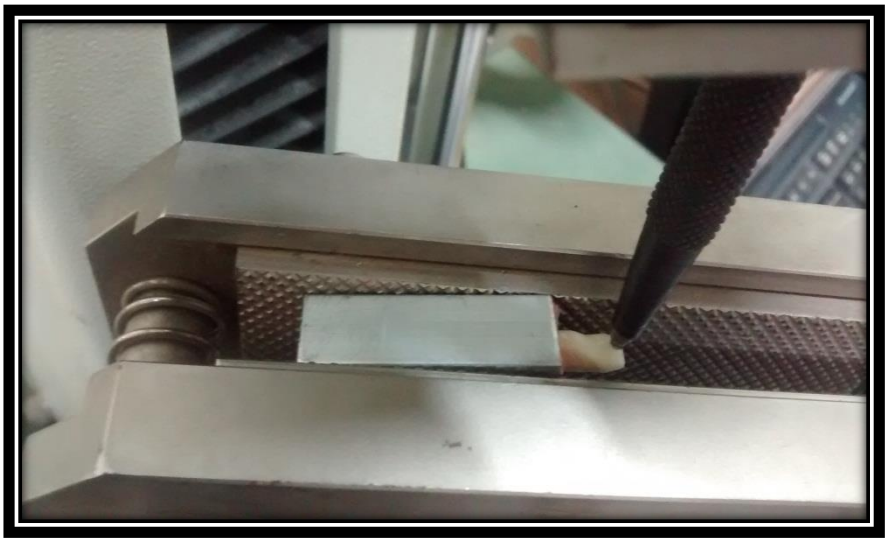


FIG 4: Mounting of specimen on UTM

TABLES:

Table 1: Fracture resistance among groups attached with composite and without composite

Group 1a	Mean	84.84
	Std. Deviation	13.41
Group 1b	Mean	51.87
	Std. Deviation	19.51
Group 2a	Mean	159.63
	Std. Deviation	35.08
Group 2b	Mean	41.64
	Std. Deviation	11.85
Group 3	Mean	124.76
	Std. Deviation	40.87
Control Group	Mean	305.35
	Std. Deviation	114.92

Table 2: Fracture resistance among subgroups

Group 1a SIMPLE REATTACHMENT (With composite)	Sub group 1	Mean	89.06
		Std. Deviation	12.94
	Sub group 2	Mean	86.95
		Std. Deviation	10.79
	Sub group 3	Mean	77.80
		Std. Deviation	14.92
Group 1b SIMPLE REATTACHMENT (Without composite)	Sub group 4	Mean	38.06
		Std. Deviation	11.25
	Sub group 5	Mean	73.19
		Std. Deviation	11.77
	Sub group 6	Mean	44.35
		Std. Deviation	13.48

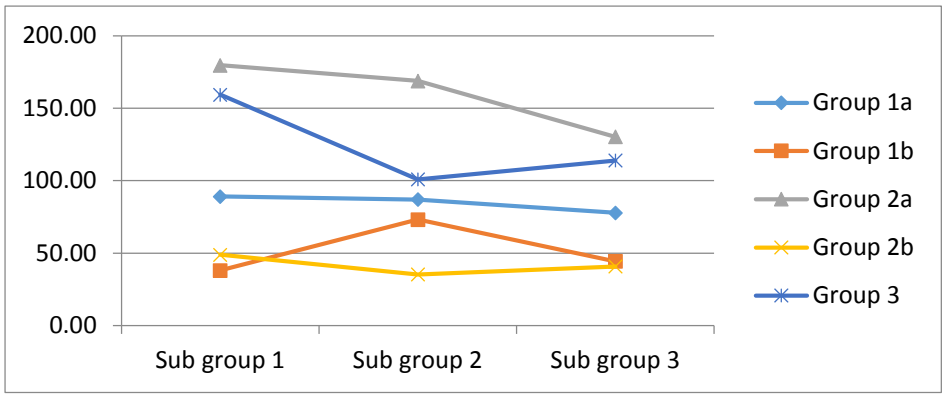
Group 2a CHAMFER (With composite)	Sub group 1	Mean	179.69
		Std. Deviation	39.10
	Sub group 2	Mean	168.85
		Std. Deviation	20.38
	Sub group 3	Mean	130.34
		Std. Deviation	22.92
Group 2b CHAMFER (Without composite)	Sub group 4	Mean	48.89
		Std. Deviation	8.17
	Sub group 5	Mean	35.24
		Std. Deviation	12.35
	Sub group 6	Mean	40.78
		Std. Deviation	11.31
Group 3 INTERNAL GROOVE	Sub group 1	Mean	159.37
		Std. Deviation	54.74
	Sub group 2	Mean	100.90
		Std. Deviation	11.48
	Sub group 3	Mean	113.93
		Std. Deviation	12.94

TABLE 3: Group wise comparison (P-value)

Group	1 = Simple Reattachment	2 = Over contouring with Chamfer	3 = Internal dentinal groove	4 = Control teeth
1 = Simple Reattachment	-	0.007	0.0001	0.0001
2 = Over contouring with Chamfer	0.007	-	0.277	0.0001
3 = Internal dentinal groove	0.0001	0.277	-	0.0001
4 = Control teeth	0.0001	0.0001	0.0001	-

GRAPHS:

Graph 1: Comparison of average force required to fracture tooth among various sub groups



Graph 2: Comparison of average force required to fracture tooth among various sub groups