“COMPARATIVE EVALUATION OF THE FRACTURE RESISTANCE OF THE REATTACHED TOOTH FRAGMENT USING CONVENTIONAL COMPOSITE AND A HYDROPHILIC SELF-ADHESIVE BIOACTIVE RESIN WITH AND WITHOUT AN INTERNAL DENTINAL GROOVE PREPARATION”– AN INVITRO STUDY.

By

REG. NO. IE0220001

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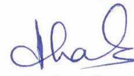

Head of Department

Principal

Dr. PREETI DODDWAD M.D.S
Professor & Head,
Department of Conservative Dentistry and Endodontics,
KLE's V.K. Institute of Dental Sciences,
Belagavi.

Date:

Place: Belagavi

Dr.(Mrs) ALKA KALE M.D.S, Ph.D
Principal,
KLE's V. K. Institute of Dental Sciences,
Belagavi.

Date : 28/12/22

Place : Belagavi

Professor and Head
Dept. of Conservative Dentistry
KLE V. K. Institute of Dental Sciences,
Belagavi

PRINCIPAL
KLE V.K. Institute of Dental Sciences
Nehru Nagar, BELAGAVI-590010

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LIST OF ABBREVIATIONS

Kgf.	Kilogram force units
LED	Light emitting diode
<	Greater Than
S	Second
H	Hour
%	Percentage
i.e	That is
Et al	And others
SD	Standard deviation
CPP-ACP	Casein phosphopeptide-amorphous calcium phosphate
UTM	Universal testing machine
Fig.	Figure
ANOVA	Analysis of variation
GIC	Glass ionomer cement
RMGIC	Resin modified glass ionomer cement
OSHA	Occupational safety and health administration
Mm	Milimetre
Min	Minute

ABSTRACT

Purpose: Purpose of this in vitro study is to evaluate and compare the fracture resistance of the tooth fragment reattached using conventional flowable composite and a new self adhesive bioactive restorative material, with and without an internal dentinal groove preparation.

Materials and Methods: A total of 44 permanent maxillary central incisors were selected and handled according to OSHA guidelines, disinfected in 0.1% thymol solution, cleaned of calculus and soft tissues and stored in 0.9% saline till use and divided into two groups (each group having 22 specimens each) according to the composite resin used for reattachment.

- Group 1: Reattachment using conventional flowable composite (3M ESPE Filtek Z350xt)
- Group 2: Reattachment using bioactive flowable restorative material (Activa Bioactive)

Group 1 and Group 2 were then divided into two subgroups depending on the reattachment procedure used (With or without internal dentinal groove).

Subgroup 1A (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) without the preparation of internal dentinal groove.

Subgroup 1B (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) with the preparation of internal dentinal groove.

Subgroup 2A (n=11): The fragments were reattached using new self adhesive bioactive material (Activa Bioactive) without the preparation of internal dentinal groove.

Subgroup 2B (n =11): The fragments were reattached using new self adhesive bioactive material (Activa Bioactive) with the preparation of internal dentinal groove.

These teeth were embedded in an auto polymerizing acrylic resin block of 4 x 4 inch dimension and stored in tap water at room temperature for 24 hours.

The specimens were mounted on the custom made fixture for determination of shear bond strength using universal testing machine. A knife edge chisel (0.5 mm in cross section) was used to deliver the force so that contact was achieved 4 mm apical to the incisal edge. The shearing load was applied at crosshead speed of 1mm/min. The shearing force was noted and shear bond strength was calculated and recorded in kilogram force units (Kgf).

Results: The results of the present study revealed the mean force and standard deviation required to fracture each group was as follows:

Subgroup 1 A : 10.33 +/- 0.25

Subgroup 1 B : 11.42 +/- 0.469

Subgroup 2 A : 13.25 +/- 0.61

Subgroup 2 B : 16.78 +/- 0.7

Conclusion: Based on the present study following comparison can be drawn Subgroup 2B :Reattachment using a new self-adhesive bioactive restorative material,(Activa Bioactive) after the preparation of internal dentinal groove had the highest fracture resistance and the least being Sub Group 1A :Simple reattachment using flowable composite

Keywords: Internal Dentinal Groove, Activa Bioactive, flowable composite, Simple reattachment

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INTRODUCTION

Traumatic dental injuries are a relatively common event that affects all age groups. However, children and adolescents (26-76%) get affected more. The most common teeth to be affected are the upper incisors due to their protrusive nature and anterior position.[1,2,3] Recent investigations into the pediatric and adolescent population about the incidence of dental trauma have shown that it affects almost 1/3rd of the population.[4]

Traumatic fractures impact the patient both psychologically and socially, as well as functionally. Hence, treating this traumatic dental fracture becomes prudent[5]. Through the yester years keeping the primary goal of preservation of the dental tissues and re-establishment of the natural esthetics of traumatized teeth in mind, various treatment options have been proposed such as direct composite restoration, post and core, laminate and veneers[6]. Veneers and crown sacrifice the healthy tooth structure too much and poses difficulty for esthetic matching with adjacent tooth structure[7]. But with the acceptance of the acid etch technique and advancements in adhesive dentistry, more minimally invasive treatment options like reattachment have been proposed.

Traumatic dental fractures can be both complicated and uncomplicated. In uncomplicated fractures where the fragment is fully intact reattachment of the fractured fragment can be a viable treatment option. Treating an uncomplicated tooth fracture is always challenging to the dentist because many parameters play a role in the successful outcome of the restoration - mimicking the natural form and dimensions, opalescence, and translucency, for obtaining a better esthetic result.

With minimal intervention dentistry being a norm today, reattachment of fractured fragments which have been documented since 1964 seems to be here to stay. Reattachment restores tooth function and provides immediate natural aesthetics in the least possible time. It also maintains the contour and translucency of the original tooth and maintains colour stability over time. Reattachment being a more conservative and cost effective approach is preferred.[8]

Inspite of having several advantages, rebonding offers several limitations like colour change of fragment. Discolouration of fracture line over a time period and lesser strength compared to other full coverage restoration and even long term survival rate is unknown.[9,10,11,12] And whether the available fragment is intact or not also plays a major role in the procedure of reattachment.

However, in the age group of 8-14 years occlusion is not fully developed. In such scenarios reattachment of tooth fragment is always a more feasible option as indirect restoration like crowns and veneers will not be possible in such cases. Moreover, shade matching for a single prosthesis is comparatively difficult. So, in that case, reattachment is always a better option.[13]

Overtime a spectrum of materials have been used for the process of reattachment like – adhesive resin cement, chemical cure resin composite, light cure resin composites as well as conventional flowable composite. But among these conventional flowable composite seems to be the most promising.[14]

And it was seen that merely reattaching the fragments didn't seem to solve the purpose, one had to intervene with different techniques. Pusman et al in their study compared a simple reattachment procedure, overcontour, and internal dentinal groove

to reattach the fractured fragments and concluded that the internal dentinal groove provided the maximum fracture resistance.[15] Evidence based literature reviews have shown that internal dentinal groove restored with resin composite provided fracture strength as high as sound teeth. So, this internal dentinal groove was the preferred technique of reattachment in this study.

Literature shows that detachment of these fragments can also occur if there is a future episode of trauma. A systematic review by Adebayo et al has shown that these fractured fragments can get detached due to new trauma, tangential and shear forces and bond failure.[16]

New material in the horizon Activa Bioactive – is a self adhesive material with better bond strength. It is a flowable resin-based material incorporating the properties of both glass ionomer and resin composite. It releases and recharges significant amounts of calcium, phosphate, and fluoride from the saliva and thus stimulates apatite formation and mineralization. It thus, prevents marginal microleakage and discoloration of the restoration margin.[17,18]

Manufacturers claim that bioactive resin (Activa Bioactive) has the following properties- a)It is a self-adhesive material b)It has better esthetics c) It has better fracture resistance d) It has better wear resistance e) It has better resistance to marginal discoloration and better retention. Compared with other materials it was found that self adhesive bioactive resin (Active Bioactive) has a fracture resistance that is 2-3 times greater than conventional composite and 5-10 times greater than glass ionomer cement and resin-modified glass ionomer cement.[19]

Not much literature is available regarding the reattachment procedure conducted using self adhesive bioactive resin (Activa Bioactive). Hence, this was the chosen material for our study.

Thus, the present study was undertaken to evaluate and compare the fracture resistance of reattached tooth fragments using self adhesive bioactive resin (Activa Bioactive) and by incorporating an internal dentinal groove in the fractured fragment.

AIM OF THE STUDY

Evaluation and comparison of the fracture resistance of the tooth fragment reattached using conventional flowable composite and a new self-adhesive bioactive restorative material, with and without an internal dentinal groove preparation.

OBJECTIVES:

- To assess the fracture resistance of the tooth fragment attached by using conventional flowable composite resin with and without an internal dentinal groove preparation. To compare the fracture resistance of the reattached tooth fragment with and without internal dentinal groove preparation attached using conventional flowable composite resin.
- To assess the fracture resistance of the tooth fragment reattached by using a self-adhesive bioactive restorative material with and without an internal dentinal groove preparation. To compare the fracture resistance of the reattached tooth fragment with and without internal dentinal groove preparation attached using a self-adhesive bioactive restorative material.
- To compare the fracture resistance of the tooth fragments reattached by using a conventional flowable composite resin and a self-adhesive bioactive restorative material with and without internal dentinal groove preparation.

HYPOTHESIS

NULL HYPOTHESIS:

There is no difference in the fracture resistance of the tooth fragment reattached using conventional flowable composite resin and a self adhesive bioactive resin with and without an internal dentinal groove preparation.

ALTERNATIVE HYPOTHESIS:

There is a difference in the fracture resistance of the tooth fragment reattached using conventional flowable composite resin and a self adhesive bioactive resin with and without an internal dentinal groove preparation.

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REVIEW OF LITERATURE

1. The fracture strength rehabilitation of reattached anterior tooth fragments utilising various re-attachment strategies was examined in an in vitro investigation. The study claimed that the four reattachment techniques - simple reattachment, external chamfer, over contour, and internal dentinal groove - were used to restore both the fragment and the remaining damaged tooth. In comparison to over contour, external chamfer, and basic reattachment, the internal dentinal groove demonstrated the highest fracture resistance of 89.5%. Thus, it was determined that the preferred reattachment technique is the internal dentinal groove[20].
2. An 18-year-old male presented to general practice with a fractured upper central incisor. He gave a history of a strong knock to the upper jaw the day before while playing football. The fragment was already housed in a milk container since the occurrence on the instruction of the parents. A minimum amount of tooth structure had already been lost, according to the evaluation of the tooth fragment. The patient opted for tooth fragment reattachment with a double chamfer and composite resin technique. At the six-week clinical and radiographic review according to the IADT guidelines, the upper right central incisor remained vital and demonstrated normal mobility. All aspects of the clinical and radiographic examination appear consistent with the hydrated fragment successfully bonded to a vital tooth[21].
3. According to this case report, the patient was a 16-year-old girl presenting on an emergency basis. Her maxillary central incisors were fractured in an outdoor activity accident 11 h before the treatment. The fragment of tooth number 11 had been brought to the office in a paper tissue. Examination of the

fragment revealed a very clean break. The pulp chamber may be seen but there was no sign of pulpal exposure or blood. The juxtaposition of the fragment with the tooth showed that the margins of each fitted well against each other and no interfragmentary space was present. After the application of primer, the surface was air-dried gently and the adhesive was applied to both surfaces. The fragment was positioned in its original place and light cured for 10 s from various directions. After re-attaching the fragment, a groove in the fracture site was prepared. The groove and the fracture site of tooth number 21 were acid etched with 37% phosphoric acid for 20 s and rinsed thoroughly with water but not dried. A single-step adhesive was applied to the surfaces and light cured for 20 s. The groove and the tooth were restored with a hybrid resin composite (Z250, 3M). The esthetic result was excellent and the repair was barely visible. A week later, the patient was called for a follow-up appointment. The patient reported that she had a little sensitivity to cold for about 12 h after the treatment which disappeared after that. One year post-treatment checkup revealed the tooth to be vital.

4. This was the first case of a 15-year-old male patient who presented to the private pediatric dental clinic with a chief complaint of the fractured left maxillary central tooth sustained during sports activity. The recovered fracture fragment was brought to the clinic stored in water by the patient. Upon examination of the fractured fragment, it was found to be Ellis Class II fracture and the fragment was in a healthy condition and it fit satisfactorily well on the fractured tooth. The patient opted to have reattachment of the tooth fragment, and since the fracture line was in close proximity to the pulp a pulp capping procedure was carried out using calcium hydroxide. The calcium

hydroxide lined with a layer of Glass ionomer cement such that it did not extend onto the peripheral dentine and enamel. On the fractured fragment, a recess was created corresponding to the position of GIC using a round bur and it was ensured that the fragments approximated properly. Selective acid etching of enamel with 37% orthophosphoric acid for 15 s, then rinsed thoroughly with water and air-dried. Self-adhesive resin cement was applied to the fractured fragment and the tooth surface. The fractured fragment was then repositioned onto the tooth, final light curing was done for 20 s each on the labial and palatal side. A double chamfer was created along with the fracture line using a round bur. The chamfer was restored with microhybrid composite after etching and bonding the surface. The composite was cured for a time of 20 s per increment.[13]

5. A 23 year old patient who was injured in a motorcycle accident three days prior presented with the primary complaint of a broken upper front tooth. Upon clinical examination, it was discovered that the right maxillary incisor h ad a horizontal fracture in the middle part of the tooth, exposing the pulp and i mplicating enamel and dentin. An oblique fracture labiopalatally was discover ed by periapical radiographic examination; the root development was complet e and the tooth had not yet extruded.

The treatment plan included endodontic therapy, followed by reattaching the dental cr own using a fiber post. After the endodontic treatment, bevels were placed on the tooth and the fractured fragment, in order to enhance the retention. Space was also prepared in the pulp chamber of the fractured crown fragments for receiving the coronal portion of the post and also the core. The placement of the post & core was followed by etching and bonding of the inner portion of the coronal fragment using

flowable composite resin (Ivoclar Vivadent). The tooth was polished with a polishing disc. Clinical and radiographic examinations were carried out after 1 month, 3 months, and 6 months and the tooth responded favorably.[23]

6. In this invitro study perpendicular load was applied on the buccal aspect of the tooth crown of 350 intact human mandibular permanent incisors to achieve uncomplicated crown fractures. They were then randomly assigned into one of three reattachment protocols:(i) Simple reattachment, (ii) Overcontour preparation, and (iii) Internal-dentin groove. The first and second groups were divided into 10 subgroups, and the third group into five subgroups (n = 10 per group) with respect to five different adhesive systems (Prime&Bond NT, Adper Single Bond II, Adper Prompt L-Pop, Clearfil S^3 Bond, G Bond) used with or without a hybrid resin composite (Z250). Following thermal cycling, the same loading methodology used to fracture intact teeth, restored teeth were put through. The proportion of the initial fracture strength that remained following the reattachment techniques was reported. The positioning of an intermediate layer of resin composite and the type of adhesive used both had an impact on the fracture resistance. The internal dentin groove technique produced the maximum fracture strength recovery (54 0.58%, P 0.05), which was followed by the overcontour and simple reattachment protocols (49 0.58% and 32 0.82%, respectively, P 0.05).[15]
7. In this invitro study they evaluated the effect of fractured or sectioned fragments on the fractured strength recovery of four techniques used for reattachment and resin composite buildups . 91 sound permanent lower central incisors were used. Half the teeth were fractured in the incisal proximal edge ; the other half had the incisal proximal edge sectioned by a diamond saw.

Teeth from each half were divided randomly into five techniques. 1) Bonded only 2) Chamfer 3) Over Contoured 5) Internal Dentinal Groove 5) Resin composite buildup. An adhesive system and dual cure resin cement were employed for the reattachment. They concluded that no difference could be detected among reattachment techniques when fragments were obtained by sectioning. In groups where fragments were fractured i.e. Techniques 3 and 4 showed the highest fracture strength recovery[24].

8. According to this reported case study the patient presented with uncomplicated Ellis Class II fracture in the permanent maxillary left lateral incisor. Clinical crown was fractured obliquely without any pulpal involvement. The patient presented after 3 days of trauma with his tooth fragment stored in water. No signs and symptoms of pulpal and periapical infection were present hence no root canal treatment was performed and vitality of pulp was conserved. To save the tooth structure and achieve optimal adaptation of the tooth fragment, tooth was left unprepared. First premolar to first premolar anterior isolation was performed using rubber dam followed by which fractured fragment were etched with 37% Phosphoric Scotchbond™ Etchant applied to enamel and dentin for 15 s and rinsed for 10s. Excess water was blotted using a cotton pellet. This was followed by application of 2–3 consecutive coats of 3M ESPE Adper Single Bond Plus bonding agent to etched enamel and dentin for 15 s with gentle agitation using a fully saturated applicator, gently air thinned for 5 s to evaporate solvents followed by light curing for 10 s The fragment was reattached to the tooth using flowable composite resin 3M ESPE Filtek Z350 XT flowable composite resin and light cured[25].

9. A 35-year-old female presented with pain and mobility of her fractured left maxillary central incisor. Hard tissue examination revealed an Ellis class III fracture of 21 and a class I fracture of 11 . RCT, fiber post (Glassix-NORDIN, Switzerland, diameter 1.1 mm) cementation, and reattachment of the fractured segment were planned and performed on 21. 11 was restored with composite resin. The 1-year follow-up clinical evaluation revealed acceptable aesthetics and function[26].
10. A 7-year-old patient reported to the department of conservative dentistry and endodontics following fracture of the crown in the left maxillary central incisor. The fractured tooth segments was recovered at the site of the injury and placed in water. The trauma had occurred due to a fall about 2 hours ago. The clinical examination evidenced a fracture involving the enamel/dentin aspect with no symptoms. The crown fragment analysis showed a perfect margin adaptation of the fragment to the tooth remnant. The fractured fragment was stored in physiological saline for the time being. After the placement of rubber dam, the glass ionomer cement base was given covering the exposed dentine, excess cement was carefully trimmed. The adaptation of the fragment was checked. Phosphoric acid gel 37.5% (Scotch BondTM, 3M ESPE, St. Paul, USA) was applied to the enamel of the fragment and the teeth for 20 seconds. Air-water spray was used to remove the acid and the surface was air-dried. An adhesive system (Adper Single Bond PlusTM, 3M ESPE) was applied to the tooth fragment. A small increment of resin composite was applied to the tooth fragment which was then reattached to its proper position. Visible light polymerization was done for 60 seconds to the facial and palatal surfaces of the tooth, while the fragment was kept in position under pressure.

The tooth was polished with polishing discs and the rubber dam was removed. Clinical and radiographic examination was carried out after 3 month & 6 months .Teeth responded positively to the pulp vitality tests and the radiographs showed no periapical changes[27].

11. A 9-year-old female patient reported to the Department of Pedodontics and Preventive Dentistry, Yenepoya Dental College, Mangalore, after sustaining an uncomplicated crown fracture to her maxillary left central incisor while playing about 24 hours ago. Patient recovered the fractured tooth fragment and brought it to the clinic in an empty box. The fractured part of the tooth was intact, with some crack and craze lines. No abnormal mobility of the injured tooth was recorded and the surrounding tissues were healthy. A periapical radiograph showed that the root formation was complete and there were no other injuries. The tooth fragment was analyzed and tried intraorally to check for proper fit with the fractured coronal structure and immediately maintained in normal saline. The operating field was isolated with rubber dam, the fractured fragment and the tooth surface was treated with 37% phosphoric acid, followed by rinsing. The adhesive system Excite (Vivadent, Liechtenstein) was applied to the fragment and the tooth, followed by placement of a small increment of flowable composite resin, Tetric flow (Vivadent). The fragment was properly positioned on the fractured tooth surface and was held under pressure, followed by removal of excess resin and light cureing for 60 seconds. The immediate postoperative view showed adequate esthetic results with restored functionality. Nine years follow-up showed a predictable outcome of the reattached fragment[28].

12. A 14-year-old boy presented at Royal Newcastle Hospital, Newcastle 40 minutes after colliding with a team-mate in a volleyball game. The 21 had been fractured resulting in a pin-point exposure of the pulp. The large fractured tooth fragment had been transported dry in a plastic bag, packed with ice. Clinical and radiographic examination indicated no other dental injuries. A partial pulpotomy procedure" was performed, the pulp was capped with a calcium hydroxide paste, and overlaid with a hard-setting calcium hydroxide linings such that all exposed dentine was covered. The fracture margins of both crown and fragment were prepared to produce an approximately 45 degree bevel in enamel, 1 mm wide. The dentine in the fragment was hollowed out to accomodate a bulk of composite resin. All prepared surfaces were etched for 60 seconds with 35% phosphoric acid and then rinsed and dried. An intermediate resin layer was applied to the etched surfaces and cured with a white-light source. A thin layer of microfilled resin was spread on the prepared surface of the fragment which was then repositioned over the fractured surface of the crown. Excess resin was removed and the composite resin photocured for two minutes. At a six-month follow-up examination, the 21 had been asymptomatic and responded within normal limits to vitality tests. The labial margin was evident although the composite resin was satisfactory in terms of marginal integrity and abrasion. The fragment had discoloured slightly[4].
13. Munkasgaard et al. investigated the impact strengths of anterior teeth that have been fractured and restored by bonding with a dentin bonding agent and a composite resin. Twenty sheep central incisors were divided into two groups, 10 in each. One group (intact teeth) served as the control and the teeth in the

other group were fractured and the bonded with one-step dentin bonding system & Aetiteflo composite resin. It was concluded that the bonding fragments to the remaining tooth structure might restore to the tooth to its original strength, measured at the modest velocities of the traumatized fractured anterior teeth restored with one-step dentine bonding system and Aeliteflo composite resin would withstand a second trauma to some extent as with the intact teeth[29].

14. Pagliarina et al. studied the effect of the current enamel dentin adhesives on the reattachment of the fractured dentinal fragments. The objective of this study was to determine the strength needed to detach the coronal fragments reattached with the most recent adhesives. A composite coronal fracture was caused on the incisal one third of the forty non-carious maxillary and mandibular laterals and central incisors, each fractured coronal fragments was reattached to its tooth with the enamel dentin adhesive. Scotch bond MP, All – BOND2, Dentastic. Or One Step. They found no statistically significant difference between two similar, fourth-generation adhesives that use orthophosphoric acid as etchant (Dentastic and All Bond) and a fourth generation adhesive that uses ma;eic acid as etchant Scotch Bond MP. The values obtained with the other 3 enamel dentin adhesives. They finally concluded that the reattachment of the fractured tooth fragments, 4th generation adhesives can gurantee a bonding force stronger than the fifth generation adhesives[6].
15. Investigated the shear bond strengths of sectioned human mandibular incisor edge fragments reattached using luting cements, bonding agents or restored with composite resins 70 teeth were randomly distributed among 6

experimental groups & control group. The fragments in 1-4 were bonded to their respective teeth using Clearfil Linear bond 2V; Scotch Bond Multi purpose plus, Panavia-f and 3M Opal luting cement. The 5th and 6th groups were restored with composite resin (Silux 3M and Clearfil AP-X) using their bonding agents (Single bond and Clearfil SE bond) the rsults indicated that the reattachments of fractured incisal fragments by using new generation bonding agents was effective against shear stresses, comparable with the intact teeth[30].

16. Presented a clinical case of a seven & half year old boy who had fractured incisal, 1/3rd of 21. The fractured fragment was brought in a plastic bag. The dentin in both tooth and tooth fragment was cleaned with pumice, disinfected with 2% chlorhexidine gluconate and washed again with NaOCl the fragment and the tooth were then etched, bonded with clearfil SE Bond and restored with dual cured resin. The patient was recommended for a postoperative visit within a few weeks. The author concluded that a fractured maxillary anterior tooth could be bonded with excellent results as long as the fractured fragment is not lost and is in one piece[31].
17. Determined the static load bearing capacity of fractured incisors restored with conventional adhesive composite technique or by using fiber re-inforced with conventional adhesive composite technique or by using fiber re-inforced composite (FRC), for which the authors had used twelve extracted sound maxillary incisors which were prepared by cutting the incisal third part of the crown horizontally. Restorations were made by using three techniques . Group- A (control group) was restored by reattaching the original incisal edge to the tooth. Group-B was restored using particulate filler composite (PFC). Group-C was restored with PFC and FRC by adding a thin layer of FRC on

the palatal surface of the tooth. the bonding system was the conventional etch system with the primer and adhesive. All the restored teeth were stored in water at room temperature for 24 h before they were statically loaded until fracture in a universal testing machine. Data were analysed using ANOVA (P=0.05). Results of the study Group A (reattaching fractured incisal edge) reveal the lowest load bearing values, whereas preparation of new incisal part with PFC revealed 148% higher load bearing values compared to Group A. Group-C (teeth restored with FRC) revealed 254% higher load bearing capacity than the control group. ANOVA A revealed that the restoration technique significantly affected load-bearing capacity (p<0.001). The failure mode in Groups- A and B was debonding of the restoration from the adhesive interface, while in Group C, 50% of teeth fractured below the cementoenamel junction. However they concluded based on the results that an incisal fracture tooth restored with a combination of PFC and FRC provide the highest load bearing capacity[32].

18. A 22-year-old female patient presented with a broken front tooth after an accident in the morning of the same day. Clinical examination revealed a class III fracture in 11 with the fracture line running oblique from the gingival third of the tooth on the labial aspect to subgingival palatally. Intraoral examination revealed the fractured fragment still held by the palatal periodontal tissues. A radiograph indicated complete root formation with no periapical radiolucency. The tooth was stabilised in the mouth to prevent it from getting dehydrated which was later detached after obturation. Following cleaning and shaping, the root canals were obturated with gutta-percha and resin-based sealer using the lateral compaction technique. The gutta-percha was then partially removed,

leaving the apical 5 mm of the filling to maintain a good seal and a glass-fibre-reinforced composite root canal post was placed in the canal. A dual-cure luting system *(SmartCem2, Dentsply Maillefer)* and a glass-fibre-reinforced composite root canal post *(Easypost, Dentsply Maillefer)* were sequentially placed according to the manufacturer's instructions A trough was created in the centre of the original crown fragment, and both the intact coronal portion of the tooth and the original crown fragment were etched with 37% phosphoric acid gel for 20 s, rinsed for 20 s and dried. Flowable composite resin *(EsthetX Flow, Dentsply Caulk)* was applied at the intact coronal portion of the tooth and the original crown fragment followed by accurate placement of them and photopolymerisation for 40s[33].

19. A 10.5-year-old child presented with broken front central incisor (#21) after falling down the stairs two days before. Fragment of the broken tooth was brought stored in a plastic container. She was complaining of tooth sensitivity while exposing to air and drinking. A comprehensive intraoral and radiographical examination was performed and clinical examination revealed a class II fracture. It was found that tooth #21 was intact and immobile after fracturing, with no sign of gingival inflammation. A vitality test was conducted to evaluate the blood supply to the tooth, and a sensitivity test (thermal cold test) was performed to assess the sensory response. The outcomes were positive, and a normal response was noticed. The fragment was cleaned and checked with the broken tooth in order to ensure that no part was lost. The fragment was in good condition and fit reasonably well on the fractured tooth. However, the perceptible shade difference was observed between the broken tooth and the fragment due to the dehydration of the tooth

fragment during the last two days. The fragment was stored in saline (for one hour) until reattached with the tooth. Topical and local anesthesia was administered to the patient. Bevels were created on a broken tooth to help in increased retention. The beveling was performed from the palatal as well as the buccal surfaces. Vitrebond (3M-ESPE, St. Paul, MN, USA) was used to fix the retentive holes into the dentin. Next, a self-etching primer (Clearfil Liner Bond SE Primer, Kuraray, Osaka, Japan) was applied for 20 seconds and light-cured according to the manufacturer's instructions. Next, a broken tooth and a fragment were air-dried gently. Dual cure flowable composite (SmartCem2, Dentsply Maillefer, USA) with A2 shade was applied on the broken incisal edge of the tooth and the fragment. The fragment was positioned accurately and photopolymerized for 20 seconds each from the labial and palatal sides[34].

20. A 24 year old male patient, a basketball professional player, suffered a traumatic crown fracture of the upper right central incisor (11), with the fracture line being located in the middle third of the tooth. The patient reported promptly to the clinician with the fractured fragment. The tooth involved showed no evidence of pulpal exposure or of periodontal lesions. Our operative protocol, preliminarily to any restorative step, started with a clinical examination in order to evaluate the traumatic injury, and the condition and the margins of the fragment. In the radiographic assessment, there was no fracture of the root or the alveolar bone. The fractured portion was disinfected with 0.2% chlorhexidine, and stored in physiologic solution (Ogna Sodiomu Clorum 0.9 %®) to maintain the hydration. Tooth vitality test was performed by giving thermal stimulus to the tooth (cold) and it responded as vital.

Isolation of the operating field was done with rubber dam after the administration of local anesthesia. This was followed by cleansing, polishing and trying in of the fractured tooth to check any disruptions and defects in the tooth structure and fragment.To facilitate its handling, the fragment was fixed on its vestibular aspect to a holder with an adhesive tip (Pic-n-stic, Pulpdent Corp.). As there was no loss of dental hard tissues, the fragment and the fractured tooth was treated with an "etch and rinse" technique using 37% phosphoric acid (The acid time application was related to the different tooth surface. It was 30 seconds for enamel, 1s seconds for dentine), followed by a separate application of priming and bonding agents (Scotchbond MP, 3M ESPE).The fragment was thus placed in its proper position followed by polymerization was carried out on both the vestibular and lingual aspects using a 60 seconds for each surface light-emitting diode (LED) light-curing unit (Elipar Freelight 2, 3M Espe). The restored tooth was then finished and polished using silicon points immediately after the fragment reattachment (HiLuster Plus Identoflex, KerrHawe)[35].

21. In the in vitro study conducted by Badami et al, to investigate the shear bond strength of secondary dentin bonding agents for the reattachment of Incisal edge fragment, 72 bovine mandibular incisors were used for the study. The collected samples were grouped in 3 sections as 1) control group 2) Bonded with GLUMA 2000 3) Bonded with Scotcbond 2 with 24 teeth in each group. Followed by this the teeth were Sectioned 3mm from the incisal edge using Acutome -2 and were bonded using GLUMA 2000 under group 2 and Scotchbond 2 under group 3. Once the fragments were rebonded, they were mounted on the dental stone and was placed in a test Jig to be tested for the

strength using custom made fracture testing blade. And, they concluded with the mean fracture force (930 ± 144)N of control group is Significantly greater ($p<0.01$) than that required to fracture fragments rebounded with GLUMA 2000(609±116)N and Scotchbond 2(393±97)[1].

MATERIALS AND METHOD

SOURCE OF DATA:

The study was conducted in the Department of Conservative Dentistry and Endodontics, KLE Academy of Higher Education & Research, KLE VK Institute of Dental Sciences, Belagavi

Extracted human maxillary central incisor teeth were collected from the Department of Oral and Maxillofacial Surgery, KLE Academy of Higher Education & Research, KLE VK Institute of Dental Sciences, Belagavi.

Specimens were evaluated for fracture resistance in Praj Metallurgical Lab, Pune.

INCLUSION CRITERIA:

Human permanent maxillary central incisors with intact crown structure.

EXCLUSION CRITERIA:

- Teeth with cracks or fracture lines.
- Carious teeth
- Teeth with attrition, abrasion, and other structural defects
- Root canal treated teeth.
- Already restored teeth
- Teeth with anatomic variation.

SAMPLE SIZE ESTIMATION:

Standard deviation in the Ist group S1 = 3.03

Standard deviation in the IInd group S2 = 1.46

Mean difference between Ist and IInd sample d = 1.99

Z_α = 1.96 at 5% α error

Z_β = 0.84 at 20 % β error

Using the following formula, sample size was calculated as,

$$n = \frac{2S^2 [Z_\alpha + Z_\beta]^2}{d^2}$$

Number needed (n) = 22 in each group

So the estimated sample size is 22 in each group which makes the sample size 44 in total

Thus the sample size for the study was calculated as 22 extracted teeth in each group (group 1 and group 2) with a total of 44 extracted teeth.

MATERIALS:

- Human permanent maxillary central incisor teeth
- 0.1% thymol, 0.9% saline
- 37% phosphoric acid etchant gel
- Universal bonding agent (3M ESPE)
- Composite resin A2 Shade (3M ESPE Filtek Z350)
- Activa BioACTIVE Restorative Resin (Pulpdent)

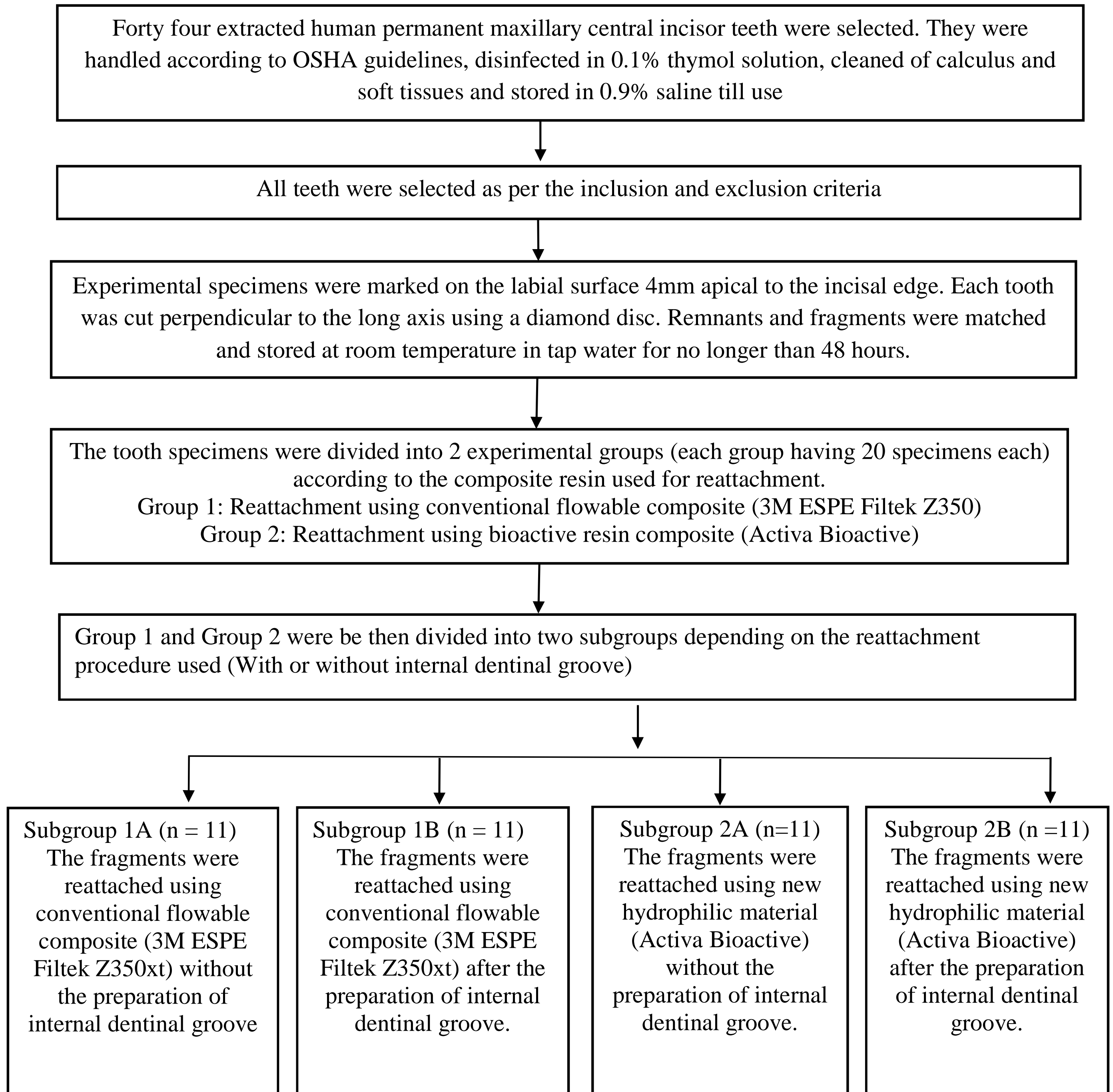
ARMAMENTARIUM:

- Kidney tray
- Straight probes(GDC)
- Pair of tweezers (GDC)
- Ultrasonic scaling unit
- Polishing flexible disc (Soflex Pop-on Polishing disk 3M dental)
- Composite Instrument (Hu-Freidy #3 Goldstein Flexi-Thin Composite Instrument)
- Light Curing Unit (Woodpecker iLED)
- Universal testing machine
- Microtip Applicator tip (Cortisen)
- Diamond Disc with Mandrel
- Carbide Bur (SS White FG-330)
- Straight Micromotor Hand Piece (NSK)
- Airotor Handpiece (NSK PanaAir FX)
- Stereomicroscope (LABOMED)

STUDY DESIGN:

Analytical study (Prospective Cohort)

METHODOLOGY WITH FLOWCHART:



After obtaining the fragments the following protocol was followed—
Subgroup 1B and 2B: Before the reattachment an internal dentinal groove, 1mm deep and 1mm wide was prepared within the fragment and the remaining tooth by means of a water cooled high end carbide bur.
Subgroup 1B and 2B: No Preparation was made.

↓

The specimens in both Group 1 and Group 2 were etched for 15 seconds using 37% phosphoric acid etchant gel, rinsed and gently dried. Universal adhesive was applied on the etched surface of Group 1 and 2 using microbrushes and reattached accordingly as mentioned above.

↓

The teeth were finished and polished using a flexible polishing disk. These teeth were embedded in auto polymerizing acrylic resin block of 1 x 1 inch dimension and stored in tap water in room temperature

↓

Then the force required to fracture the tooth was recorded using the Universal Testing Machine with the load applied in a buccolingual direction with a crosshead speed of 1mm/min. The force was recorded in KgF

DETAILS OF THE PROCEDURES CONDUCTED DURING THE RESEARCH:

Forty-four extracted human permanent maxillary central incisors without any cracks, restorations or caries were used for the study. They were then handled according to the OSHA guidelines, disinfected in 0.1% thymol solution, cleaned of calculus and soft tissue and stored in 0.9% saline solution till use. All teeth were selected as per the inclusion and exclusion criteria.

The test consisted of three procedures:

1) **Sectioning of sound teeth**- Experimental specimens were marked on the labial surface 4mm apical to the incisal edge. Each tooth was cut perpendicular to the long axis using a diamond disc. Remnants and fragments were matched and stored at room temperature in tap water for no longer than 48 hours.
2) **Restoration of the Fractured teeth** – The tooth specimens were divided into 2 experimental groups (each group having 22 specimens each) according to the composite resin used for reattachment.

    - Group 1: Reattachment using conventional flowable composite (3M ESPE Filtek Z350xt)
    - Group 2: Reattachment using bioactive hydrophilic restorative material (Activa Bioactive)

Group 1 and Group 2 were then divided into two subgroups depending on the reattachment procedure used (With or without internal dentinal groove)

Subgroup 1A (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) without the preparation of internal dentinal groove

Subgroup 1B (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) with the preparation of internal dentinal groove

Subgroup 2A (n=11): The fragments were reattached using new self adhesive hydrophilic material (Activa Bioactive) without the preparation of internal dentinal groove.

Subgroup 2B (n =11): The fragments were reattached using new self adhesive hydrophilic material (Activa Bioactive) with the preparation of internal dentinal groove

After obtaining the fragments the following protocol was followed—

Subgroup 1B and 2B: Before the reattachment, an internal dentinal groove ,1mm deep and 1mm wide was prepared within the fragment and the remaining tooth by means of a water cooled high end carbide bur.

Subgroup 1A and 2A: No Preparation was made.

The specimens in both Group 1 and Group 2 were etched for 15 seconds using 37% phosphoric acid etchant gel, rinsed and gently dried.

Universal adhesive (3M Universal Single Bond) was applied on the etched surface of both Group 1 and Group 2 using disposable microbrushes. Then the fragments were and reattached accordingly.

The teeth were finished and polished using a flexible polishing disk. These teeth were embedded in auto polymerizing acrylic resin block of 1 x 1 inch dimension and stored in tap water in room temperature for 24 hours.

3) Fracture strength of restored teeth: The specimens were mounted on custom made fixture for determination of shear bond strength using the universal testing machine. A knife edge chisel (0.5 mm in cross-section) was used to deliver the force so that contact was achieved 4 mm apical to the incisal edge. The shearing load was applied at a crosshead speed of 1mm /min. The shearing force was noted and shear bond strength was calculated and recorded in kilogram force units KgF.

FIG 1. ARMAMENTARIUM

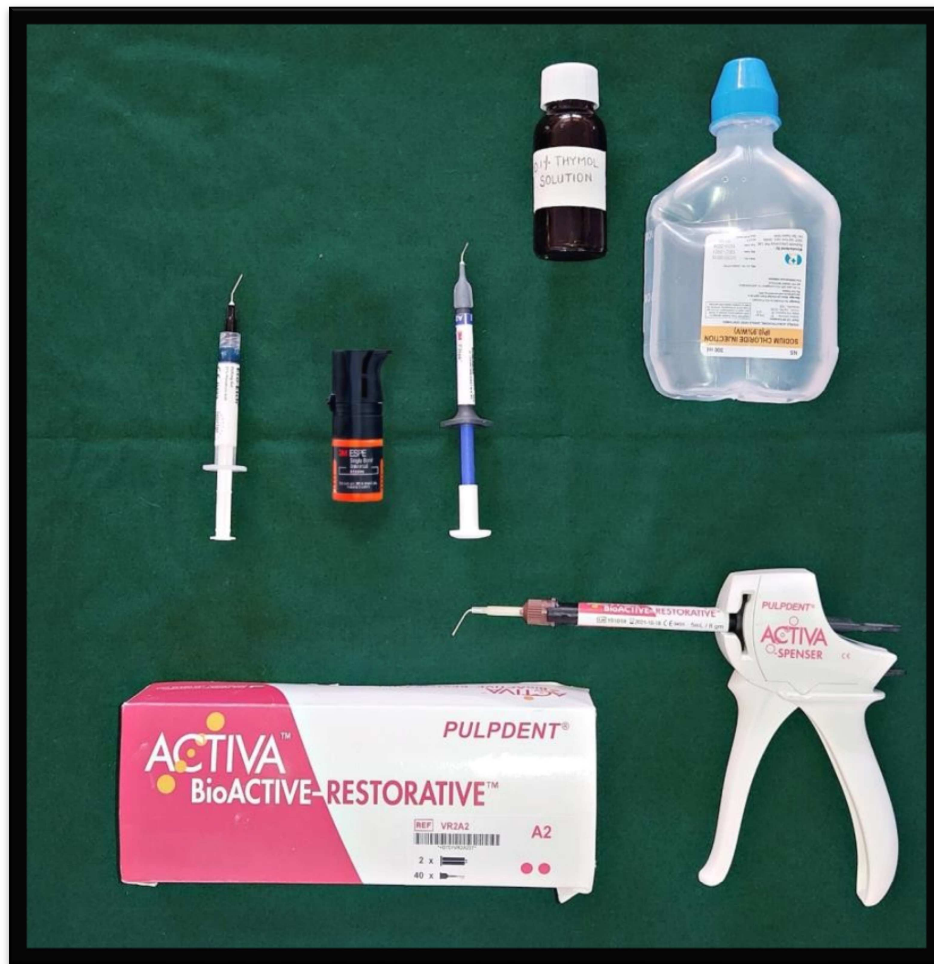


FIG 2. MATERIALS

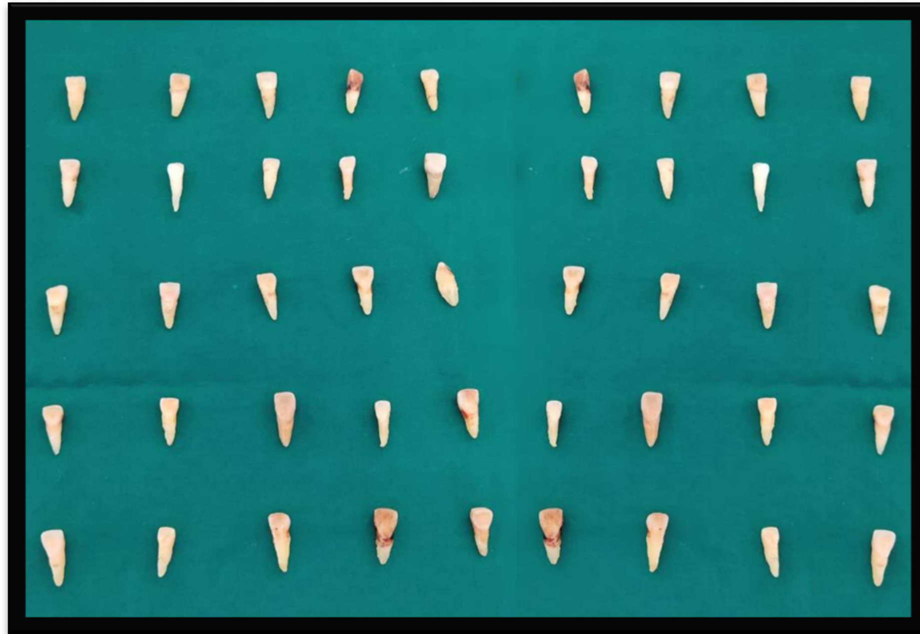


FIG 3. EXTRACTED MAXILLARY CENTRAL INCISOR

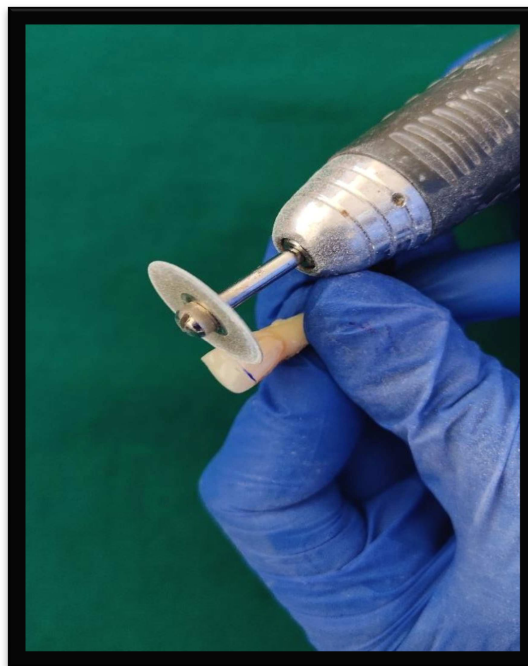


FIG.4 SECTIONING OF THE TOOTH 4MM BELOW THE INCISAL EDGE

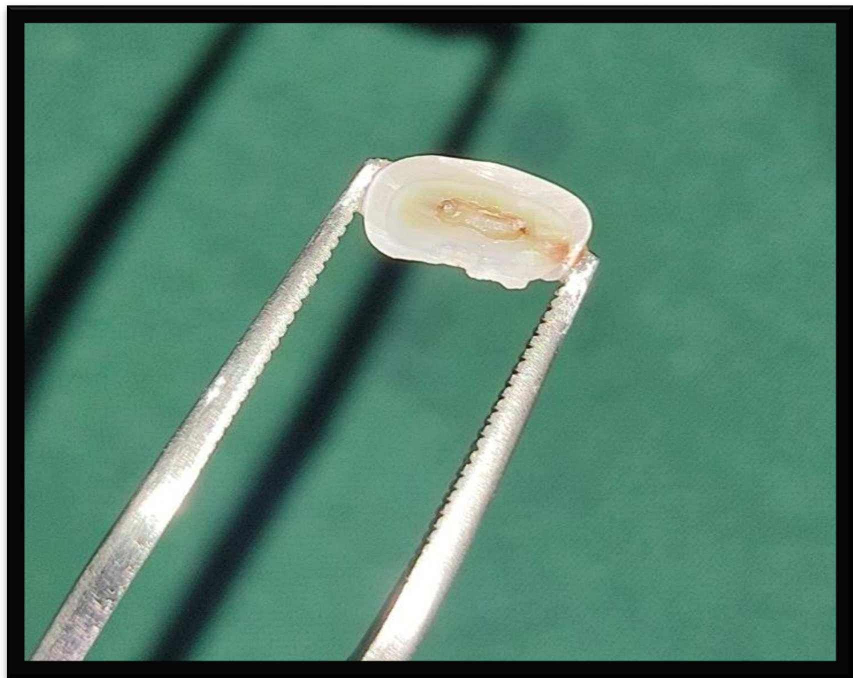


FIG 5. PREPARATION OF INTERNAL DENTINALGROOVE

FIG 6. APPLICATION OF 37% PHOSPHORIC ACID ETCHANT GEL

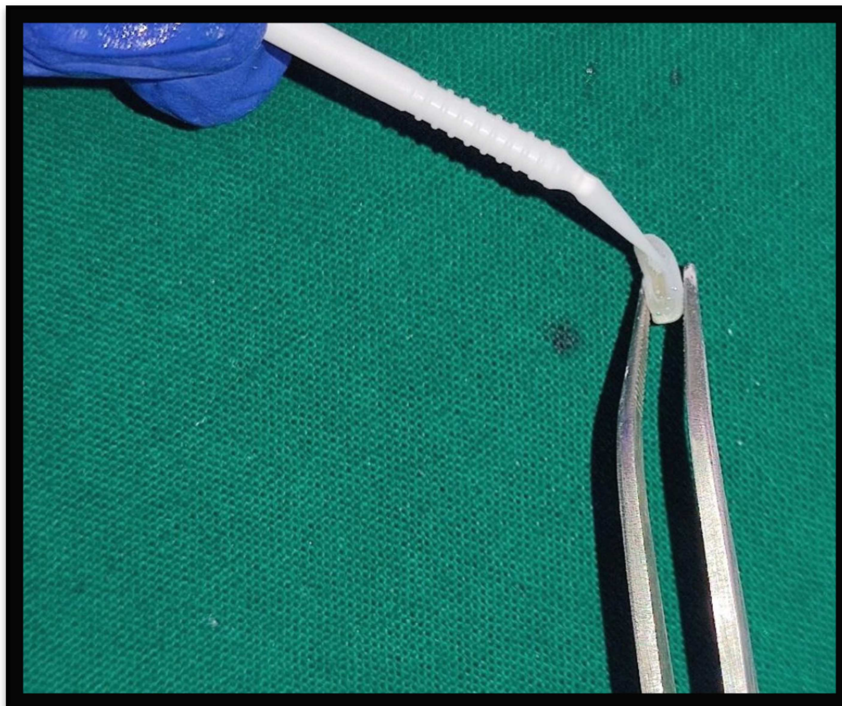


FIG 7. APPLICATION OF BONDING AGENT

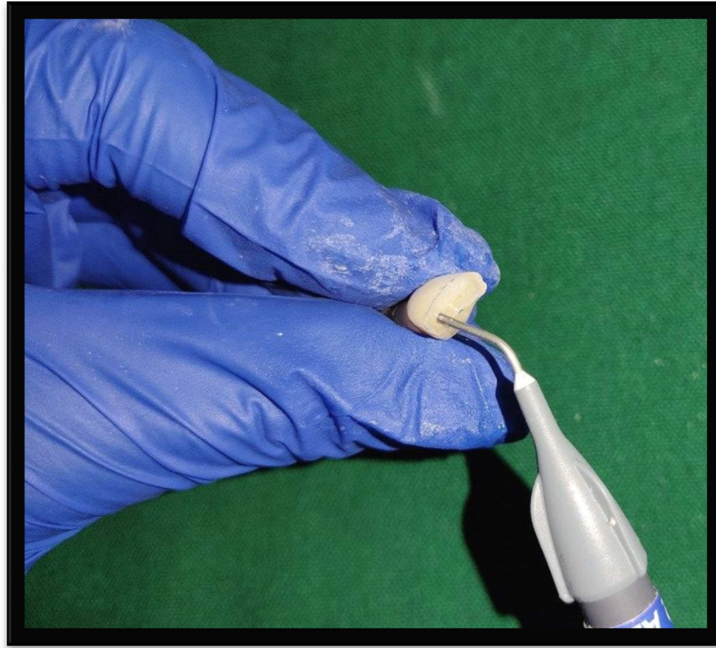
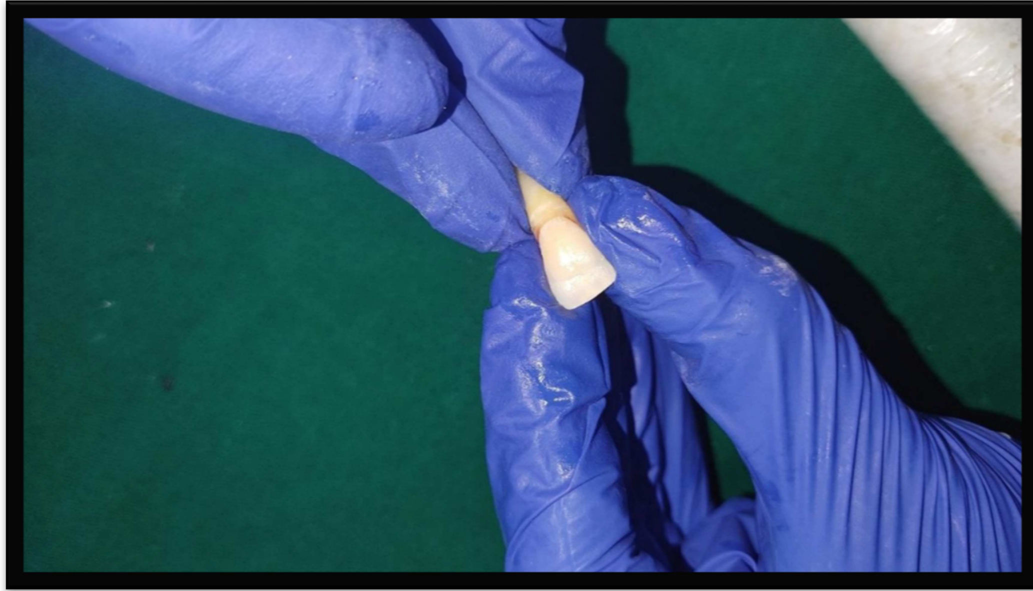


FIG 8. APPLICATION OF FLOWABLE COMPOSITE RESIN

FIG 9. APPLICATION OF SELF ADHESIVE BIOACTIVE RESIN (ACTIVA BIOACTIVE)



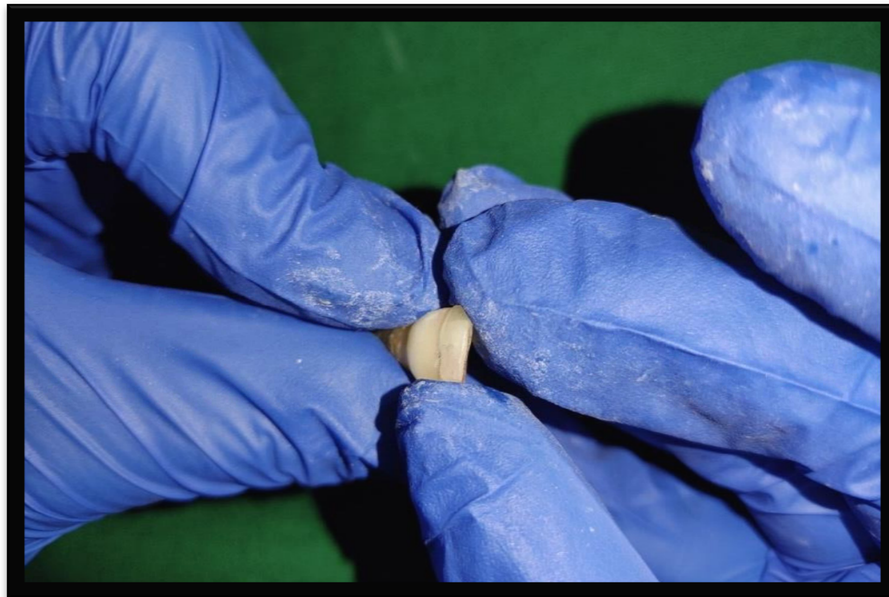


FIG 10. RE-ATTACHMENT OF THE FRAGMENT

FIG11.CURING AFTER RE-ATTACHING THE FRAGMENT

FIG 12. UNIVERSAL TESTING MACHINE

FIG 13. UNIVERSAL TESTING MACHINE WITH SPECIMEN UNDER SHEARING LOAD

RESULTS

The aim of the study was to compare the fracture resistance of the tooth fragment reattached using a conventional flowable composite and a new self-adhesive bioactive restorative material, with and without an internal dentinal groove preparation.

A total of 44 (forty-four) extracted permanent human maxillary central incisors which were non carious, free of attrition, abrasion, and other structural defects were used for the present study.

The tooth specimens were divided into 2 experimental groups (each group having 22 specimens each) according to the composite resin used for reattachment.

- Group 1: Reattachment using conventional flowable composite (3M ESPE Filtek Z350xt)
- Group 2: Reattachment using bioactive flowable restorative material (Activa Bioactive)

Group 1 and Group 2 were then divided into two subgroups depending on the reattachment procedure used (With or without internal dentinal groove).

Subgroup 1A (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) without the preparation of internal dentinal groove.

Subgroup 1B (n = 11): The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) with the preparation of internal dentinal groove.

Subgroup 2A (n=11): The fragments were reattached using new self-hydrophilic material (Activa Bioactive) without the preparation of internal dentinal groove.

Subgroup 2B (n=11): The fragments were reattached using new material (Activa Bioactive) with the preparation of internal dentinal groove.

These teeth were embedded in an auto polymerizing acrylic resin block of 4 x 4-inch dimension and stored in tap water at room temperature for 24 hours.

The load required to fracture the tooth was calculated in KgF and is expressed in tabular column represented in Table 1,2, 3, 4

FRACTURE RESISTANCE

TABLE 1

Sub Group 1 A: Flowable W/o Internal Dentinal Groove		
Sr.No.	Sample No.	Fracture Load (KgF)
1	No.1	10.40
2	No.2	10.60
3	No. 3	10.04
4	No. 4	10.21
5	No. 5	10.66
6	No. 6	9.97
7	No. 7	10.04
8	No 8	10.26
9	No. 9	10.45
10	No. 10	10.69
11	No. 11	10.36

TABLE 2

Sub Group 1 B: Flowable with Internal Dentinal Groove		
Sr.No.	Sample No.	Fracture Load (KgF)
1	No.1	11.24
2	No.2	11.57
3	No.3	11.08
4	No. 4	10.97
5	No. 5	12.18
6	No. 6	12.36
7	No.7	11.23
8	No. 8	10.99
9	No.9	11.60
10	No. 10	11.30
11	No. 11	11.10

TABLE 3

Sub Group 2 A: Self adhesive resin (Activa Bioactive)W/o Internal Dentinal Groove		
Sr. No.	Sample No.	Fracture Load (KgF)
1	No.1	13.20
2	No.2	13.95
3	No. 3	12.92
4	No. 4	13.55
5	No. 5	12.52
6	No. 6	14.14
7	No. 7	13.23
8	No 8	13.96
9	No. 9	13.44
10	No. 10	12.50
11	No. 11	12.43

TABLE 4

Sub Group 2 B: Self adhesive resin (Activa Bioactive) with Internal Dentinal Groove		
Sr. No.	Sample No.	Fracture Load (KgF)
1	No.1	15.76
2	No.2	17.58
3	No.3	17.45
4	No. 4	15.89
5	No. 5	16.56
6	No. 6	17.05
7	No.7	17.76
8	No. 8	17.34
9	No.9	16.45
10	No. 10	16.04
11	No. 11	16.78

STATISTICAL ANALYSIS

Table 5: Summary of fracture resistance in two groups (1 and 2) and two subgroups (A and B)

Factors	Levels	N	Mean	SD	SE	95% CI	
						Lower	Upper
Groups	Group 1	22	10.88	0.67	0.14	10.58	11.17
	Group 2	22	15.02	1.92	0.41	14.17	15.87
Subgroups	Subgroup A	22	11.80	1.57	0.33	11.10	12.49
	Subgroup B	22	14.10	2.81	0.60	12.86	15.35
Groups with subgroups	Group 1A	11	10.33	0.25	0.08	10.16	10.51
	Group 1B	11	11.42	0.47	0.14	11.10	11.74
	Group 2A	11	13.26	0.62	0.19	12.84	13.67
	Group 2B	11	16.79	0.71	0.21	16.31	17.26

Table 6 : Comparison of two groups (1 and 2) and two subgroups (A and B) with mean fracture resistance by two way ANOVA

Sources of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F-value	p-value
Main effects					
Groups	189.033	1	189.0327	650.9025	0.0001*
Subgroups	58.559	1	58.5586	201.6366	0.0001*
2-way interaction effects					
Groups *Subgroups	16.421	1	16.4212	56.5438	0.0001*
Error	11.617	40	0.2904		
Total	275.629	43			

*p<0.05 indicates significant

Table 7: Pair wise comparison of two groups (1 and 2) and two subgroups (A and B) with mean fracture resistance by Tukeys multiple posthoc procedures

Interactions	Group 1A	Group 1B	Group 2A	Group 2B
Mean	10.3345	11.4200	13.2582	16.7873
SD	0.2547	0.4695	0.6157	0.7052
Group 1A	-			
Group 1B	P=0.0003*	-		
Group 2A	P=0.0002*	P=0.0002*	-	
Group 2B	P=0.0002*	P=0.0002*	P=0.0002*	-

*p<0.05 indicates significant

Figure 14: Comparison of two groups (1 and 2) and two subgroups (A and B) with mean fracture resistance

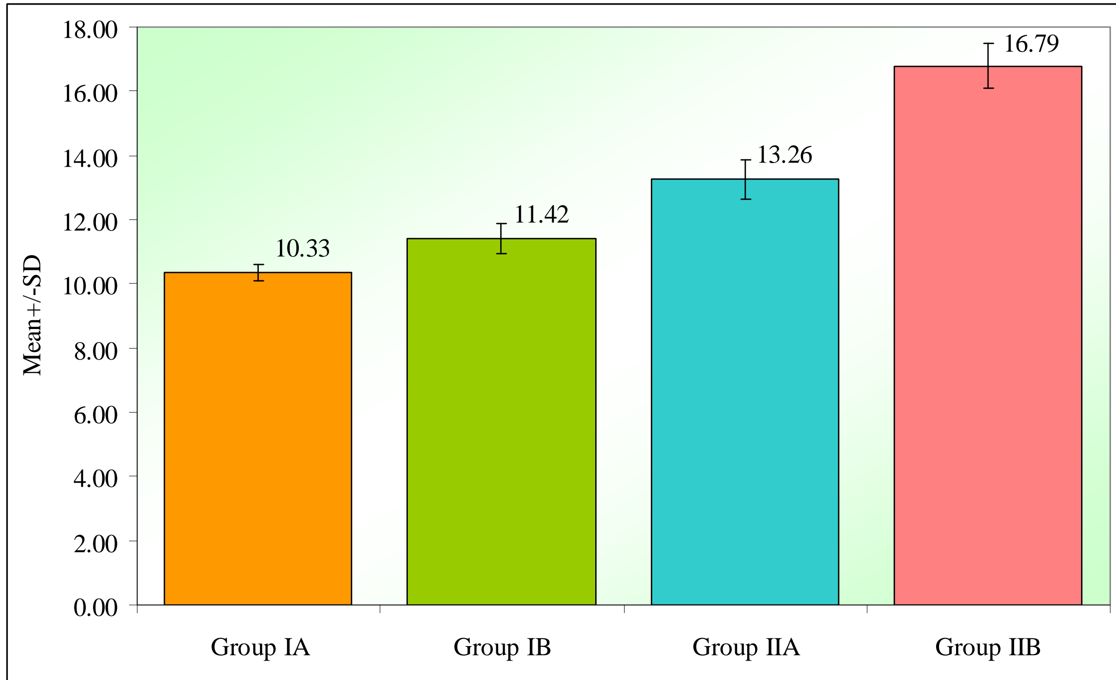


Figure 15 : Comparison of subgroups 1A, 1B, 2A, 2B with mean fracture resistance

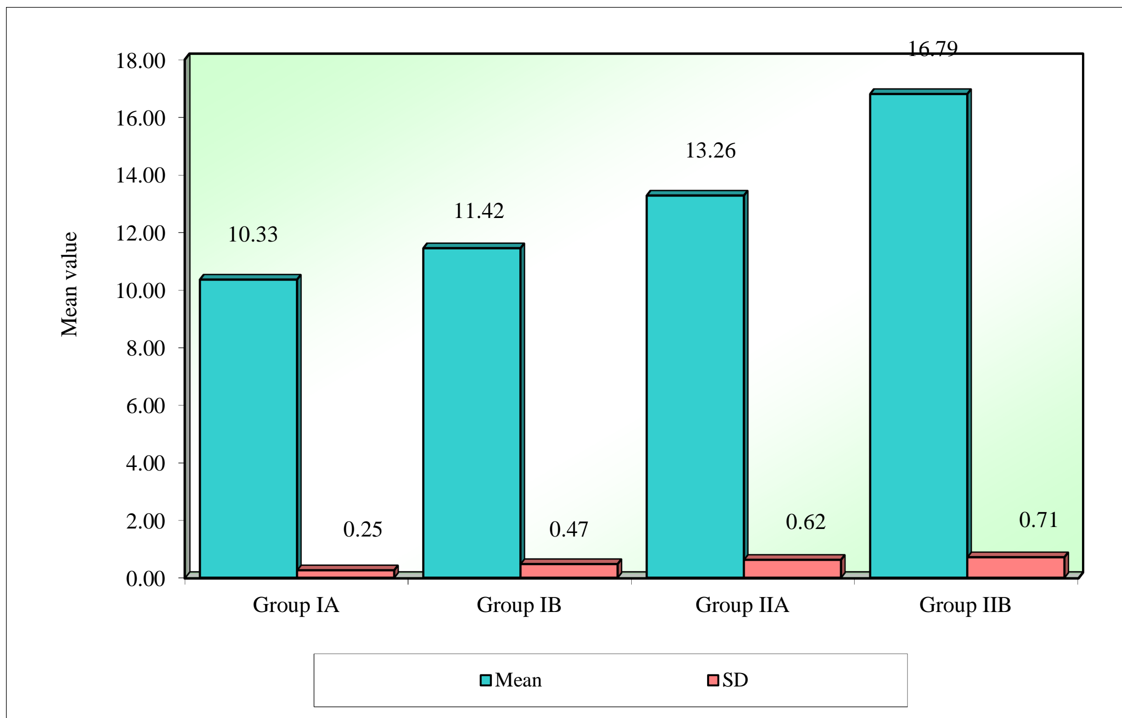


Table 5 gives the summary of fracture resistance in two groups (1 and 2) and two subgroups (A and B). The mean fracture resistance of the groups and subgroups and the standard deviation are displayed in the table

Table 6 gives the Comparison of two groups (1 and 2) and two subgroups (A and B) with mean fracture resistance by two-way ANOVA

- A significant difference in main effects was observed between two groups 1 and 2 with mean fracture resistance. It was found to be significant with (f value = 650.902) (p value =0.0001)
- A significant difference in the main effects was observed between two subgroups A and B with mean fracture resistance. (f value= 201.6366) (p value = 0.0001)
- Interaction effects of two groups and two subgroups with mean fracture resistance were found to be significant (f value = 56.5438) (p value = 0.0001)

Further to know the pairwise comparison between two groups 1 and 2 and two subgroups A and B, the Tukeys Multiple Post Hoc Analysis procedure was applied as displayed in Table 7

The mean Fracture resistance of Subgroup 1 A is 10.335 followed by 1 B which is 11.42, followed by 2 A which is 13.258, and 2 B which is 16.78.

Subgroup 2 B shows the highest mean fracture resistance of 16.78 with a standard deviation of 0.7052

Subgroup 1B when compared with Subgroup 1 A shows a p value of 0.0002 which is statistically significant.

Subgroup 2 A when compared with Subgroup 1 B shows p value of 0.0002 which is statistically significant

Subgroup 2 B when compared with 1A, 1B, and 2A shows significant p values of 0.0002

Thus to conclude from Two way ANOVA and Tukeys Multiple Post hoc test the results are statistically significant.

DISCUSSION

The fracture of an anterior tooth is one of the most traumatic experiences for any individual, especially more in the case of children.[36] Although there are differences in the percentage rates, a spectrum of studies agree in the following aspects:

- Traumatic accidents and sport activities are the most common cause of dental trauma.[37]
- The age group commonly affected are the children and young adolescents, with boys being the most affected.
- Mesio- incisal angle fracture in central incisors accounts to be the highest
- The injury most commonly seen are the uncomplicated crown fractures (Ellis class 1 and 2) ,which includes enamel and enamel-dentin without pulp exposure.

Trauma to the anterior teeth affects the patients both psychologically and socially.

So as a clinician we need to intervene as early as possible and give a quick and esthetic solution which will survive for a longer period of time. Through the yester years fractured teeth were restored using acrylic resin and complex ceramic restorations associated with metal. These restorations didn't provide adequate long-term esthetics and led to a larger loss of tooth structure.

With the intention to preserve the tooth structure, the fractured fragment was reattached. Reattaching the fragment showcased more advantages over resin composite restoration when compared to esthetics, maintenance of better tooth form and colour, increased wear resistance thus providing improved function.[39]

Owing to the lack of technology, material science and dearth of knowledge reattachment of fractured fragment was very challenging. Today we witness a paradigm shift in dentistry towards a more minimally invasive approach due to the advancements in adhesive technology. Hence reattachment of fractured tooth fragment is considered to be one of the most viable treatment options today.

Reattachment of fractured fragments have been documented since 1964. Systematic review and reviews of literature reflect detachment of these fragments occurring in episode of new trauma, tangential and shear forces,and bond failure.[16]

It was also observed that the tooth fragment exhibited less than ideal esthetics if allowed to dehydrate; a discernible “line” at the reattachment junction was observed due to colour instability of the composite resins and predicted eventual separation of repair due to progressive breakdown of bonded junction implying a need of continuous monitoring. [40,41]

To resolve the problems various invitro studies were designed experimenting with combinations of different materials and techniques to make the fracture line inconspicuous. This helped achieve the ultimate goal to enable the fracture fragment to survive for a longer period of time with a better esthetic outcome.

Overtime the spectrum of materials used for the reattachment included adhesive resin cement, chemical cure resin composite, light cure resin composite as well as conventional flowable composite. Amongst these, conventional flowable composite seemed to be the most promising in agreement with the article by Demarco et al.[14].

Activa BioACTIVE which is a flowable resin-based composite contains both glass ionomer and resin composite components was introduced by Clark (2014). The manufacturers claim that it has a very promising fracture resistance, a quality most desired in a material during reattachment of fractured fragment. The acid-base setting reaction occurs when fluoroaluminum silicate particles and polyacid components are combined. The smart material (Activa BioACTIVE) has the capacity to release and replenish large quantities of calcium, phosphate, and fluoride from saliva or in the presence of a source like CPP-ACP paste, which in turn promotes the formation of apatite as shown in an article by Firouzmandi et al.[19] Literature shows that self-adhesive bioactive resin (Activa BioACTIVE) has fracture toughness far superior to all other conventional restorative materials. Fracture resistance of self-adhesive hydrophilic resin (Activa BioACTIVE) is 2-3 times greater than composites and 5-10 times greater than GICs and RMGICs as shown in article by Chao W et al.[42]

Hence one of the goals in this study was to evaluate and compare the fracture resistance of the reattached fragments using self-adhesive hydrophilic resin (Activa BioACTIVE) and conventional flowable composite resin.

Invitro Studies by Abdulmujeeb et al, Reis et al, Chazine et al ,Demarco et al have stated that only with a simple reattachment , 37% of the strength of intact tooth structure was restored. Incorporation of bevels, overcontours and internal dentinal groove increased the fracture resistance of tooth by many folds. Amongst which it has been observed that placement of internal dentinal groove could restore 90.5% of the fracture resistance of intact tooth.(Pusman et al)[15,20,38]

Recent systematic review done by Adebayo et al stated these retentive features were not necessary and simple reattachment was considered the preferred technique when there is complete fragment adaptation.[16]

Hence it is prudent to evaluate the fracture resistance of reattached tooth fragments using a conventional flowable composite and a self-adhesive bioactive resin (Activa Bioactive) with and without internal dentinal groove

The study was conducted in the department of Conservative dentistry and Endodontics at KAHER's Vishwanath Katti Institute of Dental Sciences, Belagavi.

Studies have shown that majority of the dental traumatic injuries involve trauma to the permanent incisors, 96% of which affect the maxillary central incisors. Hence human permanent maxillary central incisors with intact crown structure were selected for our study.

The sample size was calculated to be 44 that is 22 in each group. As per the statistical formula to justify my result this was the minimum number of teeth required.

$$n = \frac{2S^2 [Z_\alpha + Z_\beta]^2}{d^2}$$

with Standard deviation in the Ist group S1 = 3.03

Standard deviation in the IInd group S2 = 1.46

Mean difference between Ist and IInd sample d = 1.99

$Z_\alpha = 1.96$ at 5% α error

$Z_\beta = 0.84$ at 20 % β error

Similar sample size was also used in studies by Reis et al.[37]

The tooth specimens were collected from the department of Oral and Maxillofacial Surgery at KAHER's Vishwanath Katti Institute of Dental Sciences, Belagavi. The specimens were stored in a leakproof container in 0.9% normal saline till use after disinfection with 0.1% thymol as per the OSHA Guidelines which is similar to the study by Firouzmandi et al.[19]

The specimens were examined under a stereomicroscope under 2X magnification which is as per the study by Reis et al and Michelle et al strictly abiding to the inclusion criteria.[37,38]

Teeth with cracks or fracture lines, carious and already restored teeth and teeth with anatomic variations were excluded from our study as it can cause alteration in the readings of fracture resistance.

For in vitro studies teeth needing to be assessed for fracture resistance are exposed to specific forces in a Universal Testing Machine, sectioned with a diamond disc or a saw to simulate a fracture line. A naturally occurring fracture is very different from the fracture produced in invitro studies as claimed by Badami and Reis et al where the fractured surface tends to be parallel to the direction of the enamel prisms, while the orientation of the surface exposed by cutting is dictated by the direction of the cut'[1,37] Employing a disc produced flat surfaces, which is advantageous because it reduced the amount of adhesive contact faults and allowed for standardisation of the mode of "fracture" that would have otherwise been unpredictable. In the attempt to obtain an equal amount of area exposed, all of the teeth were cut at the same distance from the incisal margin (4 mm) using a diamond disc of diameter 22mm (Stardent) which is as per the study by Firouzmandi et al.[19] A water-cooled low speed diamond disc was used in accordance with a study by

Michelle Chozine et al, to prevent the generation of heat during sectioning thus minimising the variation in resistance to fracture resulting from the thickness of the layers of enamel and-dentin present.[38]

Once the fragments were obtained, they were stored in tap water at room temperature for 24-48 hours. Studies have shown that the fractured fragments can be stored in both tap water and normal saline, but tap water was chosen here as it would help recreate a clinical scenario where tap water will be more easily accessible then saline in case of fracture.

The tooth specimens were then randomly divided into two groups

- Group 1: Reattachment using conventional flowable composite (3M ESPE Filtek Z350xt)
- Group 2: Reattachment using bioactive flowable restorative material (Activa Bioactive)

Group 1 and Group 2 were then divided into two subgroups A and B depending on the reattachment procedure used (With or without internal dentinal groove)

In Subgroup 1B and 2B prior to reattachment an internal dentinal groove, 1mm deep and 1mm wide was prepared within the fragment and the remaining tooth by means of a water cooled high end carbide bur (Abdulmujeeb et al)[20]

The specimens in both Group 1 and Group 2 was etched for 15 seconds using 37% phosphoric acid etchant gel, rinsed and gently dried.

Universal adhesive (3M ESPE Single Bond Universal) was applied on the etched surface of Group 1 and 2 using microbrushes. Universal Bonding agent (3M ESPE) was used in our study in total etch mode, that is enamel etching prior to

application of bonding agent was done. This was done as per a study by Pouyarfar et al and Lauduyf et al where it was observed that enamel etching prior to bonding with universal adhesive increases the microtensile bond strength of composite to enamel.[43] A study by Firouzmandi et al, Poitevin et al.25 and Doozaneh et al. compared the use of self-adhesive bioactive resin (Activa Bioactive) with or without bonding to find if application of bonding agent could improve the bonding of self-adhesive bioactive resin (Activa Bioactive) to dentin and enamel. It was seen that for specimens without bonding agent the fracture resistance decreased significantly. Therefore, using adhesive system with self-adhesive composite (Activa Bioactive) is suggested.[19,46,47]

Visible light cured flowable resin composite (Filtek Supreme Flowable Restorative 3M ESPE Z350) was chosen as the material for reattachment in Group 1 as it has advanced filler technology, which contains surface treated engineered nanoparticles with the inorganic filler loading of 65% by weight and 46% by volume.[48]

The study material (Activa Bioactive) was chosen for reattachment in Group 2 because of its superior properties of increasing fracture resistance and hydrophilic nature.

The teeth were finished and polished using a flexible polishing disk. These teeth were embedded in auto polymerizing acrylic resin block of 1 x 1 inch dimension and stored in tap water in room temperature for 24 hours.[49]

The specimens were mounted on custom made fixture for determination of shear bond strength using Universal testing machine (Computerized, Software Based)

Company: ACME Engineers, India., Model: UNITEST 10

System Accuracy of the Machine: ± 1%, C/hd Speed: 1 mm/minute.

Universal Testing Machine was chosen for testing the fracture resistance of the reattached fragments as literature claims it to be the most reliable technique for the same.(Demarco et al, Firouzmandi et al, Abdulmujeeb et al)[14,19,20]

A knife edge chisel (0.5 mm in cross section) was used to deliver the force so that contact was achieved 4 mm apical to the incisal edge. The shearing load was applied at crosshead speed of 1mm /min. The shearing force was noted and shear bond strength was calculated and recorded in kilogram force units KgF.(Kumar et al, and Firouzmandi et al) [19,49]

The force at which the teeth specimens fractured were calculated and tabulated.

The results of the present study revealed the mean force and standard deviation required to fracture each group was as follows:

Subgroup 1 A : 10.33 +/- 0.25

Subgroup 1 B : 11.42 +/- 0.469

Subgroup 2 A : 13.25 +/- 0.61

Subgroup 2 B : 16.78 +/- 0.70

The readings were evaluated, compared and analysed. The readings were statistically significant. ($p < 0.05$)

In the present study Subgroup 2B : Reattachment using self-adhesive bioactive resin (Activa Bioactive) after the preparation of Internal Dentinal Groove had the

highest fracture resistance and the least being Sub Group 1A : Simple reattachment using flowable composite.

The current findings showed that the fracture resistance of the teeth reattached with self-adhesive bioactive resin (Activa Bioactive) was superior to the conventional flowable composite which is in accordance with the study showed by Chao W et al.[42]

The bioactive ingredient in self-adhesive bioactive resin (Activa Bioactive) interacts dynamically with tooth structure and physically and chemically resembles natural teeth. The components of self-adhesive material (Activa Bioactive) include a bioactive ionic resin, a rubberized resin and a bioactive glass ionomer. The matrix of bioactive ionic resin releases and recharges a large amount of calcium phosphate and fluoride. The rubberized resin is tough, durable and contains reactive glass ionomer filler. Therefore, it was assumed that this material may establish continuity and integrity of the two fragments.[19]

Internal dentinal groove placement offers superior fracture strength and increased aesthetic durability that is nearly identical to intact tooth structure. The positive outcomes in this group were most likely caused by the increased adhesion area and permeability of an internal resin bar that functions as an opponent to the compression load exerted on the buccal surface.

Sub Group 2A where reattachment was done with self-adhesive material (Activa Bioactive), without placement of internal dentinal groove a mean fracture resistance of 13.25 was noted. The group performed better than the groups reattached with flowable composites (1A and 1B)

This is because fracture resistance of self-adhesive composite (Activa Bioactive) is 2-3 times greater than conventional flowable composites as shown in article by Chao W et al.[42]

Use of a bonding agent prior to application of self-adhesive material (Activa Bioactive) increases the retentive properties. Reattached teeth fragments are prone to detachment and hence one mustn't rely on the glass ionomer-like biologic capabilities of the hybrid material.

Sub group 1 B where reattachment was done using flowable composite resin with the placement of internal dentinal groove, a mean fracture resistance of 11.42 was noted which was higher than Subgroup 1A (Simple Reattachment using flowable composite). This was due to the superior retentive features of the internal dentinal groove.

Activa Bioactive is a self-adhesive hydrophilic material which has superior fracture resistance compared to the other conventional composite materials used routinely in our practice. The material is also smart and moisture-friendly with dynamic role in the mouth; hence it can substitute the older conventional composites without bioactive potential for reattaching the tooth fragments after the placement of Internal Dentinal Groove.[46]

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CONCLUSION

Within the parameters of the invitro study according to the methodology used, the following conclusion can be drawn-

1. Reattaching the fragments with further preparation is a realistic solution for restoring the traumatized tooth's esthetics and functionality.
2. Of the preparation techniques employed and the materials used in the present study, Subgroup 2B: Reattachment of the fractured fragments using self adhesive bioactive resin (Activa BioACTIVE) with internal dentinal groove preparation had the highest fracture resistance.
3. On the contrary, Subgroup 1A: Simple reattachment using Flowable composite without any additional preparation had the least fracture resistance

Thus, it can be concluded that Activa BioACTIVE can be used as a promising material for the reattachment of anterior tooth fragments when used with an internal dentinal groove.

With the newer self adhesive materials available today, in conjunction with an appropriate technique, esthetic results can be achieved with predictable outcomes. Thus within the limitations of the study it can be concluded that the reattachment of a tooth fragment is a viable technique that restores function and esthetics with a very conservative approach, and it should be considered when treating patients with coronal fractures of the anterior teeth, especially younger patients.

SUMMARY

The present in vitro study was conducted in Department of Conservative Dentistry and Endodontics, KLE VK Institute of Dental Sciences, Belgaum in association with Praj Metallurgical Lab , Pune to determine the fracture resistance of the reattached tooth fragment using conventional composite and a hydrophilic self adhesive bioactive resin with and without an internal dentinal groove preparation.

A total of 44 permanent maxillary central incisors were selected and handled according to OSHA guidelines, disinfected in 0.1% thymol solution, cleaned of calculus and soft tissues and stored in 0.9% saline till use and divided into two groups (each group having 22 specimens each) according to the composite resin used for reattachment.

- Group 1: Reattachment using conventional flowable composite (3M ESPE Filtek Z350xt)
- Group 2: Reattachment using bioactive flowable restorative material (Activa Bioactive)

Group 1 and Group 2 were then divided into two subgroups depending on the reattachment procedure used (With or without internal dentinal groove)

Subgroup 1A (n = 11) : The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) without the preparation of internal dentinal groove

Subgroup 1B (n = 11) : The fragments were reattached using conventional flowable composite (3M ESPE Filtek Z350xt) with the preparation of internal dentinal groove

Subgroup 2A (n=11) : The fragments were reattached using new self adhesive bioactive material (Activa Bioactive) without the preparation of internal dentinal groove.

Subgroup 2B (n =11) : The fragments were reattached using new self adhesive bioactive material (Activa Bioactive) with the preparation of internal dentinal groove.

These teeth were embedded in auto polymerizing acrylic resin block of 4 x 4 inch dimension and stored in tap water in room temperature for 24 hours.

The specimens were mounted on custom made fixture for determination of shear bond strength using universal testing machine. A knife edge chisel (0.5 mm in cross section) was used to deliver the force so that contact was achieved 4 mm apical to the incisal edge. The shearing load was applied at crosshead speed of 1mm /min .The shearing force was noted and shear bond strength was calculated and recorded in kilogram force units (Kgf)

The results of the present study revealed the mean force and standard deviation required to fracture each group was as follows:

Subgroup 1 A : 10.33 +/- 0.25

Subgroup 1 B : 11.42 +/- 0.469

Subgroup 2 A : 13.25 +/- 0.61

Subgroup 2 B : 16.78 +/- 0.70

Thus in the present study Subgroup 2B i.e Reattachment using Activa Bioactive after the preparation of Internal Dentinal Groove had the highest fracture resistance (16.78 +/- 0.70) and the least being Sub Group 1A i.e Simple reattachment using flowable composite(10.33 +/- 0.25)

The statistical analysis, done using two way ANOVA and Tukey's multiple posthoc test revealed statistical significance of the performed study as per the recorded data.

Based on the present study following comparison can be drawn - Subgroup 2B :Reattachment using Activa Bioactive after the preparation of Internal Dentinal Groove had the highest fracture resistance and the least being Sub Group 1A :Simple reattachment using flowable composite.

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ANNEXURE – I

ETHICAL APPROVAL CERTIFICATE

Research and Ethics Committee
KLE V K INSTITUTE OF DENTAL SCIENCES
KLE University
Accredited 'A' Grade by NAAC Placed in Category 'A' by MHRD (GoI)
Nehru Nagar, Belagavi - 590 010, Karnataka State
☎: 0831-2470362 Web: http://www.kledental-bgm.edu.in
FAX: 0831-2470640 E-mail:principal@kledental-bgm.edu.in

Sl. No. : 1476

CERTIFICATE

This is to Certify that the synopsis titled comparative evaluation of the fracture resistance of the reattached tooth fragment using conventional composite & a hydrophillic self adhesive bioactive resin with & without an internal dentinal groove preparation - an invitro study *Submitted by Dr.* ______ *P. G. Student / Staff, Guided by* ______ *from Department of* Conservative dentistry & Endodontics *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 5/5/21

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

ANNEXURE – II

BIOSTATISTICS CERTIFICATE

KLE V.K. Institute of Dental Sciences
(A Constituent unit of KLE Academy of Higher Education & Research
Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Nehru Nagar, Belagavi-590 010 INDIA
Re-Accredited 'A' grade by NAAC (2nd Cycle) & Placed in Category 'A' by MHRD (GoI)
: 0831-2470362 **Web**: http://www.kledental-bgm.edu.in
FAX: 0831-2470640 **E-mail**: principal@kledental-bgm.edu.in

Biostatistics Clearance Certificate

This is to certify that the Biostatistics aspect of the Dissertation / Research work of **Post Graduate Student**, under the guidance of M.D.S, **Professor, Department of Conservative Dentistry and Endodontics**, entitled **"Comparative Evaluation of fracture resistance of the reattached tooth fragment using conventional composite and a hydrophilic self adhesive bioactive resin with and without internal dentinal groove preparation – An Invitro study"** has been done under my guidance and considered satisfactory.

Place: Belagavi
Date: 07/11/2022

Name & Signature of Biostatistician
(Dr. S.B Javali)

ANNEXURE – III

PLAGIARISM CERTIFICATE

Scientific Correspondence and Review Committee

KLE VK Institute of Dental Sciences

A Constituent Unit of KLE Academy of Higher Education and Research
(Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Nehru Nagar, Belagavi - 590 010, Karnataka State

Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)

☎: 0831-2470362 Web: http://www.kledental-bgm.edu.in
FAX: 0831-2470640 E-mail:principal@kledental-bgm.edu.in

Date : 26|12|2022 Serial No. : 143

PLAGIARISM CHECK REPORT

Name of the Applicant :
UG / PG / Ph.D / Staff : Post graduate student
Batch & Year : 2020 - 2023
Department : conservative Dentistry

The soft copy of Research Work / Manuscript by .... entitled "comparative evaluation of the fracture resistance of the re-attached tooth fragment using conventional composite and a hydrophillic self adhesive bio-active resin with an internal dentinal groove preparation - An invitro study" under the guidance of ....has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of ....4..........%, which is **within** / **not within** the acceptable limits of 10% as per the UGC guidelines.

Member Secretary
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER-Belagavi

Chairman
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER - Belagavi