ORIGINAL ARTICLE

A COMPARISON OF IMPACT STRENGTH OF REATTACHED INCISOR TOOTH FRAGMENTS USING DIFFERENT RESTORATIVE MATERIALS: AN IN VITRO STUDY

[1]VINEET INDER SINGH KHINDA
[2]PUNEET DANG
[3]PARAMJIT KHINDA
[4]GURLAL SINGH BRAR
[5]SHIMINDER KALLAR

ABSTRACT

Study was done to evaluate and compare the impact strength of reattached fractured incisor tooth using five different adhesive materials 1) Composite 2) Giomer 3) Dual Cure Resin Cement 4) Resin Modified GIC 5) Compomer.

Ninety sound freshly extracted human permanent incisors were selected according to the inclusion criteria. 15 teeth were taken as a control (Group I) and remaining 75 teeth were divided equally and randomly into five Groups; Group II – Composite, Group III – Giomer, Group IV – Dual Cure Resin Cement, Group V – Resin Modified GIC, Group VI - Compomer based upon the materials to be used for reattachment. The specimen teeth in the experimental groups were fractured by Custom-made vice. The fractured fragments were reattached using their respective adhesive materials. Then the impact resistance was recorded in an impact testing machine and data was analyzed.

On comparing the mean impact strength by using One Way ANOVA and Unpaired 't' test it was observed that statistically highly significant difference was present when comparison was made between mean impact strength of intact teeth and reattached fractured teeth.

Statistically highly significant difference was obtained on comparing impact strength of intact tooth with reattached tooth using adhesive materials. So, no material studied was able to attain the impact strength of intact tooth. However, when materials were compared, decreasing order of their impact strength was Compomer > Composite > Dual Cure Resin Cement > Giomer > Resin Modified GIC.

Key Words: *Reattachment, Fracture Anterior Teeth, Impact Strength.*

INTRODUCTION

Traumatic dental injuries are the most unanticipated events that, if not managed appropriately can have serious consequences for the patient. Dental trauma especially of anterior teeth is a tragic experience for children and teenagers. Involvement of children and teenagers in contact sports, automobile accidents, outdoors activities and falls leads to rise in incidence of dental trauma. Maxillary central incisors are frequently involved (95%) because of their protrusion and position taken during the eruptive process.[1]

There are various treatment modalities for managing dental trauma. In the past methods such as resin crowns, stainless steel crowns and pin-retained inlays have been used with varying degrees of success. More recently esthetic techniques such as porcelain laminate veneers, porcelain fused to metal crowns and all ceramic crowns have largely replaced the older techniques. Although these more recent techniques deliver a highly esthetic result, they suffer from the disadvantage of jeopardizing the tooth structure and in cases of esthetic emergency their application is not possible. Thus the esthetic restoration of fractured teeth in cases of esthetic emergency still represents a big challenge.[2]

[1] Dr Vineet Inder Singh Khinda, Professor and Head, Department of Pedodontics and Preventive dentistry, Genesis Institute of Dental Sciences and Research, Ferozepur
Email: khindavineet@gmail.com
[2] Dr Puneet Dang, Post Graduate Student
Email: dangpuneet23@gmail.com
[3] Dr Paramjit Khinda, Professor and Head, Department of Periodontology and Oral Implantology
E-mail- khindavineet@gmail.com
[4] **Corresponding Author:** Dr Gurlal Singh Brar, Reader, Department of Pedodontics and Preventive dentistry, Genesis Institute of Dental Sciences and Research, Ferozepur, Punjab — India
Cell: 094663709878 Email: brar_rock001@yahoo.co.in
[5] Dr Shiminder Kallar, Reader, Department of Pedodontics and Preventive Dentistry, *(Author number 2, 3 & 5 are also from Genesis Institute of Dental Sciences and Research, Ferozepur)*
Email- shiminderbhangoo@gmail.com

Received for Publication: February 17, 2016
Approved: March 25, 2016

In today's era of evidence - Reattachment procedures have proven to be a boon for patients with clinical crown fracture due to dentofacial trauma. Reattachment of fragment can provide good and long lasting aesthetics. It is more conservative, simple procedure and also restores tooth function.[3] In addition; tooth fragment reattachment allows restoration of the tooth with minimal sacrifice of the remaining tooth structure. So reattachment of a tooth fragment should be preferable to restoring fractured teeth. It is a widely accepted and popularly established procedure.

The prognosis of the treatment depends on firm attachment of the fragment to the tooth. The reattached fragments are prone to re-fracture. Therefore, a strong, durable and predictable union between the fractured fragment and the remaining tooth is the prime determinant.[3] An ideal dental material used for reattachment must possess good fracture resistance, biocompatible, minimal gingival irritation and good bond strength.[4] Various materials such as adhesive systems, alone or in conjunction with flowable composite, microfilled composite, hybrid composites, nanocomposites, dual or chemically cured resin cements and glass ionomers; have been used for crown reattachment.

Studies have reported that the primary cause of fragment loss is new dental trauma or the non physiological use of the restored tooth. Therefore, most concerns about reattachment techniques have been directed toward the fracture strength of the restored tooth. As there are many adhesive materials now available in market, but the choice of material with higher impact strength and which can retain the reattached fractured tooth fragment for longer time is still not clear. The aim of this study is to evaluate and compare the impact strength of different restorative materials used to reattach the fractured tooth fragment.

METHODOLOGY

After ethics committee approval 90 sound freshly extracted human permanent incisors which were caries free, devoid of any cracks, fracture or restorations were selected and stored in normal saline throughout the study. Out of these, 15 teeth were maintained as a control group. Remaining 75 teeth were divided equally and randomly into 5 groups (n=15) based upon the materials used for reattachment of fractured tooth fragments.

Group Distribution

Group 1 - Intact Teeth (n=15)

Group 2 - Fractured Tooth Fragments Reattached by using Composite Resin (n=15)

Group 3 - Fractured Tooth Fragments Reattached by using Giomer (n=15)

Group 4 - Fractured Tooth Fragments Reattached by using Dual Cure Resin Cement (n=15)

Group 5 - Fractured Tooth Fragments Reattached by using Resin Modified Glass Ionomer Cement (n=15)

Group 6 - Fractured Tooth Fragments Reattached by using Compomer (n=15)

Preparation of Sample

Small guiding notches on the approximal surfaces of the tooth were placed with a bur at a distance of 3mm from incisal edge in all the specimens. Then teeth were fractured (Fig 1) by using two microtomes mounted in a Custom- made vise (Fig 2), perpendicular to the long axis of the tooth. All specimens were mounted in self-curing acrylic resin with a layer of additional silicon impression material between tooth and acrylic so as to simulate the periodontal ligament of healthy dentition, in such a way that the long axis of the tooth was aligned with the central axis of the custom made rectangular block.

Reattachment

Prior to re-attachment, all the specimens and fractured fragments were subjected to prophylaxis with pumice using a soft rubber cup in a slow speed handpiece. Reattachment (Fig 3) in each group was done by using respective adhesive materials (Fig 4) as recommended by manufactures:

De-Bonding

After reattaching the fractured fragments with their respective materials, all the samples were thermocycled between ± 5 degree and ± 55 degree for 150 cycles (Fig 5). All specimens were subjected to test in an IZOD Charpy Digital Impact Tester (Fig 6). The block containing reattached tooth was engaged in the clamp at an angle of 90 degree between the incisal edge and hammer (pendulum) of impact tester. The hammer was then aligned to contact the predetermined standardized spot i.e. 2mm from the incisal edge on lingual aspect of the specimen and the hammer was released to refracture the sample (Fig 7). The impact resistance (in KiloJoules) at which the tooth refractured was recorded from digital meter of IZOD Charpy Digital Impact Tester. Area of each specimen was calculated by using AutoCAD software 2015 (in mm^2). Impact Strength was calculated by dividing impact resistance (in KiloJoules) to area (in mm^2) and finally calculated in $KJ/m.^2$

Statistical Method

The statistical analysis was carried out by using Statistical Package for Social Sciences. For more than two groups, One Way ANOVA test was applied then unpaired 't' test was applied to determine the inter group comparison.

RESULTS

The mean and standard deviation for the impact strength of intact (control group) and reattached fractured teeth (in KJ/m^2) by using composite, giomer,

TABLE 1: MEAN IMPACT STRENGTH OF ALL THE GROUPS (ONE WAY ANOVA) DESCRIPTIVE TABLE

Group	No. of teeth	Mean	Std. Deviation	Std. Error	Minimum	Maximum
1 (Control)	15	12.84057	3.267411	0.843642	6.816	17.927
2 (Composite)	15	1.73041	0.361882	0.093438	1.096	2.729
3 (Giomer)	15	1.33058	0.178303	0.046038	1.037	1.644
4 (Dual Cure Resin Cement)	15	1.62028	0.333262	0.086048	1.217	2.267
5 (Resin Modified GIC)	15	0.99542	0.423116	0.109248	0.510	1.834
6 (Compomer)	15	1.99085	0.751798	0.194113	1.028	2.926
Total	90	3.41802	4.460350	0.470162	0.510	17.927

One Way ANOVA Impact Strength

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1606.914	5	321.383	164.896	.000**
Within Groups	163.716	84	1.949		
Total	1770.630	89			

TABLE 2: INTERGROUP COMPARISONS BETWEEN DIFFERENT MATERIALS

Group	N	Mean ± SD	't' value	P value
Composite	15	1.73±0.36	3.839	.001**
Giomer	15	1.33±0.18		
Composite	15	1.73±0.36	.867	.393
Dual Cure Resin Cement	15	1.62±0.33		
Composite	15	1.73±0.36	5.11	.000**
Resin Modified GIC	15	0.99±0.42		
Composite	15	1.73±0.36	-1.209	.237
Compomer	15	1.99±0.75		
Giomer	15	1.33±0.18	-2.969	.006*
Dual Cure Resin Cement	15	1.62±0.33		
Giomer	15	1.33±0.18	2.827	.009*
Resin Modified GIC	15	0.99±0.42		
Giomer	15	1.33±0.18	-3.310	.003*
Compomer	15	1.99±0.75		
Dual Cure Resin Cement	15	1.62±0.33	4.493	.000**
Resin Modified GIC	15	0.99±0.42		
Dual Cure Resin Cement	15	1.62±0.33	-1.7545	.092
Compomer	15	1.99±0.75		
Resin Modified GIC	15	0.99±0.42	-4.469	.000**
Compomer	15	1.99±0.75		

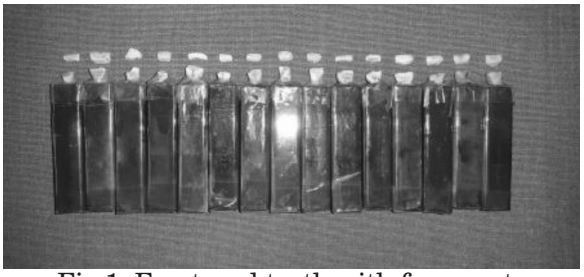


Fig 1: Fractured teeth with fragments

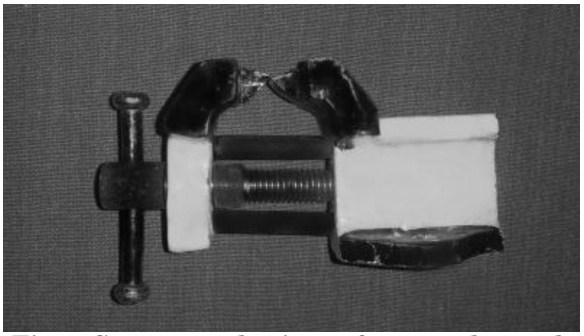


Fig 2: Custom made vise to fracture the tooth

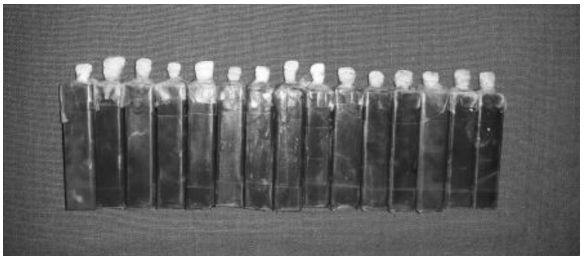


Fig 3: Reattached teeth

Fig 4: Adhesive materials

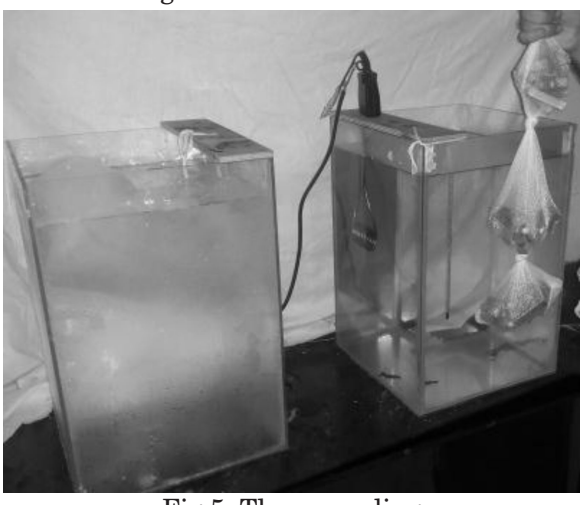


Fig 5: Thermocycling

Fig 6: IZOD charpy digital impact tester

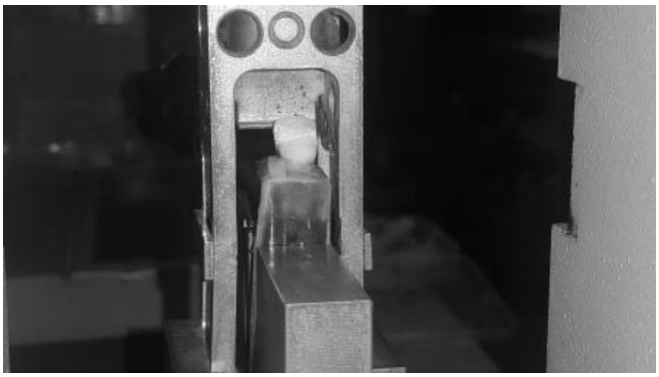
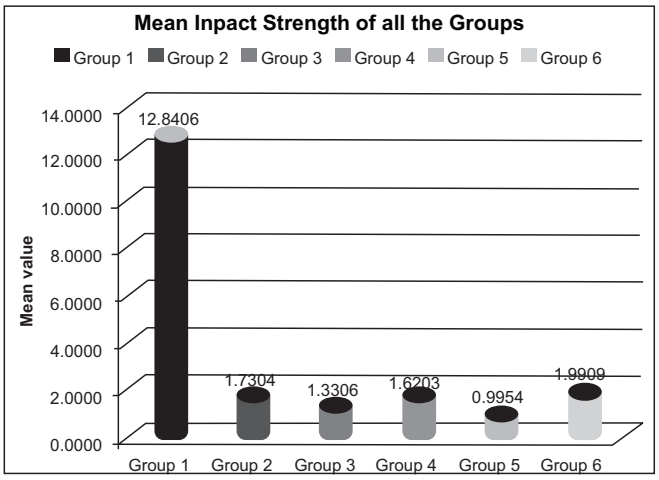


Fig 7: Testing of specimens under impact tester



Graph 1: Mean Impact Strength of all the groups

dual cure resin cement, resin modified glass ionomer cement and compomer were recorded and statistically analyzed using One way ANOVA test and unpaired "t" test. Graph 1 shows the comparison of impact strength between control (Group 1) and experimental groups [Composite resin (Group 2), Giomer (Group 3), Dual cure resin cement (Group 4), Resin Modified Glass Ionomer Cement (Group 5) and Compomer (Group 6)]. One Way ANOVA test revealed statistically highly significant difference among the mean values of all experimental groups in comparison with Control group. The inter-group comparison between the groups was analyzed by using unpaired "t" test.

DISCUSSION

Fracture of permanent incisors is a tragic experience for young patients and creates psychological impact on both the parents and in children that makes him/her a target for teasing and ridicule by other children.[5] Therefore, restoration of a fractured tooth is important both aesthetically and functionally. Most commonly used clinical procedures to manage the fractured tooth include full coverage crowns and composite build up.

Under esthetic point of view fracture reattachment is one of the best options, provided the tooth fragment is available. IERT (incisal edge reattachment technique), is a technique in which fractured tooth fragment is reattached by using different adhesive restorative materials.[6]

According to Badami AA et al replacement of the fragment confers potential durability of the restoration since the fragment wears at the same rate as that of the other teeth. In addition, the natural enamel translucency and surface finish of the fragment is restored. Moreover, this technique is clinically more conservative. Tooth fracture reattachment procedure is a simple and conservative technique with various advantages like aesthetics, colour, texture, shades, low incisal wear and maintenance of tooth contours.[7]

According to Liew, reattachment procedure is an excellent short to medium term temporary restoration. Andreasen et al demonstrated a 25% retention rate of reattached coronal fragments in a span of 7 years. Similarly, Cavalleri and Zerman proved a 90% retention rate of 5 years. In the present study, only maxillary central incisors were included as they are the teeth that are mostly affected by dental traumatic injuries (80%). To simulate the natural conditions, the specimens in the present study were fractured transversely to the long axis of the tooth using two microtomes mounted in a custom- made vise so as to obtain natural Ellis Class II fracture with almost complete fragment available and can be easily bonded to the tooth with the help of reattachment procedure.

The incisal edge reattachment technique involves procedure that can be done with or without preparation. Many operative procedures have been suggested by literature: from no additional tooth preparation to various preparations such as Chamfer, Overcontour, Internal dental groove, Bevel, Modified Bevel, Stair step chamfer.

In the present study, no enamel preparations were done on the tooth or a fragment before reattachment which is in favor of Farik et al 2000. We preffered "no enamel preparation" in order to prevent further insult to the fractured tooth which is in accordance with studies done by Jordan, Buonocore and Fuks. Ideally, it would seem that the restorative procedure should require minimal tooth preparation in order to decrease manipulative trauma to the tooth. Thus "no preparation" technique better fulfills this requirement compared to the "beveling technique". Our results revealed highly statistically significant differences between intact teeth and reattached tooth fragment by using composite, giomer, dual cure resin cement, resin modified glass ionomer cement and compomer. The high mean impact strength of intact natural teeth is a proven fact in a large number of studies previously conducted. Our results also matched the findings by Demarco et al. 2004, Prabhakar et al 2007, Bhargava et al 2010 who confirmed that no material and technique studied was able to attain the strength of the intact teeth.

The intergroup comparison for impact strength between reattached teeth with different restorative materials was evaluated by using unpaired "t" test. Composite resin, Dual cure resin cement and Compomer did not show any statistically significant differences in impact strength between each other. But Composite, Dual cure resin cement and Compomer showed statistically significant difference when compared with Giomer and Resin modified glass ionomer cement.

Amongst the tested materials, the highest impact strength was found with Compomer followed by Composite, Dual Cure Resin Cement, Giomer and least with Resin Modified Glass Ionomer Cement. Giomer and Resin modified GIC are both basically glass ionomer cements with addition of small quantity of resin component. The presence of high amount of glass ionomer as filler may be the reason of lower impact strength as compared to others materials used to reattach fractured tooth. Other, reason may be that glass ionomer cements are adhesive to dentine and mainly relies on chemical bond through ion-exchange between the material and the tooth substrate rather than mechanical bond.

Composite resin when compared with Dual Cure and Compomer showed statistically non-significant difference. Resin composite consists of a resin matrix, filler particles, interfacial coupling agents and polymerisation initiators. Filler loading contributes to the physical and mechanical properties. The size and distribution of filler particles affects the characteristics of the material. The total filler content of Filtek Z250 XT (3M ESPE) is about 82% by weight (68% by volume). In addition, the surface modified Zirconia/Silica filler particles of size less than 3 micron provides superior strength and high fracture toughness.

Compomer is a polyacid-modified composite resin. Compomer is made predominantly from resin composite (90%) with the addition of a polyacid-modified molecule

similar to that found in traditional GIC. Compomers are initially light-cured, but subsequently absorb water, allowing for an acid-based reaction to set the polyacid-modified molecule. Physically, their properties are similar to those of a composite. The results of the present study showed no statistically significant difference with composite and compomer. It could be due to the physical properties of compomers approaching those of composites.

Dual cure resin cement showed statistically non-significant difference when compared with composite and compomer it may be due to its physical and polymerization properties. The filler content in this cement ranges from 60-70%, which could be accounted for its high mechanical properties. The use of dual curing resin cements intends to combine chemical and light-polymerization and at the same time allows polymerization to take place this causes unpolymerized resin to polymerize which contributes to its high mechanical properties.[8]

Statistically non-significant difference was obtained on comparing impact strength of intact tooth with reattached tooth using adhesive materials. No material studied was able to attain the impact strength of intact tooth, which is in accordance with findings of Reis, A et al 2002; Prabhakar, AR, Kurhokoti, AJ and Kayalvizhi, G 2007; Alonso, RCB et al 2010. The reason that may be cited is the absence of any preparation before reattaching the fractured fragment with tooth. Many authors stress upon the necessity of the use of additional preparations to augment the retention of the re-bonded fragment, while others believe in the improvement of consolidated techniques of dentinal bonding that offer a resistance equal to that which is offered by the enamel. Reis et al 2001 and Stellini et al 2008 highlighted that the resistance of reattached fragments with an additional preparations have given values as high as 60% of the intact tooth. In a current era of minimal invasive dentistry, the reattachment without any preparations either on a tooth or fragment conserves the tooth structure as much as possible. In our present study we followed that approach by not carrying out any preparations. The results showed that reattaching tooth fragments by using only adhesive materials can act as short to medium term semi-permanent restoration in management of anterior tooth fracture in Pediatric Dentistry.

CONCLUSION

Incidence of traumatic injuries involving maxillary anterior teeth has increased from last few years. So, immediate management of such traumatic injuries can preserve the vitality of tooth and hence forth decrease the subsequent appointments and cost of treatment. Reattachment of fractured tooth fragment is a simple and conservative procedure for restoring the fractured teeth. Diverse class of restorative materials is available in the current era for reattaching the fractured tooth fragment. Hence the choice of the restorative material that should be used for reattachment is obscure. So, the present study was consummate to compare the impact strength of different restorative materials.

From the present study conclusions are;

1) Impact Strength of intact teeth was highest. No restorative material was able to achieve same strength as that of intact tooth.

2) Among the restorative materials tooth reattached with compomer showed higher impact strength followed by Compomer > Composite > Dual Cure Resin Cement > Giomer > Resin Modified GIC.

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