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Comparative evaluation of fracture strength of reattached anterior tooth fragment using difference reattachment procedures: an in vitro study

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Abstract

Aim of The Study: Aim of the study was to evaluate the fracture strength and fracture strength recovery of reattached anterior tooth fragments by using different reattachment procedure.

Materials And Methodology: A total number of 40 human permanent central incisor teeth were selected for the study. The roots of the teeth were confined in a special device (holder) and adapted in a Universal Testing Machine. Load was applied to each tooth in bucco-lingual direction, by using a small stainless steel chisel. The force which was required to fracture the intact tooth was recorded and the mean obtained from 40 teeth is considered as the fracture strength for the control group. Both the fragment and remaining fractured tooth was restored by using four reattachment techniques - external chamfer, over contour, internal dentinal groove and by using flexible glass fiber post. fracture strength was determined for each technique using universal testing machine and and it was correlated with the fracture strength of an intact tooth.

Results

The results of this study showed following mean value of fracture strength in KgF.

group I(external chamfer)- 11.54, group II(over contour)- 15.91, group III(internal dentinal groove)- 21.86, group

IV(using flexible glass fiber post)- 26.83. Group I(external chamfer) and group II(over contour) showed fracture strength recoveries of 45.6% and 56.2% respectively. However, these values were lower than those which were obtained by using group III (internal dentinal groove) - 72.8% and group IV (using flexible fiber post) -85.5%.

Conclusion: Highest fracture strength and fracture strength recovery was obtained when the fragments were reattached with flexible glass fiber post followed by internal dentinal groove,over contour and external chamfer.

Keywords: External chamfer, over contouring, internal dentinal groove, flexible glass fiber post, fracture strength, fracture strength recovery

Introduction

Traumatic dental injuries are the most disruptive and distressing emergencies which are presented in the dental practice. A majority of fractures and displacements result from simple fall, accidents which occur during sports activities or childish pranks, that may alter the facial appearance from an attractive to an unattractive profile, leaving patients in pain and discomfort[1]. Dental trauma usually affects single tooth; however, certain injuries like automobile accidents and sports injuries involve multiple teeth. It is estimated that nearly 15–20% of population under the age of 18 years would have suffered injuries to upper and lower incisors [2]. Coronal fractures of anterior teeth are the most frequent form of acute dental injury that mainly affects children and adolescents [3].The position of maxillary incisors and their eruptive pattern carries a significant risk for trauma [4].

There are certain Factors which influence the management of coronal tooth fractures which includes extent of the fracture , the pattern of fracture and restorability of fractured tooth. Secondary traumatic injuries, presence/absence of fractured tooth fragment and its condition for use, occlusion, esthetics, finances and the prognosis aslo influence the mangement of fracture [5] .

In the pre-adhesive era, fractured teeth needed to be restored either with pin-retained inlays or cast restoration that sacrificed healthy tooth structure and were a challenge for clinicians to match with adjacent teeth [4]. In the past fractured anterior teeth were restored by endodontic treatment followed by cast post and core. This procedure provides custom fit to the root configuration and the clinician can change the axial angulation of the core. Despite of having long track record cast post and core have sevevral limitations like removal of additional tooth structure, casting inaccuracies and it involves multiple appointments. They also exhibit high stress concentration at the post dentin interface. Introduction of prefabricated adhesive post discouraged the use of cast post and core. They provided a viable alternative to cast metal posts for the restoration of root filled teeth. The major advantage of fiber posts is the similar modulus of elasticity to that of dentin. Prefabricated posts do not require intermediate phase and, therefore, allow the whole restoration to be performed in one visit, resulting in an easier, less expensive technique. Moreover, the failure mode for these post systems will allow for further repair. However, adaptation of the post to the root canal may be less accurate [6].

Introduction of recent adhesive materials has allowed dentist to use the patient's own fragment to restore the fractured teeth, especially when there is no or minimal violation of the biological width [4]. Restoration of such traumatized incisors by reattachment of the original tooth fragment appears to be the most conservative treatment approach, even when a coronal fragment is not completely recovered intact [7]. Compared with other restorative techniques like composite restorations, laminate veneers, post and core, reattachment procedure can offer several

advantages such as improved esthetics and function, restoration of the surface anatomy with increased wear resistance. The chair side time for the completion of the restoration is also minimal [8]. Tooth fragment reattachment offers a conservative, esthetic, and cost effective restorative option that has been shown to be an acceptable alternative to the restoration of the fractured tooth with resin-based composite, post core and full-coverage restorations [5].

Clinicians have tested a variety of retentive preparation designs, as well as different resin-based composites and adhesive materials for the reattachment of tooth fragments. Reattachment of fractured enamel-dentin crown fragments using the glutaraldehyde hydroxyethyl methacrylate (GLUMA) dentin bonding system was begun as a routine treatment of complicated and uncomplicated crown fractures[9]. With improvements in hydrophilic adhesives that offer high bond strength values, some investigators have attempted to reattach fragments using these materials without an additional retentive preparation. Simple reattachment with no further preparation of the fragment or tooth may not be able to restore even half of the fracture strength of intact teeth[10]. Consequently, many authors have advocated the necessity of using additional preparations to augment the retention of the reattached fragment [11]. Such preparation methods include enamel beveling of the fragment and remaining crown , internal dentin groove , external chamfer , and the over contouring technique, all of which have their own advantages and disadvantages.

The primary cause of failure of the reattached tooth fragment may be due to further trauma or the use of the restored tooth with excessive masticatory forces, which justifies many previous attempts that have been directed toward improving the fracture strength of the re -bonded fragment. Resin based restorative materials are frequently used in restoration of the fractured teeth. Because of the poor mechanical resistance of these materials, different approaches developed to strengthening resistance of composite resin such as fiber reinforced posts. They have several advantages, such as esthetic, bond to tooth structure, have a modulus of elasticity similar to that of dentin, but still require dentin preparation to fit into the canal [12].

A novel method introduced for restoring fractured tooth is through soft, flexible and adaptable unpolymerized glass fiber post. It is also called as electrical glass fiber post as its chemical composition makes it an excellent electrical insulator [13]. They are made of silanated glass fibers in thermoplastic polymer and light curing resin matrix, address the advantages of minimally invasive dentistry where the patient´s own healthy tooth tissue is saved for as long as clinically possible[14]. A unique interpenetrating polymer network structure (IPN) which allows superior bonding enabling reliable surface retained applications and perfect handling properties. It also Adapts to the morphology of the canal to maximize the adhesive surface and offers High flexural strength after light-curing [15].

In light of many published studies that verified the efficacy of the fragment reattachment techniques, it has become apparent that both the preparation technique and the kind of material used to bond fractured fragments may have significant effects on the fracture strength of such restored teeth[11].

These observations highlight the need for further investigation for comparing fracture strength of different reattachment procedures under standardized conditions.

Aims and Objectives of the Study

Aim of the study is to evaluate the fracture strength of reattached anterior tooth fragments by using different reattachment technique.

- To compare fracture strength recovery of different reattachment techniques

Materials And Method

Materials

1. 40 extracted human maxillary central incisor
2. 0.9% saline
3. One bottle adhesive system (3M Single Bond)
4. Dual cure resin cement (3M Rely X)
5. Composite Resin Universal Resolution A2 shade (3M Z-100)
6. Glass fibre reinforced post (GC Everstick post- 0.9 mm diameter)
7. Curing light(Light Emitting Diode-WOODPECKER)
8. Artificial saliva(Wet Mouth, CPA Health Products LTD)
9. Universal Testing Machine(SHIMADZU)

Methodology

Forty human permanent central incisor teeth were selected for the study. The teeth were equally divided into four test groups. They were disinfected and stored in 0.9% saline solution.

The test basically consisted of three procedures.

1) Method of obtaining fragment.

2) Reattachment of the fractured teeth.

3) Fracture of the reattached teeth.

Method for obtaining fragments

The buccal surface of each tooth was divided into transversal and longitudinal third parts. The roots of the teeth were confined to a special device (holder) and adapted in a Universal Testing Machine. The load is applied to each tooth in a buccal – to – lingual direction by using a small stainless steel chisel which is inserted at the end of a pin which is held in the cross head of the Universal Testing Machine at a cross head speed of 0.6 mm/minutes.The teeth with uncomplicated type of fracture during application of load was selected for the study. The force which was required to fracture the intact tooth was recorded and the mean obtained from 40 teeth is considered as the fracture strength for the control group. Forty teeth were then randomly divided into 4 experimental groups which represents the various reattachment techniques.

The 4 experimental groups are as follows:

1. External Chamfer(N=10)
2. Over Contour(N=10)
3. Internal Dentinal Groove(N=10)
4. Flexible Fibre Post (N=10)

Reattachment of the Fractured Teeth by using different reattachment techniques

Both the fragment and the remaining fractured tooth surface were kept in 0.9% saline solution until the restoration procedure was performed. The material which is used was one bottle of adhesive, dual cure resin cement and composite resin which were applied by following the manufacturer's instructions. The adhesive system was applied to both the fragment and the remnant. However, the adhesive is not immediately light-cured, in order to avoid any interference with the fit between the parts which had to be bonded. After that, the resin cement was applied, the fragments were reattached and they were light cured for 40 seconds (both buccal and lingual surfaces). The fragment and the remaining fracture tooth surface were restored by using different reattachment techniques such as;

1) External chamfer.

2) Over contour.

3) Internal dentinal groove.

4) Reattachment using flexible fibre post

Technique 1: External chamfer

After re-attachment of fractured tooth fragments, a 1.0 mm depth chamfer was placed in the fracture line, in the buccal surface, by using a diamond round bur.

Technique 2: Over contour

Prior to performing the re-attachments of fractured tooth fragments,preparation was done in the buccal surface by using a cylindrical diamond finishing bur. The preparation extended 2.5 mm coronally and apically from the fracture line, with a depth of 0.3 mm. The increment of resin composite was used to restore the buccal surface after applying the adhesive system. This created a slightly over contoured tooth surface.

Technique 3: Internal dentinal groove

Prior to performing the re-attachment of fractured tooth fragments, an internal groove (1 mm deep and 1 mm wide) was placed within the fragment and the remaining tooth by using a carbide bur with a water coolant and a high speed hand piece. The adhesive system was applied to each surface. Prior to light curing, dual cure resin cement was placed within the groove. The fragment was reattached and the excess was removed. Each surface was then light cured for 40 seconds.

Technique 4 : Reattachment using flexible fibre post

Before reattachment an internal groove (2.5mm deep and 1.2 mm wide) were placed within the fragment and the remaining tooth by using a carbide bur with a water coolant and a high speed hand piece. Flexible fibre post of 2cm in length was cut into four equal halves (of length 5mm each). The adhesive system was applied. Prior to light curing flexible fibre post coated with dual cure resin cement was placed in the prepared space and light cured for 40 seconds.

In-order to simulate the oral conditions all reattached tooth specimens were stored in artificial saliva.

Fracturing of the reattached teeth after reattachment techniques

The specimens were loaded in the same pre-determined area which was used in procedure, to obtain fragments. The force which was required to detach each fragment was recorded in KgF. The fracture strengths of all sound teeth were averaged. For each tooth, the fracture strength was expressed as a percentage of the load which was required to fracture the sound tooth. This result was establishment of a relationship between the fracture strength of an intact tooth and those which were obtained after reattachment procedures which were done for all groups.

Results

Table 1: Mean fracture strength (KgF) and standard deviation in experimental groups

Groups	Mean	SD
External Chamfer	11.54	1.93
Over Contour	15.91	2.16
Internal Dentinal Groove	21.86	1.73
Flexible Glass Fiber Post (Everstick Post)	26.83	2.29

Group IV (using flexible glass fiber post) showed higher mean fracture strength value of 26.83 followed by group III (internal dentinal groove)- 21.86, group II(over contour)- 15.91. Group I (external chamfer) presented least mean fracture strength value of 11.54.

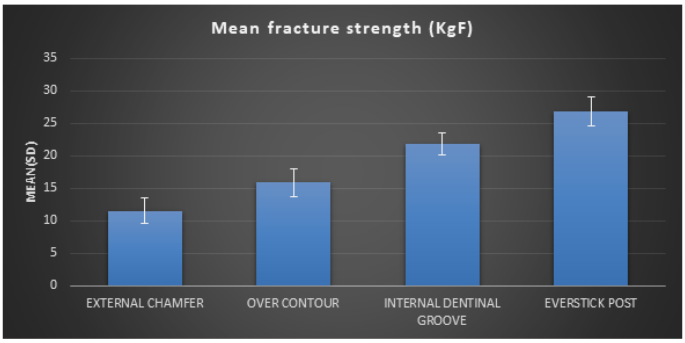


Table 2: comparison between fracture strength (KgF) in experimental groups

Groups	Mean	SD	F value	P value
External Chamfer	11.54	1.93		
Over Contour	15.91	2.16		
Internal Dentinal Groove	21.86	1.73		
Flexible Glass Fiber Post (Ever stick Post)	26.83	2.29	101.74	<0.001**

One way ANOVA; Tukeys post hoc test; ($p < 0.05$ - Significant*, $p < 0.001$ - Highly significant **)

Multiple Comparisons						
Tukey Hsd						
(I) Var00005	(J) Var00005	Mean Difference (I-J)	Std. Error	P Value	95% Confidence Interval	
					Lower Bound	Upper Bound
External Chamfer	Over Contour	-4.36254*	.91471	.000	-6.8261	-1.8990
	Internal Dentinal Groove	-10.28553*	.91471	.000	-12.7490	-7.8220
	Everstick Post	-14.84245*	.91471	.000	-17.3060	-12.3789
Over Contour	External Chamfer	4.36254*	.91471	.000	1.8990	6.8261
	Internal Dentinal Groove	-5.92299*	.91471	.000	-8.3865	-3.4595
	Everstick Post	-10.47991*	.91471	.000	-12.9434	-8.0164
Internal Dentinal Groove	External Chamfer	10.28553*	.91471	.000	7.8220	12.7490
	Over Contour	5.92299*	.91471	.000	3.4595	8.3865
	Everstick Post	-4.55692*	.91471	.000	-7.0204	-2.0934
Flexible Glasss Fiber Post(Ever stick Post)	External Chamfer	14.84245*	.91471	.000	12.3789	17.3060
	Over Contour	10.47991*	.91471	.000	8.0164	12.9434
	Internal Dentinal Groove	4.55692*	.91471	.000	2.0934	7.0204
*. The Mean Difference Is Significant At The 0.05 Level.						

Table 3: Comparison between fracture strength (KgF) normal teeth in each group

Groups	Mean	SD	F value	P value
External Chamfer	26.50	1.46	5.75	0.003*
Over Contour	28.51	3.51		
Internal Dentinal Groove	30.21	2.93		
Flexible Glass Fiber Post (Everstick Post)	30.95	2.04		

One way ANOVA; Tukeys post hoc test;($p < 0.05$ - Significant*, $p < 0.001$ - Highly significant**)

Multiple Comparisons

Dependent Variable: VAR00006

Tukey HSD

(I) VAR00005	(J) VAR00005	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
External Chamfer	Over Contour	-1.99729	1.16738	.333	-5.1413	1.1467
	Internal Dentinal Groove	-3.71320*	1.16738	.015	-6.8572	-.5692
	Everstick Post	-4.44855*	1.16738	.003	-7.5926	-1.3045
Over Contour	External Chamfer	1.99729	1.16738	.333	-1.1467	5.1413
	Internal Dentinal Groove	-1.71591	1.16738	.466	-4.8599	1.4281
	Everstick Post	-2.45126	1.16738	.173	-5.5953	.6928
Internal Dentinal Groove	External Chamfer	3.71320*	1.16738	.015	.5692	6.8572
	Over Contour	1.71591	1.16738	.466	-1.4281	4.8599
	Everstick Post	-.73535	1.16738	.922	-3.8794	2.4087
Flexible Glass Fiber Post(Everstick Post)	External Chamfer	4.44855*	1.16738	.003	1.3045	7.5926
	Over Contour	2.45126	1.16738	.173	-.6928	5.5953
	Internal Dentinal Groove	.73535	1.16738	.922	-2.4087	3.8794

*. The mean difference is significant at the 0.05 level.

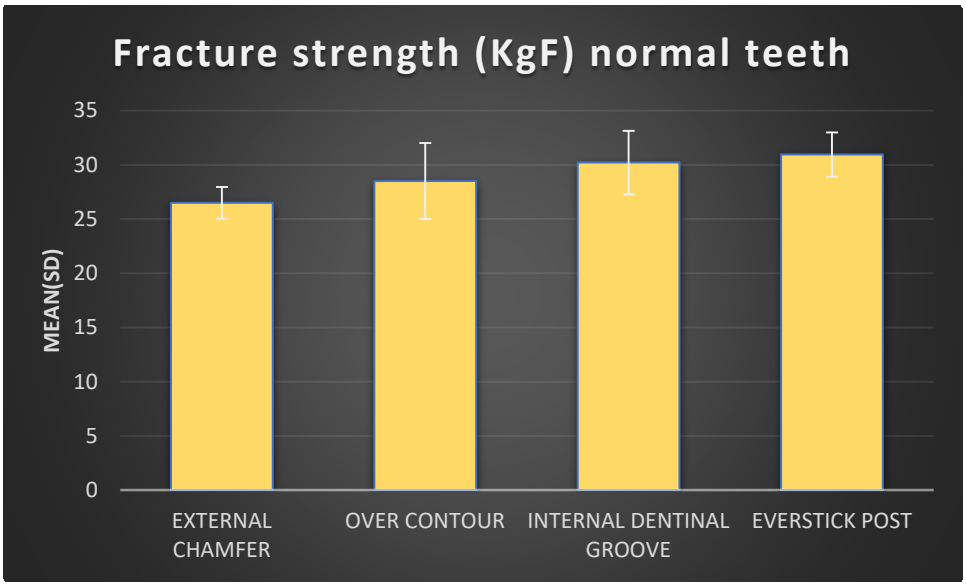


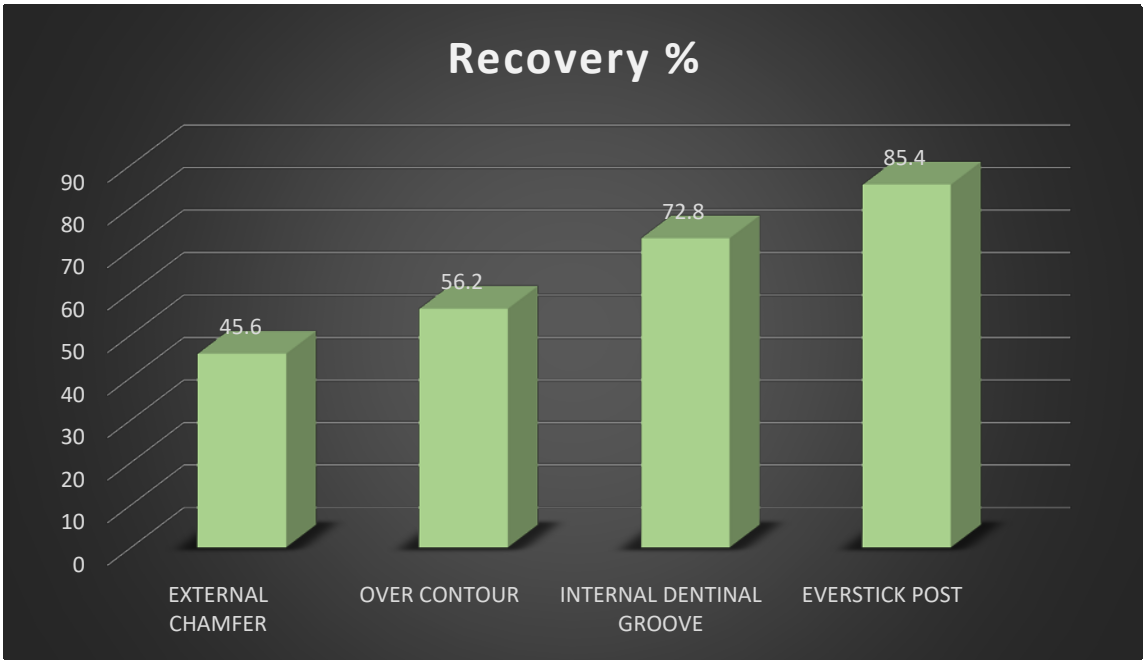
Table 4: Comparison between fracture strength (KgF) recovery experimental groups

Groups	Recovery % Mean	SD	F value	P Value
External Chamfer	45.6	7.3	51.33	<0.001**
Over Contour	56.2	7.4		
Internal Dentinal Groove	72.8	8.6		
Flexible Glass Fiber Post(Everstick Post)	85.4	9.1		

One way ANOVA; Tukeys post hoc test;($p < 0.05$ - Significant*, $p < 0.001$ - Highly significant**)

Multiple Comparisons						
Dependent Variable: VAR00002 Tukey HSD						
(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
External chamfer	Over contour	-12.59517*	3.63824	.007	-22.3938	-2.7966
	Internal dentinal groove	-29.24134*	3.63824	.000	-39.0399	-19.4427
	Everstick post	-41.97034*	3.63824	.000	-51.7689	-32.1717
Over contour	External chamfer	12.59517*	3.63824	.007	2.7966	22.3938
	Internal dentinal groove	-16.64617*	3.63824	.000	-26.4448	-6.8476
	Everstick post	-29.37517*	3.63824	.000	-39.1738	-19.5766
Internal	External	29.24134*	3.63824	.000	19.4427	39.0399

dentinal groove	chamfer					
	Over contour	16.64617*	3.63824	.000	6.8476	26.4448
	Everstick post	-12.72900*	3.63824	.007	-22.5276	-2.9304
Flexible glass fiber post (everstick post)	External chamfer	41.97034*	3.63824	.000	32.1717	51.7689
	Over contour	29.37517*	3.63824	.000	19.5766	39.1738
	Internal dentinal groove	12.72900*	3.63824	.007	2.9304	22.5276
*. The mean difference is significant at the 0.05 level.						



Discussion

Management of dental trauma in children and teenagers is a major challenge. Success of identification and management of traumatic fractures lies in thorough patient examination and treatment planning. For uncomplicated crown fractures, "Reattachment of fractured tooth fragments" is one of the treatment options[16]. Reattachment procedure utilizing fractured fragment of natural tooth present several advantages over restorations obtained with composite resin systems such as better and long-lasting esthetics, improved function, and positive psychosocial response. It is faster and less complicated procedure than conventional restorative procedures[17].

After reattachment improved esthetics is obtained since it retains the original shape,colour, brightness and surface texture of the natural teeth. In addition, a composite restoration is likely to wear more rapidly than natural teeth when it is placed as an incisal edge restoration,furthermore fractured tooth reattachment is less time consuming and provides more predictable long term results[17].

Maxillary incisors are most commonly affected by traumatic injuries [3]. In the present study; maxillary central

incisors were included because in natural conditions also, these teeth are most prone to trauma. Their proneness to fracture can be attributed to their anterior position and proclination.

Incisors of comparable external crown size were selected because the other variables like external crown size, internal geometry (pulp chamber), enamel thickness and structure of dental tissues could not be controlled

The methodology employed in the present study was based on the study of **Badami A A et al** [18]. All the teeth in this evaluation were fractured at 3 mm from the incisal edge in an attempt to standardize the depth of dentin at which the adhesive was applied. It has been shown by **Causton et al** [19] that bond strength at different depth of dentin vary considerably.

Ellis Class II fracture pattern was selected for this study since fracture provides an ideal indication for reattachment procedure. In case of simple enamel fracture, the fractured surface is so small that either rounding off of the enamel margins is done or else the fragment obtained is not intact to allow reattachment due to brittle nature of enamel. However, in case of enamel and dentin fracture, as the fracture is quite massive, there are greater chances of availability of intact fragment, which can be bonded to the tooth with the help of reattachment procedure.

Various techniques and designs have been proposed for reattachments of fractured tooth fragments, like bevel designs, chamfers, dentin and enamel grooves,over contour and placement of resin composite materials[20].Reattachment procedure can also be carried out using using glass fiber post. Tooth fragment reattachment is advantageous, since it conserves dental tissue, it retains shade of the natural tooth, maintains original tooth contour, reduces chair side time and is an economical procedure[21].

In the present study four different reattachment procedures were compared, such as external chamfer(group I), overcontour(group II), internal dentin groove(groupIII), reattachment using flexible glass fiber post(group IV).

Reattachment procedure in this study utilized hybrid composite (3M ESPE Z100), single bond universal adhesive (3M ESPE), and dual cure resin cement (RelyX-3M ESPE). Dual cure resin cement is preferred for reattachment of fractured tooth fragment since it provides extended working time and adequate degree of polymerization. Dual curability allows light cure what can be visualized and the resin cement that is not accessible to light will undergo selfcure, ensuring that no cement is left uncured. Dual cure resin cement also offers better impact strength over flowable composite[22].

In group I (External chamfer) after re-attachment of fractured tooth fragments, a 1.0 mm depth chamfer was placed in the fracture line in the buccal surface, using a diamond round bur.Where as in group II (over contour) Prior to performing the re-attachments of fractured tooth fragments, preparation was done in the buccal surface,which is extended 2.5 mm coronally and apically from the fracture line, with a depth of 0.3 mm. The increment of resin composite was used to restore the buccal surface after applying the adhesive system. Group III (internal dentinal groove) consists of an inernal groove preparation (1 mm deep and 1 mm wide) on both fractured tooth fragment and remaining tooth. The adhesive system was applied to each surface. Prior to light curing, a resin composite was placed within the groove.In group IV(reattachment using flexible fiber post), before reattachment an internal groove (2.5mm deep and 1.2 mm wide) were placed within the fragment and the remaining tooth and flexible fibre post of 2cm in length was cut into four equal halves(of length 5mm each).After application of adhesive system, Prior to light curing flexible fibre

post coated with dual cure resin cement was placed in the prepared space and light cured for 40 seconds.

Munksgaard et al, Worthington, Murchison & Vandewalle [23];**Dean, Avery & Swartze** [24] have demonstrated reattachment techniques shows fracture strengths recovery of approximately 50% to 60% that of the intact tooth.

More recently with improvement in hydrophilic adhesives **Andresen& Andreasen**[3]**; Badami, Dunne & Scheer** [18] **; John Kanca III** [25]**; Amedeo Pagliarini et al** [26]; have attempted to reattach fragments using no additional preparation or simple reattachment. ln addition to the assortment of techniques presented, **Simonsen** [27] describes the association of a v- shaped internal groove and lingual enamel bevelling. **Burke F.J.T** [28]explained the placement of an internal dentin groove and the circumferential beveling of enamel margins.

In this study it was found that Group I (external chamfer) had shown low fracture resistance. This may be due to the minimal bonded surface. **Reis et al** [10]have shown that external chamfer show recovery strength of 60.6% .These findings oppose the results published by **Farik& Munksgaard** [29]and **Farik et al** [30], showing better bond stength using this technique ,which may be due to the differences in the methodology used as well as inclination of the load. Only a few studies have attempted to evaluate the fracture strength of the reattached tooth utilizing external chamfer technique & their results vary considerably among different research personnel. **Reis et al** [11] have shown that external chamfer showed fracture strength recovery of 60.60% of intact tooth while the over contouring and internal dentinal groove techniques nearly reached intact tooth fracture strength recovery of 97.2% & 90.5% respectively.

The controversy among laboratory studies may result from methodological differences like, the mechanical test chosen, teeth whether it is young adults, old age, the method used to obtain tooth fragments and the fracture pattern.

Tooth fragments from the 40 teeth used in this study fit the remaining tooth structure perfectly with no visible disruption of the cavosurface margin at the fractured site. As a result the thickness of the adhesive and resin cement in the interface were less which may have contributed to the lower fracture strength found in Group I specimens.

In Group II (over contouring technique), the fracture strength was increased when compared to Group I (external chamfer). This may be attributed to the increased surface area of the adhesion provided by tooth preparation around the fracture site.

According to **Andreasen et al** [31], the greater extension of the material on the surface, the better the force distribution over a large enamel area.This technique has some drawback like greater exposure of a resin composite to the oral environment will diminish the long term esthetics due to the process of abrasion and discoloration that occurs to composite with time. Polishing at recall appointments may solve this problem. In another study **Andreasen et al** [32] explain that when enamel structure is lost in the trauma event, it may be more convenient to use an over contouring technique (depending on the extension of the tooth structure loss) so that the esthetics can be obtained simultaneously with the increase in adhesion area.

Placement of an internal dentinal groove (group III) provides higher esthetic durability as well as excellent fracture strength. It is likely that the greater adhesion area and placement of an internal resin bar, which acts as an opponent of the compression load applied on the labial surface, were responsible for the good results in this group. Also this technique did not alter the precise fit between the fragment and the remaining tooth. Esthetically, the most favorable situation exists when there

is minimal disruption of enamel at the labial fracture site, and the segments fit together with no visible defect. This facilitates an accurate apposition of the fragment and minimizes enamel composite interface.

Reis et al [10] have shown that reattachment by internal groove technique nearly reached intact tooth fracture strength (90.5%). They also explain that the qualities of fit between segments are an important factor to be considered. When the segments fit together with no appreciable disruption or defects, techniques that prevent resin composite from being exposed to the oral environment, such as placement of an internal groove, would be preferable.

Reinforcement of the reattached fragments using glass fiber posts has been widely reported in the literature. Although many techniques with various materials have been suggested, resin-based restorative materials with tooth-colored fiber post may be considered the best option because of several advantages such as a suitable elastic modulus, esthetics, good bonding between post and cement, lower chair time, and minimal tissue removal [33].

In this study reattachment using flexible fiber post (group IV) showed higher fracture resistance and fracture strength recovery compared to other methods such as external chamfer(group I),overcontour (group II) and internal dentinal groove(groupIII).

S. N. Akyu reported that Reattachment of fractured tooth fragment using glass fiber post showed higher fracture strength as it interlocks the two fragments, minimizes the stress on the reattached tooth fragment [34].

Doshi P et al showed that E-glass fiber posts showed significantly higher fracture resistance than the other fiber posts like glass fiber post, carbon fiber post. Flexbility of E glass fiber post allows better handling and adaptability[35].

The present study utilized flexible glass fiber post(E-glass).They are made up of silanated glass fibers in thermoplastic polymer and light curing resin matrix. Address the advantages of minimally invasive dentistry where the patient,s own healthy tooth tissue is saved for as long as clinically as possible. A unique interpenetrating polymer network structure (IPN) which allows superior bonding enabling reliable surface retained applications and perfect handling properties. The significance of IPN structure is that surfaces can be reactivated even after the final polymerization[11]

Most laboratory studies that have tested adhesive systems showed that the kind of adhesive system used can alter the fracture strength of the reattached teeth.**Badami et al** [18]; **Farik et al** [36]; **Pagliarini et al** [26] found that fracture resistance of reattached tooth fragment using different adhesive system is in the range of 4O% to 60%of the fracture strength of natural teeth. Thus the choice of adhesive system may depend on the clinician's expertise with a specific material and the literature reports on its performance such as bond strength values and the percentage of micro leakage when tested in vitro.

Fragment reattachment is advantageous, since it conserves dental tissue, is colour matched with natural tooth, maintains original tooth contour, reduces chair side time and it is an economical procedure. Whereas, it has some disadvantages such as lesser than natural aesthetics if the tooth fragment is allowed to dehydrate which causes change in colour of the bonded fragment. So continuous monitoring is necessary due to chances of separation of the repair caused by progressive breakdown of the bonded junction.

With use of available newer materials, in conjunction with appropriate techniques, aesthetics, we can improve the longevity of the reattached tooth. Reattachment of fractured fragment is a conservative approach which can

be used for restoring function and aesthetics of fractured tooth. Whereas, further research is needed to test the long term success of reattachment of a fractured fragment using newer materials like flexible fiber post.

Conclusion

As per the results obtained and discussed in this in vitro study, it can be concluded that:

- The fracture strength invariably varies with the technique used to reattach fractured fragments. In this present study reattachment using flexible fiber post significantly has higher fracture strength than internal dentinal groove, over contouring. External chamfer proved to have low fracture strength as compared to the other three techniques.
- Reattachment using flexible fiber post has higher fracture strength recovery compared to internal dentinal groove, over contour and external chamfer techniques.
- Not many studies are there in conservative dentistry related to fractured tooth fragment reattachment using flexible glass fiber post. Use of flexible glass fiber post is a novel method that can revolutionize reattachment procedures.
- Reattachment of fractured fragment is faster, easier, and cost effective. Highest strength can be achieved by using a combination of techniques and bonding materials. Hence, reattachment of fractured fragments can be a preferred technique.

Summary

Reattachment of fractured tooth fragment offers several advantages over other restorative procedures following crown fracture .As it results in an exact restoration of crown and surface morphology in a material that abrades at the same rate as adjacent teeth. More over the chair time required is also less as compared to other restorative techniques.

Taking into consideration the importance and advantages of reattachment procedures, this in vitro study emphasis on the same. In this study various techniques of reattachment were compared and their influence on fracture strength of fragment.

In the present study 40 freshly extracted human maxillary central incisor were used.The roots of the teeth were confined in a special device (holder) and adapted in a Universal Testing Machine. Load was applied to each tooth in bucco-lingual direction, by using a small stainless steel chisel which is inserted at the end of a pin which is held in the cross head of the Universal Testing Machine at a cross head speed of 0.6 mm/minutes. The force which was required to fracture the intact tooth was recorded and the mean obtained from 40 teeth is considered as the fracture strength for the control group.

40 teeth were then randomly divided into 4 experimental groups which represents the various reattachment techniques.

GROUP - 1: External chamfer (n-10)

GROUP - 2: Over contour (n-10)

GROUP - 3: Internal groove (n -10):

GROUP - 4: Reattachment using flexible fiber post (n- 10)

The specimens were loaded in the same pre-determined area which was used in procedure, to obtain fragments. The force which was required to detach each fragment was recorded in KgF. The fracture strengths of all sound teeth were averaged. For each tooth, the fracture strength was expressed as a percentage of the load which was required to fracture the sound tooth. This result was establishment of a relationship between the fracture strength of an intact tooth and those which were obtained after reattachment procedures which were done for all groups.

Among the tested groups reattachment using flexible fiber post significantly has higher fracture strength than internal

dentinal groove, over contouring. External chamfer proved to have low fracture strength as compared to the other three techniques. Reattachment using flexible fiber post has higher fracture strength recovery compared to internal dentinal groove, over contour and external chamfer techniques.

Use of flexible glass fiber post in reattachment procedure is a novel method with several advantages. They provide better strength, adaptability, superior bonding enabling reliable surface retained applications and perfect handling properties.

In vitro studies cannot duplicate clinical condition; Further in vitro and in vivo studies and extensive research is required to prove the same.

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