AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES

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DEPARTMENT OF CONSERVATIVE DENTISTRY AND ENDODONTICS

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CERTIFICATE

This is to certify that the Dissertation entitled **"AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES"** by **Dr. USHA.S,** Post Graduate student, **MDS Conservative Dentistry and Endodontics**, Madha Dental College & Hospital -Chennai – 69 Submitted to Tamilnadu Dr. M. G.R. Medical University for the MDS Degree Examination May 2020 is a bonafide research work carried out by her under my super vision and guidance.

Guided By

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Chennai - 600 069

CERTIFICATE - II PLAGIARISM

This is to certify that this dissertation work titled **"AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES"** of the candidate **Dr. USHA. S** with Registration Number **241717652** for the award of M.D.S degree in the branch of Conservative Dentistry and Endodontics. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows 8% percentage of plagiarism in the dissertation.

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DECLARATION OF THE CANDIDATE

I, **Dr. USHA. S,** hereby declare that this dissertation titled

" AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES" is a bonafide and genuine research work carried out by me under the guidance of **Dr. V. SUSILA ANAND, MDS, PhD. Professor & Head,** Department of Conservative Dentistry & Endodontics, Madha Dental College and Hospital, Chennai - 600069**.**

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Whereas the 'PG/Research student as part of her curriculum undertakes to research **"AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES"** for which purpose the PG/Principal author shall act as principal author and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co- Author.

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Kundrathur - Chennai-600069

Ref No :MDCH | IEC | 2018 | 04

DATE : 30.03.2018

(Sub :IEC review of the research proposals)

Title of the work : AN IN-VITRO COMPARATIVE EVALUATION OF FRACTURE RESISTANCE AND BOND STRENGTH OF RE-ATTACHED FRACTURED FRAGMENT OF ANTERIOR TEETH WITH DIFFERENT TECHNIQUES.

Principal investigator: Dr. USHA. S, Ist YEAR MDS

Department: Department of Conservative Dentistry and Endodontics

Madha Dental College & Hospital, Chennai-600069

The request for approval from the Institutional Ethical Committee (IEC) considered at the Institutional Ethics Committee meeting held on the 30.03.2018, at Madha Dental College and the documents related to the study referred above were discussed and reported to us through your letter dated 23.2.2018 have been reviewed. The decision of the members of the committee, the secretary and the Chairperson IEC of Madha Dental College is here under:

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LIST OF ABBREVIATIONS

%	Percentage
FRC	Fiber reinforced composite
mm	Millimeter
cm	Centimeter
LED	Light emitting diode
UV	Ultra Violet
DEJ	Dentino enamel junction
GIC	Glass Ionomer Cement
min	Minute
h	Hour
sec	Second
No.	Number
GP	Gutta Percha
Er,Cr:YSGG	Erbium chromium-doped yttrium, scandium,gallium and garnet
RCT	Root canal treatment
mm/min	Millimeter per minute
SE	Self Etch
Bis-GMA	Bisphenol A glycidyl methacrylate

INTRODUCTION

INTRODUCTION

In dental practice, traumatic injuries are the most disruptive and distressing emergencies and it is a common challenge for dental professionals because many different protocols for treatment are currently available. It also affects social and psychological well-being of children (1). Multidisciplinary approach is involved in the management of traumatic dental injuries to maintain function and esthetics. A combination of evidence-based guidelines and clinical experience is necessary to identify the most suitable treatment. One of the most difficult and perplexing problems face in adolescence is injuries to the anterior teeth. (2).

In dental trauma, coronal fracture of anterior teeth are more common and affects mainly children and young adults. Trauma to the permanent incisors represent 18-22% of all dental traumatic injuries, of which 96% involve maxillary central incisors (1).

Management of coronal tooth fractures is influenced by several factors such as violation of biological width, fracture pattern, involvement of pulp, esthetics, occlusion, restorability of tooth, presence or absence of fractured fragment (3). Hence, preservation of dental tissue, re-establishment of the natural aesthetics and maintaining the integrity of the dental arch must be the primary goal of treatment (4). Numerous techniques have evolved for the reconstruction of traumatized teeth. Two major events have significantly changed the treatment and prognosis of traumatic dental injuries, namely:

1. The use of evidence-based treatment procedures as they apply to pulp and periodontal ligament healing after dental injuries and
2. The advancements in adhesive dentistry and their application to various phases of treating dental traumatology.

In the pre-adhesive era, traumatized fractured teeth were restored either with resin crowns, ceramic crowns, steel crowns, orthodontic bands, pin retained inlays. These restorative techniques however were not an immediate solution to an esthetic emergency and did not promote adequate long term esthetics and also required significant tooth reduction during preparation. Other treatment options include the use of composite restorations with or without pins, use of laminate veneers or porcelain onlays and resin based bridges (5).

In 1964 the concept of reattachment began where Chosak and Eidelman used a cast post and conventional cement for reattaching an anterior crown fragment (6). The development in adhesive dentistry has allowed reattachment of patient's own fragment to restore the fractured tooth. Acid etch technique in reattachment was first used by Tennery at the end of the 1970's (6).

Reattachment of the tooth fragments became a more common procedure with the acceptance of the flowable composite, because of the excellent retention obtained with the fluid resin on the etched enamel. This treatment offers several advantages over conventional acid-etch composite restoration namely:

1. Minimal tooth preparation

2. Autogenous

3. Esthetic- colour matching, stability of enamel, retention of incisal translucency

4. Faster

5. Psychological benefit of having one's own tooth

6. Restores original function of the tooth

7. Economical

8. Preservation of natural occlusal contact

9. Original morphology

10. Patient acceptance

11. Rate of occlusal wear similar to original tooth structure

Some of the disadvantages of reattachment include: (7)

1. Color changes due to dehydration of fragment

2. Necessity for continuous monitoring

3. Bonding failure

Various techniques are being used for the reattachment of the fragments of a fractured tooth. These include the following.

1. Enamel beveling

This technique advocates enamel beveling of the tooth and the fragment. This technique improves retention of fragment since beveling of enamel alters the orientation of enamel prism, thereby allowing more effective acid etch pattern. It also improves fracture resistance and short-term esthetics (8).

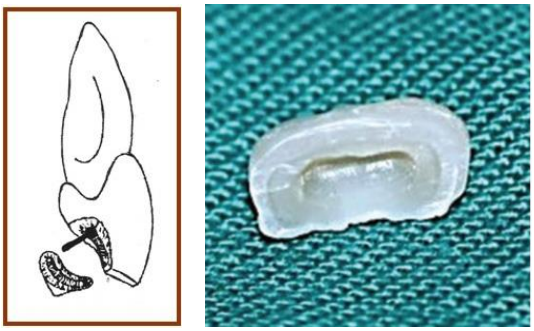
Figure 1

Circumferential bevel

2. Internal dentinal groove

Internal dentinal groove allows for placement of additional resin composite, which reinforces the reattachment. This technique however compromises esthetics as it modifies the shade of the teeth, though this is dependent on the groove size and the material (9,10).

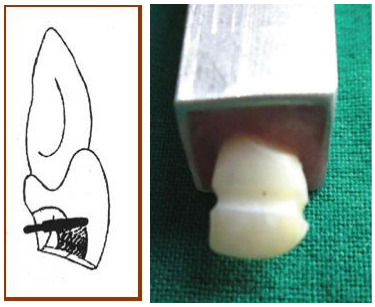
Figure 2



3. External chamfer

The previous methods have a common disadvantage of affecting the precise fit of the fragments. External chamfer technique overcomes that by first reattaching the fragments, followed by the chamfer placement externally using round diamond. It may be placed either on buccal or lingual surface or circumferentially (11).

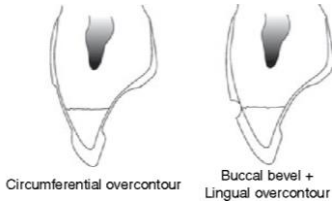
Figure 3



4. Overcontour

In this technique, after reattaching the fragment, approx. 0.3 mm depth of superficial preparation is placed on buccal surface extending about 2.5 mm coronally and apically from the line of fracture. However, exposure of resin composite to the external environment in the external chamfer and over contour methods may compromise long-term esthetics due to discoloration and abrasion (12).

Figure 4



5. Simple Re-attachment

In this technique, the fragment has been reattached to the tooth without any additional preparation. A study comparing simple reattachment and circumferential chamfer technique reported that the latter had greater fracture resistance when subjected to static and bending stresses (13).

Reis and others demonstrated that over contouring and an internal dentin groove recovered 97.2% and 90.5% of the fracture resistance of intact tooth, respectively, whereas buccal chamfer recovered 60.6% and simple reattachment recovered only 37.1% (10).

Figure 5

6. FRC POST:

In this technique, after reattachment of fragment, a groove of 2mm is placed inciso-apically to the bonded line and FRC post placed into the groove. It is considered as the best alternative because of several advantages like esthetics, good bonding, suitable elastic modulus, lower chair time. It also minimizes the stress on the reattached tooth fragment as it interlocks the two fragments (2)

Figure 6

7. CANAL PROJECTORS:

A new method was introduced by Gerald N Glickman and Roberta Pileggi for pre-endodontic buildup of badly mutilated tooth which maintains canal patency. An additional benefit of this is it acts as a hydraulic chamber during reattachment. Advantages of this are it elongates the canal and increases the surface area of bonding of fiber post and composite, prevents canal blockage, elongates chamber acts as a reservoir for irrigants and creates primary monoblock – single interface (14). Following which, EverStick Post was used to reattach the fragment of the tooth. EverStick Post is a soft, flexible individually formable resin-impregnated E-glass fiber post. It has an interpenetrating polymer network. It does not require post space preparation. It is available in three diameters of 0.9 mm, 1.2 mm, and 1.5 mm having 1600, 2000, and 4000 fibers, respectively,Its modulus of elasticity is similar to that of dentin, facilitating even distribution of occlusal stresses (16).

Figure 7 -Gutta percha canal projector

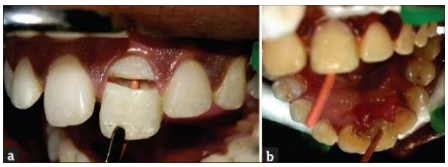
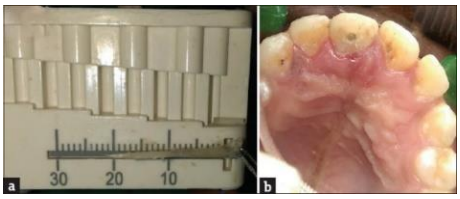


Figure 8



8. Pinhole technique:

A pinhole (1.5 mm depth and width) prepared bilaterally within the dentin's fragment, 1 mm away from the dentino-enamel junction using high-speed #4 round carbide bur has been shown to provide adequate retention to the reattached fragment. The pinholes can be connected together with a shallow dentinal groove (15).

Figure 9

9. Dentin pins

Dentin pins (biopins) obtained by cutting the dentin portion of a coronal slice, in a transverse direction so that the dentinal tubules are perpendicular along the axis of the pin also provide retention to reattached tooth fragment. The pins are then contoured until a cylindrical shape of approximately 1mm diameter, and 4 mm length is obtained. Pin holes are created in the tooth (2mm) and the fragment(2mm) to adapt the dentin pin inside the pinhole to ensure fit and reattachment is done using resin composite (16,17).

Figure 10

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES

The aim of this in-vitro study is to determine the fracture resistance and shear bond strength of reattached uncomplicated fractured fragment of anterior teeth using different techniques namely simple reattachment, metal pins and dentin pins.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Spasser HF et al, (1977) described a case report of trauma to the maxillary central incisor resulting in a diagonal fracture of the tooth from the distal incisal edge to the mesial labial aspect, 2mm below the gingival margin, exposing the pulp. The treatment included complete endodontic therapy, placement of three minipins and cold cure composite in the canal, chamber and fractured crown. The fractured lines and the chipped segment were treated with ultra-violet light polymerized restorative material to add additional strength and improve the appearance (18).

Black JB et al, (1981) concluded in a study, to determine the retentive strength of composite restorative resin to maxillary central incisors with standardized coronal fractures restored by the feather edge, chamfer and bevel restorations respectively, that the retentive force of the bevel preparation was more. This is followed by the chamfer and feather edge because beveling seemed the simplest and most efficient means of removing crazed or disrupted enamel at the cavosurface angle, which is often caused by fracture and in addition the bevel allows for a gradual transition of resin to tooth and at the same time provides bulk across the cavosurface angle (19).

Simonsen RJ et al, (1982) reviewed various types of preparation designs for reattachment of fractured teeth and reported a case in which the reattachment was done using acid-etch technique and microfilled composite resin. A V-shaped notched bevel was placed on the labial surface and a conventional bevel preparation was done on the lingual surface to avoid the potential unaesthetic band of composite on the labial surface to restore the fractured central incisor (20).

Dean JA et al, (1986) examined the relationship of tooth preparation and resin material types in reattachment of fractured anterior tooth and also the effect of the initial fracture angle on retention

of the attached fragment. They concluded that there is no significant difference between teeth reattached with no mechanical preparation and those teeth reattached after giving a 45° circumferential bevel because bevel preparation incorporates additional manipulative trauma to the already traumatized tooth. The light and chemically cured materials both performed equally well as they have similar diametral tensile strengths and compressive strengths. And also the initial fracture plane when sloping cervically in a lingual to facial direction is more retentive than other types because of the lingual support provided to the fragment by the tooth (21).

Amir E et al, (1986) reported a case in which two immature maxillary central incisors with complicated crown fractures and open apices were treated with calcium hydroxide pulpotomy technique. The crown fragments were used to restore the fractured crown using the acid-etch resin technique following 45° circumferential bevel. Follow up at 6 month showed vital, functional pulp, completion of root formation and very good esthetics (22).

Baratieri LN et al, (1990) described two cases of maxillary central incisor fracture with invasion of the biologic width. Osteotomy restricted to only those areas in which biologic width invasion had occurred was performed and fragments were reattached using the enamel acid etching, fluid resin plus a microfill composite resin. In the first case a circumferential internal bevel was used to increase the volume of composite resin used on reattachment, avoid exposure of resin lingually and ensure improved attachment stability. In the second case, besides dentinal holes and dentin adhesives, a prefabricated post was used to offer the dental fragments better retention and stabilization (23).

Munksgaard et al, (1991) tested the strength of the fractured incisors restored with different dentin bonding agents. It was concluded that, when bonding fractured incisors the use of dentin

bonding agents- Gluma, Tenure and Scotchbond 2 along with acid etching of enamel and an unfilled resin composite restored about 50% of the fracture strength of the intact teeth (24).

Burke FJT et al, (1991) reported a case of fractured central incisor involving pulp. Root canal therapy was performed in the retained portion of the tooth and the access cavity filled with Glass Ionomer Cement. The enamel margins of both tooth and fragment were beveled and then reattached using bonding agent and resin composite. Here the restoration may have been achievable without additional preparation of enamel. But this would have reduced the enamel available for bonding unless the composite extended over the labial surface, which may have led to a feather edge of composite which is found to be weak and can fracture easily. Hence enamel beveling was used in this case (25).

Diangelis AJ et al, (1992) have reviewed the techniques of reattaching fractured tooth segments and demonstrated its applications. They have described two cases, the first being a class III Ellis fracture where the pinpoint pulpal exposure was covered with calcium hydroxide and glass ionomer cement followed by placing a circumferential V- shaped notch internally and reattached using auto-polymerizing microfilled composite. The second case had a coronal oblique fracture running below the gingival crest palatally with pulp exposure. The tooth was treated endodontically and then the segments were reattached as in the previous case. In this case glass ionomer cement was incorporated as a luting agent because of its high chemical bond to enamel and dentin. Because the glass ionomer cement can be etched, it provides an added micro-mechanical retention for composite resin (26).

Andreasen FM et al, (1993) investigated the fracture strength of crown fragments reattached using newer bonding agents (Scotchbond Multipurpose, Gluma, All Bond 2). They concluded that there was no significant difference between the three bonding agents; bonding resin is the weak

link between the fragment and remaining tooth. Therefore a resin with higher mechanical properties should be used (27).

Baratieri LN et al, (1994) described a clinical case in which the fracture impinged on the biological width. Surgically the biological width was restored and the fragment reattached to the remaining tooth with Scotchbond Multipurpose/Z100 system that uses 10% maleic acid to simultaneously etch enamel and vital dentin. This provided good bonding and improved the marginal seal in enamel deficient areas. The use of this system seemed to be quite practical, as it involves no more than three steps, saving considerable chair time. Holes were made with a round bur on the dentin of both tooth remnants and the fragment to enhance retention (28).

Andreasen FM et al, (1995) studied the long term survival of fragment reattachment of fractured crowns. They concluded that fragment survival depends on several factors and the use of a dentin bonding agent in combination with acid etching provides greater initial strength to the restoration due to the mechanical properties of the dentin bonding agent and also provides protection against pulpal infection by having disinfectant and sealant effect on the dentinal tubules (29).

Badami AA et al, (1995) investigated the shear bond strengths of sectioned bovine tooth fragments reattached using Gluma 2000 and Scotchbond 2 and concluded that incisal fragments bonded with Gluma 2000 were significantly stronger that those rebonded with Scotchbond 2 and this difference may be due to their differing chemistries (30).

Dean JA et al, (1998) compared the fracture strengths of fragments reattached using a light cured composite resin material, and a hybrid light-cured glass ionomer liner, a hybrid light cured glass ionomer base. The results showed no statistical difference between the 3 groups (31).

Farik B et al, (1999) studied the fracture strength of fragments which were dried and rewetted for various periods of time prior to bonding. They concluded that crown fragments dried for more than an hour had lower bond strength when bonded to the remaining tooth structure compared to those that were not dried. Rewetting of dried fragments could be done by immersing the fragments in water for 24 hours. Drying of the fragment causes collapse of the collagen fiber network of dentin, preventing adequate penetration of the resin monomer (32).

Murchison DF et al, (1999) presented an overview of the incisal edge reattachment procedure. 3 successful case reports were described of patients with fractured teeth. For reattachment, a contemporary dentin bonding agent was used along with a highly filled composite resin added to replace lost tooth structure and optimize esthetics (33).

Worthington RB et al, (1999) evaluated the fracture resistance of reattached incisal fragments using different preparation designs and the effect of addition of resin composite to the bonding interface. External bevel, internal bevel and combination were compared and the results showed that non-conservative tooth modifications did not increase fracture resistance and thus provided no retentive advantage, also the addition of resin composite to the bonding interface did not improve resistance to fracture over the use of a dentin bonding agent alone (7).

Farik B et al, (2000) investigated the impact strength of fractured anterior teeth that have been restored by bonding with a dentin-bonding agent and composite, and the results showed that the impact strength of bonded and intact teeth are not significantly different and fragment bonding may restore a tooth to its original strength when tested at rather low velocities (34).

Pagliarini A et al, (2000) determined the strength needed to detach coronal fragments reattached with 4 and 5th generation adhesive systems. The results showed that the fourth generation

adhesives can generate superior a bonding than fifth generation adhesives because of the higher resin content (4).

Reis A et al, (2001) compared the fracture strength of fractured anterior teeth that were restored using a resin composite and four reattachment techniques- bonding without any additional preparation, chamfer placement, overcontour, internal groove and concluded that the overcontour, internal groove techniques provided fracture toughness similar to those in sound teeth because of an increase in the area for adhesion and the high toughness of resin composite (10).

Reis A et al, (2002) conducted a study for comparing the fracture strength of 2 different techniques (bonded only and buccal chamfer) and different material combinations used for reattaching the tooth fragments and concluded that the material combinations used to reattach the fragments does not play an important role in the fracture strength of reattached teeth and that chamfer technique can provide better strength recovery than simple bonding reattachment, but both are inferior to the resin composite restoration that is able to restore the original tooth fracture strength (35).

Reis A et al, (2004) have presented a literature review on materials and techniques used to restore uncomplicated dental trauma. They have described the following reattachment techniques- Enamel beveling, V-shaped internal enamel groove, overcontour, internal dentin groove, external chamfer, and simple reattachment. They have discussed the various factors involved in the choice of techniques and materials used for fragment reattachment (36).

Loguercio AD et al, (2004) evaluated the effect of the method in which the fragments were obtained by fracturing or sectioning, on the fracture strength recovery of four different techniques used for fragment reattachment and resin composite build up. It was concluded that the way fragments are obtained in laboratory tests plays an important role in fracture strength recovery of

the technique tested. When the fragments are obtained by fractures the overcontour and internal groove techniques seemed to be excellent choices because of the wider area for adhesion and the reinforcement by composite. No differences were detected among reattachment techniques when fragments obtained by sectioning because the strength of reattachment relied on the material used for bonding (37).

Demarco EF et al, (2004) investigated the fracture resistance of reattached fractured fragments of teeth using different materials and techniques and found that the presence of a bevel increased the resistance to fracture in all materials which is due to the higher surface area provided by beveling and the presence of composite resin in the interface having better mechanical properties. The best fracture resistance was obtained with chemically cured composites and worst with adhesive system alone (8).

Toshihiro K et al, (2005) described a case report of 12-year-old boy presented with complicated fracture of 11. Coronal pulpotomy was done along with placement of calcium hydroxide, after 1 week the fragment was reattached following which chamfer margin placed and filled with composite resin. At the time of reattachment, the fragment was whiter than tooth because of dehydration. After 1 month the color difference decreased, the fragment regained the original color of tooth and at 1 year the reattached tooth was intact and had satisfying esthetics and function (38).

Kalra N et al, (2005) reported a case of a 7 year old patient with Ellis class II fracture in 11 and 21. After rehydrating the fragment in normal saline, reverse bevel was placed in the fragment and the tooth, and were reattached using composite resin. At 6 months follow up, the teeth were intact with no discolouration and sensitivity (39).

Pasini S et al, (2006) described a case of 18 year old patient with crown fracture on the upper right lateral incisor without pulp exposure and subluxation on the upper right central incisor. About 1 cm of the right lower lip was lacerated and there was no root / alveolar bone fracture. Coronal fragment of the fractured incisor was found on palpation of the lower lip. Fragment was removed from the lip and then the lip was sutured. Fragment was reattached using flowable composite. On 1 year follow up the tooth revealed favourable outcome of the treatment (40).

Arapostathis K et al, (2006) described a case report of uncomplicated crown fracture in 11 and 21 of a 9 year old boy, the fragment was reattached using a photoactivated microfilled composite resin. Then a layer of composite resin material was placed across the entire reattached palatal surfaces of the affected teeth. At 1 year follow up, the teeth were intact with no periodontal or periapical pathology (41).

Canoglu H et al, (2006), described a case of a 9-year-old boy presented with fractured mandibular right first molar. The fragment was removed and stored in saline and endodontic therapy was performed in 2 visits; also the fractured second primary molar was restored with a poly acid modified resin composite. Fragment was reattached using a total etch adhesive system and a flowable resin. Clinical and radiographic examinations at 1 year follow up revealed a stable reattachment of the fragment, good esthetics, function and periodontal health (42).

Zorba YO et al, (2007) described a case of 29-year-old male patient reported with complicated fracture of 22 at subgingival level. The fragment was removed under local anesthesia and endodontic treatment was performed, parallel sided glass-fiber post inserted into the canal using GIC luting system. And the fragment reattached with flowable composite resin with no additional preparation. After 1 year of follow up, the reattached tooth was intact with satisfying esthetics and function (43).

Prabhakar AR et al, (2007) investigated the impact strength of reattached fractured anterior teeth using 3 different restorative materials namely, i) Composite resin, ii) Compomer and iii) resin-modified GIC. He found that Composite resin and Compomer had better adhesion than resin-modified GIC (44).

Alvares I et al, (2007) described a case of uncomplicated fracture of upper central upper incisors of a 10-year-old patient. The fragments were disinfected with 0.12% of chlorhexidine solution, the fragments were then approximated with tooth using composite for making impression with silicone. Silicone index used as a guide, the teeth were repositioned and reattached using microhybrid composite resin (45).

Altun C et al, (2008) described a case report of a 10-year-old male presented with a complex crown fracture of the 21. After endodontic treatment, a glass-fiber-reinforced composite post was placed to increase retention and then a hole was drilled in the crown fragment in the center to fit the post in the hole and reattached using dual-cured resin composite (46).

Stellini E et al, (2008) conducted a study to test the fracture resistance of reattached teeth using different preparation techniques namely i) circumferential chamfer, ii) overcontour and iii) chamfer preparation on the buccal surface and an overcontour on the lingual surface. He concluded that chamfer on the buccal surface and an overcontour on the lingual surface had the highest fracture resistance (47).

Capp CI et al, (2009) evaluated the fracture resistance of reattached teeth using two different techniques (chamfer preparation and dentin removal from tooth fragment) and rehydration protocols. The bonding technique with removal of dentin from the fragment before bonding

showed higher fracture strength across all groups. Dehydration of fragments for 48 h caused a reduction in fracture strength, which was recovered by rehydration of fragments for 30-min (48).

Fennis WM et al,(2009) evaluated the fracture resistance of reattached fractured teeth using two different techniques i) simple reattachment, ii) reattachment with two mini FRC anchors in the mesial and distal dentinal surface closer to dentino-enamel junction. He concluded that placement of mini FRC anchors increases the resistance to fracture of reattached incisors (49).

Saito et al, (2009) described a case of complicated oblique root fracture that extended approximately 2 mm intraosseous in the distal aspect in 21, invading the biological width in the distal aspect and reaching 2 mm below the bone crest. Fragment was reattached to the root remnant using adhesive restorative technique using a total-etch adhesive system and a light-cured microhybrid composite following which 2 visit Endodontic therapy was performed. Orthodontic extrusion was done to re-establish the biological width. Orthodontic extrusion was achieved within 21 days. After reestablishment of the biological width, the tooth was splinted with composite resin for 12 weeks and Metallic radicular post was placed. On 2 years follow up clinical and radiographic examination showed a good adaptation of the tooth fragment (50).

Bruschi-Alonso RC et al, (2010) investigated the impact strength of reattached teeth with different materials (adhesive system - Clearfil SE Bond or Single Bond; and the intermediate material- Filtek Z350 Flow or Rely X CRA) and techniques (Direct bonding or circumferential chamfer). He found that the impact strength of reattached teeth was high for circumferential chamfer with Single Bond bonding system (51).

Yilmaz et al, (2010) conducted a clinical study on 43 fractured incisors: 21 complicated crown fractures and 22 uncomplicated crown fractures on using different storage media. The patients

followed up for 2 years. The trauma type or the storage medium had no significant effect on the color, survival, and bond strength of the restored teeth (52).

Bhargava M et al, (2010) compared the fracture resistance if reattached teeth using different materials (bonding agent, resin luting cement and nano-composite) and techniques (simple reattachment and chamfer preparation). He concluded that nano-composite and chamfer preparation combination had the highest resistance to fracture (53).

Sargod SS et al, (2010) described a case report with 9 -year successful follow-up of a 9-year-old female patient who had presented with uncomplicated crown fracture of 21. The fragment was reattached with no additional preparation using adhesive system Excite and flowable composite resin, Tetric flow (54).

Pusman E et al (2010) evaluated the bond strength of different preparation techniques namely, (i) Simple reattachment, (ii) Overcontour preparation, and (iii) Internal dentin groove and five different adhesive systems (Prime&Bond NT, Adper Prompt L-Pop, Adper Single Bond II, Clearfil S^3 Bond & G Bond). Prime&Bond NT along with the internal dentin groove technique displayed the highest fracture strength (55).

Rajput A et al,(2010) compared the fracture resistance of teeth restored with three esthetic bonding materials namely: i) hybrid composite (Filtek Z100 Universal Restorative, ii) nanocomposite (Filtek Z350) and iii) Ormocer (Voco Admira) using different techniques such as i) overcontour, ii) internal dentinal groove and iii) direct buildup. He found that no differences in fracture strength between the 3 groups, however, there was a significantly higher fracture strength recovery for hybrid and the nanocomposite. Hence they concluded that the properties of material have a significant influence on the success of reattachment (56).

Vijayaprabha et al, 2012 reported a 9 year old girl with uncomplicated Ellis class II fracture in the maxillary central incisors with single fragment in the right central incisor and two fragments in the left central incisor. Fragment was stored in water to rehydrate and intra enamel circumferential bevel and lingual groove were placed in both the fragment and the remaining tooth structure and reattached using light cure composite. On 1 year follow up, the teeth showed esthetic and functional stability (57).

Puneet Goenka et al, (2012) described a case report of a 13 year old boy who presented with sensitivity in Ellis class III Fracture in maxillary left central incisor. Fragment was stored in saline and single visit root canal treatment was done. Pulp chamber was partly filled with GIC and Enamel bevel was given all around the tooth structure as well as fragment. Additional internal dentinal groove was placed within dentin of fractured fragment and reattached with flowable composite resin. On 18 month follow up the tooth was intact and functional (38).

Srilatha et al, (2012) compared the shear bond strength of teeth reattached with sixth generation dentin bonding agent: Xeno III and microhybrid resin composite: Esthet-X, using three different techniques: Simple reattachment, overcontour and internal dentinal groove. He concluded that overcontour technique showed higher fracture strength recovery (58).

Viswanath et al, (2013) described a case of 23 year old male reported after road traffic accident with horizontal fracture in the middle 3rd of right maxillary central incisor. Fragment was loosely attached to tooth and also upper lip laceration was noticed. Radiographically oblique fracture was seen labio-palatally. Fragment was removed from the lip and stored in saline. Single visit Root canal treatment was performed, beveling was given in enamel and fiber post was placed with dual cure luting cement and reattachment was done using flowable composite. One year follow up showed successful outcome clinically and radiographically (59).

Toole et al, (2013) described a case of 18 year old male reported with uncomplicated crown root fracture which was 3.5 mm subgingival in the maxillary right permanent canine. Indirect pulp capping had been done within 12 hours of trauma at emergency with Dycal and IRM and the fragment stored in water. The tooth was vital and no clinical and radiographic evidence of lesion found. Orthodontic extrusion of the tooth of about 2 mm was achieved over 6 months, IRM removed and the fragment was reattached by placing bevel and reattachment was done using Flowable composite. On 3 years follow up the tooth showed successful outcome clinically and radiographically (60).

Abdulkhayum A et al, (2014) evaluated the fracture strength recovery of reattached anterior fractured fragment to the tooth using different re-attachment techniques; he concluded that overcontour and internal dentinal groove reattachment better than simple reattachment and external chamfer (1).

Davari A, et al, (2014) conducted a study on evaluation of different bonding agents and composites on fracture resistance of reattached tooth fragment. He found that OptiBond S adhesive and Premise flowable composite improved the shear bond strength of the reattached tooth than other materials (61).

Venugopal L et al, (2014) investigated the impact strength of reattached teeth with that of control teeth using dentin bonding agent 3 M Single Bond and 3 M Z100 composite resin. The results showed that the fragment bonded teeth had impact strength similar to intact teeth (62).

Yousef MK et al, (2015) described a case of an 8-year-old female patient reported with fractured mandibular left incisors with no pulp involvement. Both Fragments were cleaned, circumferential bevel with 1.5 mm width and 0.5 mm in depth placed in the tooth; similarly in the fragment a

circumferential bevel of 3 mm width and 0.5 depth was placed. Both the fragments were reattached to fractured teeth using flowable composite resin. At 8th month recall the teeth were esthetically and functionally satisfying (63).

Manju et al, (2015) described a case of a 10 year old male reported with complicated horizontal crown fracture of 21 in cervical one-third. Fracture was oblique and the fragment was intact with no mobility. IOPA revealed pulpal involvement and open apex which was diagnosed as Ellis class III fracture with open apex. MTA apexification, root canal treatment, re-attachment using fiber post was planned. Fragment was cleaned, key and lock system of attachment of the fragment with fiber post by gingival retention slot with No.4 round bur was planned. Additional chamfer preparation was done and composite application was done after reattachment. At 1 year follow up, clinical and radiographical examination showed no periapical and periodontal changes (64).

Choudhary et al, 2015 described a case of a 22 year old male presented with Ellis Class III fracture at gingival 3rd of 22. Fragment was mobile and attached to gingiva. Single visit RCT with sectional filling was done. Prefabricated metal post was placed and a hole was placed in fracture fragment in the palatal side of the remaining tooth and grooves were placed in the fragment and reattachment was done using flowable composite. On 20 months follow up, clinical and radiographic examination showed acceptable outcome (65).

VamsiKrishna R, et al, (2015) conducted a study on evaluation of bond strength of different adhesive materials, tooth preparation designs and adhesive combinations for reattaching the fractured incisor fragments. He found that reattachment using resin luting cement showed higher bond strength than bonding agent and the preparation design of "groove with shoulder" showed superior bond strength as compared to simple attachment and chamfer (66).

Fornaini et al, 2015 described a case of a 14 year old patient reported with Ellis class III fracture right maxillary central incisor. Fragment was stored in saline, Nd:YAG laser pulp capping was performed followed by Er:YAG laser etching of tooth and fragment and rebonded with flowable composite. On 16 months follow up the tooth was vital and showed successful treatment outcome(67).

Rehman et al, (2016) investigated the shear bond strength of reattached fragment of incisors using Er,Cr:YSGG laser and conventional acid etching without any additional tooth preparation. Er,Cr:YSGG laser etching for reattaching fractured incisor fragment seemed to be a good alternative to conventional acid etching. (68).

Ramesh P et al (2016) conducted a study on evaluation of fracture resistance of maxillary central incisor fragments having two different fracture patterns (labio-palatal' and 'palato-labial') and re-attached using two different posts namely- fiber post and Ribbond. He found that labio-palatal fracture pattern and fiber post exhibited higher fracture resistance (69).

Martos et al, (2017) reported a 12 year old female with uncomplicated crown fracture in the middle 3rd of the maxillary right central incisor. No mobility was noted, periodontal tissues were healthy. Fragment was cleaned with 2% chlorhexidine digluconate and reattached using 2 bottle adhesive system and composite resin. After reattachment 0.7mm depth chamfer prepared along the fracture interface on the palatal side and restored with micro-hybrid composite resin. On 4 years follow up tooth showed successful outcome clinically and radiographically (70).

Deepa et al, (2017) reported a 23 year old male with complicated fracture in maxillary left central incisor with supragingival fracture line in cervical one-third. IOPA revealed already initiated root canal therapy and no periapical pathology. GP was used as a projector and fragment reattached

using flowable composite. Single visit endodontic treatment was done, GP removed, cleaning and shaping done and sectional obturation done. Everstick post placed. At 1 year follow up clinical and radiographical examination showed satisfactory outcome (71).

Tulumbacı F et al, (2017) compared the effect of acid etching and Er,Cr:YSGG laser for reattachment of incisal fragments, and found that it has a negative effect on fracture strength (72).

Szmidt M et al, (2017) presented a case report in which he found the part of the fractured fragment inside the lip wound, hence he used direct resin composite restoration to replace the missing part of the tooth of maxillary central incisors and the remaining fragment which was found were reattached using adhesive composite resin. On 6 months follow up, clinical and radiographic evaluation showed successful outcome (73).

Poubel DLN et al, (2017) conducted a study to evaluate the effects of different wet and dry storage intervals on multimode adhesive bonding of reattached teeth. He concluded that 15 minutes of rehydration before bonding using multimode adhesive provides sufficient moisture to increase the strength of the reattached tooth fragment (74).

Karre D et al, (2017) compared the fracture resistance of reattached fragments using three different techniques namely: 1. Circumferential chamfer 2. Vertical grooves with FRC post 3. Dentin is removed from the fractured fragment and filled with composite. He concluded that reattaching fragment by placing vertical grooves with FRC posts showed the highest fracture resistance (2).

De souse et al, 2018 presented a systematic review to analyze the reattachment techniques which were used to restore anterior fractured teeth. They have evaluated 10 different techniques namely: no preparation, bevel, anchors, chamfer, overcontour, internal groove, fragment dentin removal

associated with chamfer after reattachment, no preparation associated with chamfer after reattachment, bevel associated with overcontour, and groove associated with shoulder. And also five different materials for reattachment of the fragment such as: bonding system, luting composite resin, flowable composite, microhybrid composite, and nanocomposite. They concluded that a technique with no preparation and an adhesive system associated with an intermediate composite had higher mechanical properties & restore better resistance of the fractured tooth (75).

Beltagy TM et al, (2018) performed clinical and laboratory study on evaluation of uncomplicated fragment reattachment. In vitro study comprised of comparison of three different groups, namely: pinholes, internal dentinal groove, and simple reattachment. He concluded that pinholes technique had significantly higher fracture resistance than other groups. Clinically a prospective study was performed between 2012 and 2016 on 20 children. However, the clinical results showed no significant differences between the Internal dentinal groove and Pinholes technique (15).

Oh S, et al (2019) reported 2 cases; in case 1 - A 15 year old girl reported with complicated crown fracture in maxillary central incisors with lip laceration and fragments partly attached to gingival tissue. In 11 fracture line was supragingival in labial side & subgingival on palatal side. In 21, both labial and palatal fracture lines were subgingival & fragment was discolored. Access hole placed on the fragment for post placement and vent prepared for cement spillway. 0.5mm beveling was given and 0.5mm depth retention grooves given in the fragment. Flap elevated for exposing fracture line, fiber post placed and reattachment done using flowable composite. Non vital bleaching was performed immediately in 21. On 4 years follow up, clinical and radiographic evaluation showed successful outcome (76).

In the 2nd case, a 23 year old male presented with complicated crown fracture in maxillary right lateral incisor. RCT was completed followed by placement of FRC post using dual cure resin

cement. Access hole was placed in the palatal surface of fracture fragment and retention groove placed in dentin. Flap elevation was done on labial and palatal sides and osteotomy done in palatal side to obtain sufficient biologic width. Reattachment was done using flowable composite resin. Composite resin used for closing access hole. On 5 years Follow up, slight discoloration was seen in the cervical area, but no evidence of resorption or periapical lesion (76).

Ghorai L et al, (2019) described a case report of a 32-year-old male patient who presented with fractured upper right front tooth with the history of trauma before 3 years and repeated failure of restoration. In the 1st sitting impression was made, study model created. An extracted tooth of 11 was used for homogenous fragment bonding, which was sterilized in autoclave chamber at 121°C and 15 lb pressure for 15 min. two dentin biopins were created from the dentin portion of coronal slice of about 1mm diameter, and 4 mm length. And the fragment was cut from the extracted tooth and adapted to the model. In the 2nd session the pinholes were prepared in the fractured tooth as well as in the fragment using spherical bur of 1 mm diameter until a depth of 2 mm for each pinhole. The biopins and the fragment cemented to the tooth using composite resin. A bevel was given at the bond line, and restored using a composite resin which was then finished and polished. At 1 month recall the reattached tooth was intact, stable and esthetically satisfactory (17).

Madhubala et al, (2019) evaluated the fracture resistance of fragment reattachment using two rehydration protocols such as i) rehydration in distilled water for 15 minutes and ii) rehydration in a humidification chamber for 15 minutes. Fragments which were rehydrated in the humidification chamber had significantly higher fracture resistance (77).

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIALS USED: (Figure 11)

Self-etch adhesive system- Ivoclar Tetric N-Bond Universal

Flowable composite- Ivoclar Tetric N-Flow Enamel shade A2

Storage media- 0.9% saline solution

Sodium Hypochlorite

Metal pins

Self-cure Acrylic resin

ARMAMENTARIUM: (Figure 12)

Airotor handpiece (NSK, Japan)

Micromotor handpiece (NSK, Japan)

Diamond disc and Mandrill

Round diamond bur

Applicator brush

Teflon coated plastic filling instrument

Measuring scale

Probe & Tweezer

Gloves & Mouth mask

Composite polishing disc (Shofu super snap)

Dappen dish

Cement spatula

Human maxillary and mandibular anterior teeth (Figure-13)

EQUIPMENTS USED:

Universal testing machine AG-X Plus (Shimadzu) (Figure-14)

LED light cure unit (Figure-15)

METHODS:

SELECTION OF TEETH:

The study samples comprised of 33 intact freshly extracted human maxillary and mandibular anteriors. The criteria for selection was that:

The teeth were:

1) Free of caries
2) Free of restorations
3) Free of cracks as observed under microscope (LABOMED)

Sample Calculation:

The sample size was calculated to be a minimum of 33 samples; however to compensate for any damage during sample preparation or testing and for the preparation of dentin pins, a total of 42 samples were prepared. The samples were divided for two parameters:

I. **PARAMETER 1**: Fracture resistance

II. **PARAMETER 2:** Shear bond strength

PARAMETER 1: FRACTURE RESISTANCE (n=18)

Group 1: Control (n=3)

Group 2: Simple reattachment (n=5)

Group 3: Reattachment using metal pins (n=5)

Group 4: Reattachment using Dentin pins (n=5)

PARAMETER 2: SHEAR BOND STRENGTH (n=15)

Group 2: Simple reattachment (n=5)

Group 3: Reattachment using metal pins (n=5)

Group 4: Reattachment using Dentin pins (n=5)

PREPARATION OF SPECIMENS:

The teeth following extraction were cleaned free of debris and calculus and then were stored in 0.9% saline solution.

The study consisted of four procedures:

1. Sectioning of incisal third of sound teeth
2. Measuring of Surface area
3. Reattachment of the fragment using different techniques
4. Fracture of restored teeth

1) Sectioning of incisal third of sound teeth: (figure-16)

The labial surface of each tooth was divided into three transverse thirds equally using divider and measuring scale, and marked using marker. The incisal third of each tooth except control teeth were sectioned using diamond disc under a cooling system, eliciting an Ellis class-II fracture. The fragments were cleaned using sodium hypochlorite and water to remove the protein coating from the fragments due to sectioning of teeth. The fragment and teeth were kept moist in 0.9% saline before bonding to avoid dehydration.

2) Measuring of Surface area: (figure- 17)

The surface area of each tooth was measured using a SketchAndCalc application. The photograph of the sectioned surface of the tooth and fragment were made in an Android phone, and the surface area of both fragment and tooth were measured using SketchAndCalc application and the average of both was taken as surface area of the fractured tooth.

3) Reattachment of fractured fragment:

SIMPLE REATTACHMENT: (Figure-18)

The fragment was reattached simply without any additional preparation. The surfaces of both fragment and tooth were thoroughly rinsed with water and air dried using air blower, and one coat of bonding agent (Tetric N-Bond Universal) was applied using applicator brush on the surfaces of both the tooth and fragment and gently air thinned to avoid misfit of the bonded parts and then light activation was done using curing light for 20s on each side. A thin coat of flowable composite (Tetric N-Flow) was applied to both surfaces, the fragment was carefully repositioned to the tooth, excess removed and light cured for 40s from both labial and palatal sides, restored surfaces were then finished and polished using composite polishing kit (Shofu Super-snap).

REATTACHMENT USING METAL PINS: (Figure-19)

After determining the location of the pinhole placement in the tooth (0.5 mm away from DEJ towards dentin), a depth limiting twist drill (Kodex drill) was used to drill the pinhole, then a self-threaded metal pin was inserted into the latch type contra-angle micromotor handpiece and threaded in the pinhole. Then another pinhole was made in the fragment of about 1 mm width 2mm depth using spherical diamond to adapt the fragment in the metal pin which was threaded into the tooth.

Subsequently, bonding agent (Tetric N-Bond Universal) was applied using applicator brush on the surfaces of tooth and the fragment, gently air thinned and then light activation was done using curing light for 20s on both the sides. After the application of bonding agent, a thin coat of flowable composite (Tetric N-Flow) was applied on the surface of the tooth, and pinhole of the fragment, then the pinhole of the dental fragment was embedded into the metal pin in the tooth under gentle pressure, excess removed and photo-polymerized for 40 seconds on both labial and palatal sides, restored surfaces were then finished and polished using composite polishing kit (Shofu Super-snap).

REATTACHMENT USING DENTIN PINS: (Figure-20)

An extracted maxillary central incisor was used to cut the dentin fragment for making dentin pins. The cutting of the dentin pins was performed under extreme refrigeration using diamond disc and diamond burs. Initially a transverse coronal slice of about 2 mm was made using diamond disc, then cylindrical shaped dentin pins approximately 1mm in diameter and 4mm length was obtained in order that the dentinal tubules were perpendicular to the long axis of the pin. After obtaining the dentine pins, pinhole of about 1mm in width and 2 mm depth was prepared in both the tooth and the fragment for the placement of dentin pins using spherical diamond. Subsequently,

bonding agent (Tetric N-Bond Universal) was applied using applicator brush on the surfaces of tooth, fragment and dentin pins, gently air thinned and then light activated for 20s form both the sides. After the application of bonding agent, a thin coat of flowable composite (Tetric N-Flow) applied into the pinhole and the surface of the tooth, the dentin-pin was adapted to the pinhole of the tooth, Subsequently flowable composite was applied to the pinhole of the fragment, then the dental fragment was embedded into the dentin pin in the tooth under gentle pressure, excess removed and photo-polymerized for 40 seconds on both labial and palatal sides, restored surfaces were then finished and polished using composite polishing kit (Shofu Super-snap)

TESTING:

1) Test for Fracture Resistance: (Figure-21)

The samples were tested for fracture resistance using universal testing machine (UTM) (SHIMADZU, AG-X Plus). The specimens were positioned in the jig/fixture adapted in the UTM. Force was applied in a labio-palatal direction using a 0.5 mm thick pointed (round-end) stainless steel rod at 90° angle incisal to the bonding line with a crosshead speed of 1 mm/min. The load, at which the samples fractured, was noted, and the fracture strength was calculated according to the area of the fractured surface.

2) Test for Shear Bond Strength: (Figure-22)

The samples were tested for the shear bond strength using UTM (SHIMADZU, AG-X Plus). The specimens were positioned in the jig/fixture adapted in the UTM. Force was applied in a labio-palatal direction using a knife edge stainless steel rod perpendicular to the bonding line with a crosshead speed of 1 mm/min. The load, at which the samples fractured, was noted, and the fracture strength was calculated according to the area of the fractured surface.

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

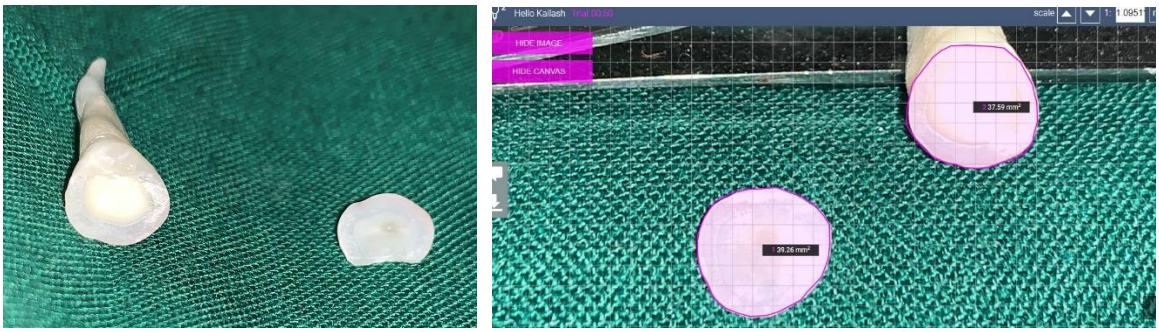


Figure 18

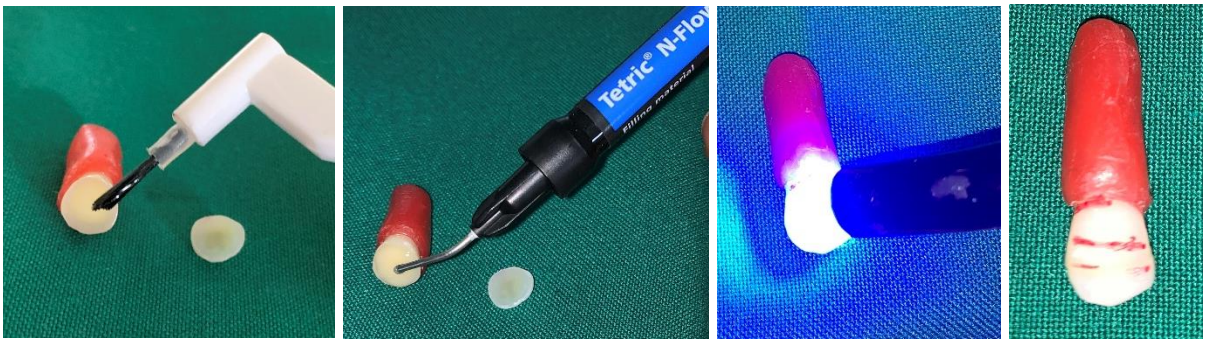


Figure 19

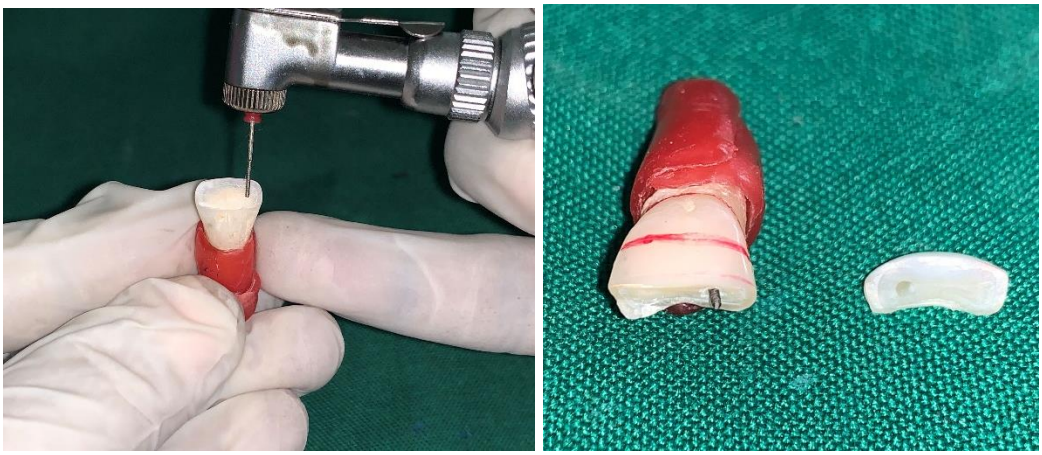


Figure 20

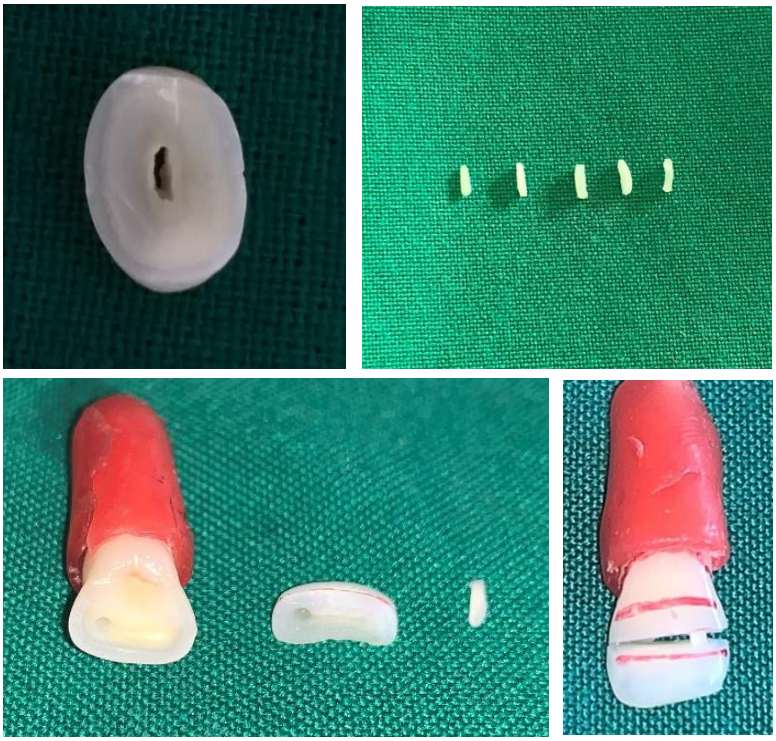


Figure 21

Figure 22

STATISTICAL ANALYSIS

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To analyze the results for fracture resistance and shear bond strength, Kruskal Wallis test were done; for intergroup analysis Mann-Whitney U test and Wilcoxon tests were performed.

RESULTS

RESULTS

The study was considered with 2 variable factors namely fracture resistance and shear bond strength. Fracture resistance was evaluated to check the nominal property of the tooth in resisting the development of the fracture whereas the shear bond was evaluated to check the amount of force required to break the connection between a bonded (dental) restoration and the tooth surface with the failure occurring in or near the adhesive/adherent interface.

a. Fracture Resistance

For the statistical analysis of the data for the fracture resistance, the descriptive mean and standard deviation for each group was calculated.

Mean and SD for each group (Table -1)

FRACTURE RESISTANCE				
	N	MEAN	SD	MEAN RANK
Group 1	3	25.6	1.7	17.0
Group 2	5	6.2	1.3	3.2
Group 3	5	12.1	2.7	9.4
Group 4	5	13.6	3.4	11.4

Legend: Group 1- Control; Group 2- Simple reattachment; Group 3- Metal pins; Group 4- Dentin pins

Since, the data was not normally distributed, non-parametric tests were run. The comparison of the variables among the four groups were run by Kruskall Wallis test to identify the statistical difference among the four groups.

Table-2

Kruskal Wallis Test	
Chi-Square	13.519
df	3
Asymp. Sig.	0.004

The p value achieved during this test is less than 0.05, therefore there is statistically significant difference among the four groups.

To find out the more specific differences among the groups, the TWO GROUP analysis was done with the Mann Whitney test and Wilcoxon test. These tests were done among the Group1&2, Group 1&3, Group1&4, Group 2&3, Group 2&4, Group 3&4.

Table-3

	Group 1&2	**Group 1&3**	**Group 1&4**	**Group 2&3**	**Group 2&4**	**Group 3&4**
Mann Whitney U	0	0	0	0	1	7
Wilcoxon W	15	15	15	15	16	22
Z	-2.236	-2.236	-2.236	-2.611	-2.402	-1.149
Asymp. Sig. (2-tailed)	0.025	0.025	0.025	0.009	0.016	0.251
Exact Sig. [2*(1-tailed sig.)]	0.036b	0.036b	0.036b	0.008b	0.016b	0.310b

Intergroup analysis revealed statistically significant differences between control and other groups, between groups 2 and 3, between groups 2 and 4; but there was no statistically significant difference between groups 3 and 4

b. Shear Bond Strength:

For the statistical analysis of the data for the shear bond strength, the descriptive mean and standard deviation for each group was calculated.

Mean and SD for each group. (Table -4)

SHEAR BOND STRENGTH				
	N	MEAN	SD	MEAN RANK
Group 2	5	8.9	2.0	3.2
Group 3	5	14.9	4.2	9.2
Group 4	5	17.8	4.1	11.6

Legend: Group 2- Simple reattachment; Group 3- Metal pins; Group 4- Dentin pins

Table- 5

Kruskal Wallis Test	
Chi-Square	9.36
df	2
Asymp. Sig.	0.009

The p value achieved during this test was less than 0.05, therefore there was statistically significant difference among the four groups.

Two group analysis were done with the Mann Whitney test and Wilcoxon test. These tests were done among the Groups 2&3, Groups 2&4, Groups 3&4.

Table- 6

	Group 2&3	**Group 2&4**	**Group 3&4**
Mann Whitney U	1	0	7
Wilcoxon W	16	15	22
Z	-2.402	-2.611	-1.149
Asymp. Sig. (2-tailed)	0.016	0.009	0.251
Exact Sig. [2*(1-tailed sig.)]	0.016b	0.008b	0.310b

There was no statistically significant difference between Groups 3&4.

DISCUSSION

DISCUSSION

The major objective of restorative dentistry is to restore teeth in a way that allows conservation of healthy dental tissues, esthetics, function and durability. The ideal treatment would be to attain restorations that are almost as strong as the natural teeth themselves and esthetically pleasing. Thus, in many clinical situations, the best option for fractured anterior teeth is reattachment of the tooth fragment, because this is a better way to reinstate the natural shape, contour, surface texture, occlusal alignment and color of the teeth (78).

The reattachment is useful for patients with the need for apexogenesis or in the mixed dentition where delaying prosthetic restoration of the tooth until eruption and root formation, have been established as a distinct advantage (33).

Until the late 1960's, temporary and permanent restoration of traumatized teeth in young individuals represented a major challenge. Temporary treatment usually consisted of adaptation of preformed steel crowns, which implied significant esthetic problems even if the design was modified using various window preparations or tooth-coloured staining of the steel crowns.

Though there are several alternatives for restoring the fractured teeth, reattachment is considered as one of the best methods to restore the function and esthetics of the teeth whenever the fragment is available. Different techniques were studied and clinically done to improve the long term survival of reattached teeth. In this study three techniques of reattachments namely simple reattachment, reattachment using metal pins and dentin pins were analyzed. These three techniques were selected because simple reattachment has been selected for comparison in majority of the studies; metal pins were selected because there are no in vitro/in vivo studies excepting one case report in which metal pins were used for fragment reattachment but used as retentive feature for

composite build ups; dentin pins were selected to analyze the effect of its fracture strength since there are only two clinical case reports and no in-vitro studies in literature. The results achieved here reveals that there is significant difference among all the three groups, but among the pins group i.e. metal pin and dentin pin the difference is not statistically very significant.

Nogueira et al (2015) reported a case using dentin pins for attachment of homogeneous dental fragment in a 9 year old patient with 1 year successful follow up, Ghorai et al (2018) used dentin pins in a 32 year old patient with 1 month follow-up. The use of this technique is inexpensive, as well as exhibits excellent biocompatibility and maintains the characteristics of tooth structure such as size, shape, color, resistance, smoothness, surface brightness, hardness, texture, functionality and esthetics. Self-threaded metal pins can generate stress into the dentin while drilling and threading pin into the dentin, On the other hand, dentin pins being passively cemented in dentin, form a micromechanical homogenous unit with the dentin, resulting in uniform stress distribution (16). And also it has the greatest advantage of biocompatibility - their resiliency and coefficient of thermal expansion being similar to that of a dental element (17).

In spite of its advantages it also has its limitations such as: difficulty in acquisition of extracted teeth; difficult to create due to its reduced size; and possibility of perforating the pulp chamber during preparation of the pin hole (16). However, this is a little known technique, and there are very few studies reporting its use in the literature. In our study, this technique has shown the highest fracture resistance and shear bond strength when compared to other groups. The reason for dentin pins to have good fracture resistance and shear bond strength may be due to,

- homogeneous retentive nature
- pinhole may act as an additional surface to receive adhesive thereby increasing the total bonded surface area.

Hence it can be used as an alternate choice for fragment reattachment.

Metal pins are mechanical features which are incorporated into the prepared tooth to support and maintain the final restoration. Though various pins and techniques are available, self-threading retentive pins are used extensively because of their excellent retentive properties. Self-threading pins along with adhesive technique enhances the retention of the composite resin restorations (79). Though there are no in vitro experimental studies using metal pin for reattachment of fragment, Spasser described reattaching an anterior tooth fragment with interlocking minipins, and a light-cured resin composite in a 8 year old boy with successful 10 months follow up (18). Attin et al compared the fracture resistance of restorations that were only bonded versus the ones that used self-threaded metal pins, revealing that the resistance to fracture was higher when metal pins were used. Use of self-threading pins increases the long-term stability of resin-based restorations. This simple and low-cost procedure increases the retention of adhesive materials, reducing the risk of fracture failures. Although, this alternative therapeutic approach preserves the tooth structure and requires simple clinical procedures, these pin retained restorations also has significant number of downsides such as loose pins, heat generation, dentinal cracks, pin breakage, esthetic failure of the restoration etc (80). The stress developed through the pin is related to its diameter, type and the application parameters on the created hole. Pin diameter and length are among the most important factors with regard to the value and direction of the stress produced. Commonly used pins measure 0.5–0.6 mm in diameter and 2 mm in length. In this study, a self-threading metal pin of 0.6 mm diameter and 2 mm length was considered. Another important point is the location of the pin. Studies show that the ideal location should be 0.5–1 mm inside of the enamel–dentin junction.

Although positive outcomes of the pin-retained direct resin restorations were found in the case reports (81,82), there are no in-vitro studies to assess the fracture strength of reattached tooth using

metal pins, or clinical case reports for assessing the long term success for reattached tooth. In the present study, the pin was introduced 0.5 mm from dentino-enamel junction towards dentin. Since self-threaded pins are thin (0.6 mm diameter), it requires minimal dentin removal and has good retention and also while testing for fracture strength and shear bond strength 70% of the tooth showed that the fracture occurred with intact fragment segment without complete separation from the tooth.

In 1978, Tennery, reported the first case where crown fragments were reattached using a bonding technique. Shortly thereafter, in 1983 Mc Donald and Avery advocated reattachment of tooth segments with minimal or no enamel preparation except acid-etching. Bonded only technique showed the lowest fracture resistance and shear bond strength value when compared to all other groups. The results are in accordance with many previous studies like Abdulkhayum(2014), Vamsikrishna (2015) (1,66).

The probable reasons for simple reattachment group to show lowest fracture resistance may be due to:

- The smaller bonded area
- The thickness of the adhesive and resin cement in the interface was low because of the perfect fit.

The development of adhesive dentistry can be traced to Dr. Michael Buonocore who discovered that he could increase the retention of acrylic-based restoratives by first treating the enamel with phosphoric acid. These adhesive systems have progressed from the largely ineffective systems of the 1970s and early 1980s to the relatively successful total- and self-etching systems. The latest

developments, the so-called “universal adhesives” have the potential to significantly simplify and expedite adhesive protocols (83).

With self-etching universal adhesive systems, various acidic primers are used to modify, disrupt, and/or solubilize the smear layer and, although the remnants are not washed away as with total-etch systems, still permit direct adhesive interaction with the dentin substrate.

Jayasheel et al (2017) found that the shear bond strength of Tetric N bond universal adhesive was higher than Single Bond Universal, ClearFil SE (84). Tetric N bond universal, Ivoclar is used in this study which contains low levels of acidic monomer, and are therefore “mild-etching” adhesives with a pH of approximately 2.5–3.0. The Tetric N-Bond Universal matrix is based on a combination of monomers of hydrophilic (hydroxyethyl methacrylate/HEMA), hydrophobic (decandioldimethacrylate/D3MA) and an intermediate monomer Bis-GMA. This combination allows Tetric N-Bond Universal to reliably bridge the gap between the hydrophilic tooth substrate and the hydrophobic resin restorative, under a variety of surface conditions.

Evaluation for bonding durability is important since the long-term clinical success of tooth colored restorations is dependent on the stability of the bond between restoration and tooth substrate. Here in this study composite acts as an interface between tooth and fragment. Shear bond strength plays a major role for the long-term clinical success of the restoration. In the mid-1990s, flowable composite was introduced into the market. Flowable composites have the advantage of easy handling, lesser polymerization shrinkage, better marginal adaptation, and better wear resistance. Rangappa et al (2018) compared the shear bond strength of flowable composite and concluded that Tetric N Flowble composite has the highest bond strength compared to Constic, Dyad™-flow (85). Tetric N-Flow is a light-curing, radiopaque flowable nano-hybrid composite based on nano-

optimized technology. Hence in the present study, Tetric N Flow flowable composite was used for reattaching the fragments to the fractured teeth.

In this study, to fracture the specimens the cross-head speed used was 1mm/min as recommended by ISO standard (ISO/TS 11405:2003-Dental Materials-Testing of adhesion to tooth structure) (66). Ellis Class II coronal fracture was simulated by sectioning one-third of each specimen horizontally, and the fragments were stored in saline until reattachment to maintain a proper hydration and ensure superior bond strength, and inhibit the fragment discoloration. For force application, the labial aspect of each specimen was selected to simulate the real traumatic injury. For determining the fracture strength, the center of the incisal thirds was selected as the point for force application and was very carefully controlled to maintain the same distance of fulcrum to all specimens (15). For shear bond strength determination, the bond line was the point of force application (1).

The quality of fit between segments is an important factor to be considered. When the segments fit together with no discernible disruptions or defects, techniques that prevent resin composite from being exposed to the oral environment, such as placement of a pin hole with dentin pin or metal pin attachment, would be preferable to simple reattachment, due to the low fracture toughness recovery of this technique. Nevertheless, when enamel structure is lost in the trauma event, it may be more convenient to use an enamel beveling and overcontour after reattachment using dentin pins or metal pins (depending on the extension of the structure loss) so that the esthetics can be obtained simultaneously with the increase in adhesion area. Since it is an in-vitro study where the fragment is obtained by sectioning the tooth, there is no discrepancy with the fit of the fragment to the tooth, and hence no additional enamel preparation was done.

Several aspects may govern the choice of a reattachment technique. Research has reported that the primary cause of fragment loss is a new trauma or the non-physiologic use of the bonded tooth and horizontal traction. Therefore, most concerns about the reattachment techniques should be directed towards their fracture toughness. Thus a technique that provides fracture toughness similar to the one presented by sound teeth, as well as that which suits the clinical situation should be selected.

The results of this study are in accordance with many studies like Demarco et al (8), Singhal et al (86), who confirmed that no material and technique was able to attain the fracture strength of the sound teeth.

In the present study, the reattachment done with metal pins and dentin pins showed good fracture resistance when compared to simple reattachment. Although the results of fracture strength is lower than that of intact control tooth, a 50% recovery could be achieved.

This is an in-vitro study but the actual presentation of a patient with a fractured tooth poses a challenge to the clinician. Nevertheless, considering the superior bond strength and fracture resistance recovery these new techniques may be adopted to improve the longevity of reattached teeth.

SUMMARY

SUMMARY

Traumatic injuries are the most disruptive and distressing emergencies and pose challenge for dental professionals because many different protocols of treatment are currently available. It also affects social and psychological well-being of children. Multidisciplinary approach is involved in the management of traumatic dental injuries to maintain function and esthetics. The aim of this study was to evaluate the fracture resistance and shear bond strength of three techniques namely simple reattachment, reattachment using metal pin and reattachment using dentin pin. For fracture resistance the intact teeth were taken as control. The teeth were sectioned to simulate uncomplicated crown fracture (Ellis class II fracture) and reattached using Tetric N Universal bonding agent and Tetric N Flow Flowable composite. Fracture Resistance and Shear bond strength were assessed using a universal testing machine. Statistical analysis was done with Kruskal Wallis test, Mann Whitney test and Wilcoxon test. Fracture resistance was the highest for control group, whereas in reattachment groups, dentin pin group was found to be having greater fracture resistance followed by metal pins while simple reattachment group showed the lowest values; in shear bond strength analysis dentin pins showed higher values followed by metal pins; the simple reattachment had the lowest shear bond strength. It is difficult to perform randomized clinical trials for such emergency situations and hence only case reports and laboratory tests can confirm the superiority of any technique of reattachment. Though this is an in-vitro study, considering the superior bond strength and fracture resistance recovery these new techniques may be adopted to improve the longevity of reattached teeth.

CONCLUSION

CONCLUSION

The reattachment of fractured dental fragments is an excellent alternative to placement of direct resin composite restorations, because it restores tooth function, esthetics, requires less treatment time and represents a cost-effective approach. Among the various materials and techniques used for the fragment reattachment, our study found that dentin pins had the highest fracture resistance and shear bond strength. Hence when the fragment is intact, with adequate size and appropriately preserved margins, this can be considered as an alternate method of reattachment.

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ANNEXURES

URKUND

Urkund Analysis Result

Analysed Document:	2 for plag.pdf (D62948550)
Submitted:	1/24/2020 5:02:00 PM
Submitted By:	${Xml.Encode(Model.Document.Submitter.Email)}
Significance:	8 %

Sources included in the report:

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