Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2019;10:1:105-110.

Fracture Resistance of Incisor Teeth Fragments Reattached Using Three Different Restorative Materials

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ABSTRACT

Aim: To compare and evaluate the fracture resistance of reattached incisor fracture fragment using three different restorative materials.

Materials and method: Sixty recently extracted sound human maxillary permanent central incisors were randomly divided into 4 experimental groups of 15 teeth each: Group A - comprising sound/unprepared teeth (control). Group B - comprising of teeth reattached with nanocomposite. Group C - comprising of teeth reattached with fibre reinforced micro hybrid composite and Group D – comprising of teeth reattached with fibre reinforced nanocomposite. Fracture resistance was then measured under universal testing machine and compared with that of sound teeth.

Results: Statistically significant difference was observed between control group, nanocomposite group, fibre reinforced microhybrid group and fiber reinforced nanocomposite group in the mean fracture resistance as well as within the groups.

Conclusion: From the results and observation obtained, it can be suggested that, fibre reinforced nanocomposite is a better material for reattachment of fractured teeth fragment and it also provides better esthetics and longevity of the restoration.

Keywords: Fiber reinforced nano composite, polyethylene fiber, fracture resistance.

INTRODUCTION

One in four people suffer from some kind of dental trauma during childhood or youth and the most common form that affects children and adolescents is anterior crown fracture.[1] Out of all the traumatic injuries happening to oral hard tissues, crown fracture of permanent anterior teeth accounts for about 18% - 22%. The position and eruptive pattern of maxillary central incisor in the arch make it more prone to the risk of trauma, as a result, 96% of anterior teeth fracture happens to maxillary

Received: June. 14, 2019**:** **Accepted**: July. 25, 2019
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incisors, in which central and lateral incisor fracture rates up to 80% and 16% respectively. Among these, more frequently encountered are uncomplicated crown fractures.[2] Restoration of the fractured crown is a major concern as it affects esthetically and functionally. Moreover, traumatic dental injuries have a psychological impact on children and adolescents.[3] Reattachment procedures are popularly established and widely accepted because of its proven benefits for the patients with clinical crown fracture. Not only that it is conservative and simple but also provides good long-lasting esthetics with the restoration of function. Thus rather than restoring, reattachment procedures should be preferred as the first choice of the treatment plan. The ideal dental material for reattachment of a fractured tooth fragment should possess properties like good bond strength, biocompatibility, minimal gingival irritation and good fracture resistance.[4] Ultimate reason for the failure of a reattached tooth is high masticatory force falling on the tooth or due to new traumatic injury itself.[5] Thus the reattachment material should have enough fracture resistance to keep the reattached fragment bonded to the tooth. Fracture resistance of a material is a measure of its ability to retard crack initiation and propagation. High fracture resistance of restorative material is required in clinical situations where high impact stresses are experienced such as incisal angle restoration and reattachment of the fractured incisal fragment are such demanding situations.[6]

Superior mechanical properties like good fracture resistance, high compressive strength, good wear resistance, diametrical tensile strength, lower polymerization shrinkage, maximum polish retention, superior esthetics, and great translucency are the highlight features of nanocomposites.[7] The impact strength, modulus of elasticity and flexural strength of composite material can be enhanced by the addition of polyethylene fibres. These fibres strengthen composite material in the most esthetic way, as they are almost invisible in the resinous matrix.[8]

Thus this study is carried out to compare the fracture resistance of nanocomposite, fibre reinforced nanocomposite and fibre reinforced microhybrid composite reattached incisor fragments.

MATERIALS AND METHODS

60 human permanent maxillary central incisors extracted for periodontal problems were collected. The collected teeth were free of caries and were thoroughly cleaned with scalers. After cleaning the debris and calculus free teeth were stored in saline solution. The ethical clearance was obtained from the institutional ethical committee for the use of these extracted teeth. Teeth were randomly divided into 4 groups with 15 teeth in each group.

Group A – control group which will be kept intact for study with the experimental groups
Group B – teeth reattached with nano composite.
Group C – teeth reattached with microhybrid composite reinforced with polyethylene fibre.
Group D – teeth reattached with nano composite reinforced with polyethylene fibre.

SAMPLE PREPERATION

The samples in Group A were not prepared and used as control. In Groups B, C and D, the incisal edge of the teeth was cut by making small guiding notches on the approximal surfaces with bur at a distance of 3 mm from the incisal edge. Fracturing of the teeth was done with a diamond disc mounted on a slow speed micromotor handpiece. The disk was directed perpendicular to the long axis of the teeth by joining the notches made on the approximal surface and thus segmenting out the incisal tip.

SAMPLE RESTORATION

Etching of the prepared tooth surface was done with 37% phosphoric acid gel. The gel was applied for 15 seconds followed by thorough washing and gentle air drying. Dentin bonding agent was applied with an applicator tip on the etched surfaces and polymerization was done using LED light-curing unit for 20 seconds. The fractured tooth structure was reattached using nanocomposite (Ivoclar, tetric N-Ceram) in group B and polymerized using a light cure unit for 20 seconds.

In Group C and Group D, a palatal groove of 4 mm length, 2 mm width and 1 mm depth was made both on the teeth and fractured fragment. A fine diamond bur on airotor handpiece was used for making the grooves. UNC - 15 Probe was used to measure the depth of the cavity. Width was measured with the help of a scale. Prepared tooth surfaces were thoroughly rinsed with water and excess moisture was removed with faint air jet leaving dentinal surface slightly moist. For restoration of the prepared surfaces same etchant and bonding agent (Ivoclar) was used as in group B. Microhybrid (Ivoclar, vivadent) and nanocomposite were applied to the groove and approximating surface. Before curing it, the required size of polyethylene fibre (Ribbond) was placed in the palatal cavity, carrying it above the fractured edge to the preparation on the fractured fragment. Light curing is done both palatally and buccally. Finishing and polishing are done using a composite finishing kit. Acrylic blocks (diameter 5 cm) were made using auto-polymerizing resin (DPI, dental products of India) and all the teeth samples were mounted onto it such that long axis of the teeth is perpendicular to the acrylic base and it covers till the CEJ (cementoenamel junction) of the teeth. Samples were kept for thermocycling for 7 days and then fracture resistance was tested in Universal Testing Machine (Mechanics). The acrylic block containing the specimen was held on a custom made metal base to provide a 45-degree angulation to the horizontal plane. A compressive fatigue load was applied with a loading tip of 2mm cross-head diameter until fracture occurred, at a speed of 1mm min-1. The load was applied to the center of the restoration on the palatal surface with a relative angle of 135 degrees to the palatal surface, so that to stimulate the protrusive function. For the control group the load was applied in a similar way as that for the experimental groups ie; on the palatal surface which corresponds to the center of the restoration. Fracture resistance testing and recording were done in the same manner for all the 4 groups. The data obtained were compiled and statistical analysis was done.

RESULTS

Multiple group Comparison was done using one-way ANOVA followed by Tukey's test for group-wise comparisons.

Table 1 shows the mean fracture resistance and standard deviation of different groups: Sound unprepared Group A- 487.41 ± 43.123 N, teeth restored with nanohybrid composite Group B- 240.75 ± 55.263 N, teeth restored with fibre reinforced microhybrid composite Group C- 324.13 ± 35.97 N, teeth restored with fibre reinforced nano composite Group D-391.97 ± 50.15N.

Multiple group analysis done by one-way ANOVA revealed that different restorative materials and techniques significantly affected the fracture resistance in different groups ($p<0.001$). Tukey's test showed that the mean fracture resistance of group A and Group D were significantly higher than group Group B and Group C. The mean fracture resistance of fibre reinforced nanocomposite was almost equal to that of intact teeth and significantly higher than that of fibre reinforced microhybrid composite and nanocomposite.

Table 2 shows that statistically significant difference was observed between control group, nano composite group, fibre reinforced microhybrid composite, fibre reinforced nanocomposite group in the mean fracture resistance as well as within the groups.

Figure 1 shows Graph comparing the fracture resistance between samples of healthy teeth, nano composites, fibre reinforced microhybrid, fibre reinforced nanocomposite. Fracture resistance was measured in Newtons.

Table 1: Mean Force required for each group.

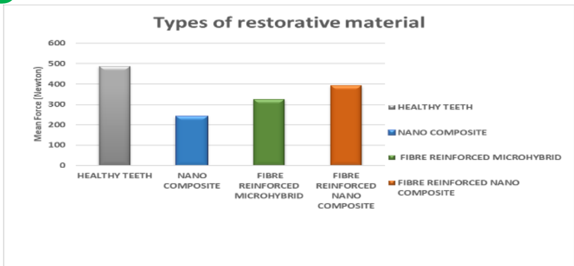
SAMPLES	Healthy teeth (controls)	Nano composite	Micro ribbond composite	Nano ribbond composite	p value
Mean force (Newton)	487.41 ± 43.123	240.75 ± 55.263 N	324.13 ± 35.97 N	391.97 ± 50.15N	<0.001

One way ANOVA

Table 2: Tukey's post hoc test showing inter group comparison.

SAMPLES	COMPARISON GROUP	MEAN DIFFERENCE	p value
Healthy teeth (control)	Nano composite	246.66	<0.001
	Micro ribbond	163.28	<0.001
	Nano ribbond	95.44	<0.001
Nano composite	Micro ribbond	-83.38	<0.001
	Nano ribbond	-151.21	<0.001
Micro ribbond composite	Nano ribbond	-67.83	<0.001

Fig1: Fracture resistance for different restorative materials.



DISCUSSION

Reattaching the fractured fragment is a practical and esthetic approach to treat uncomplicated crown fractures. Liew described reattachment technique as an outstanding short to medium term temporary restoration which can provide limitless service. Andersen et al in a multicenter clinical trial demonstrated 25% of re -attached coronal fragment retained even at 7 years. In another study done by Cavalleri and Zerman showed 90% of the reattached fragments retained at 5 years and this excelled over resin composite repairs.[2]

In this study, the fracture resistance of the reattached incisor fragment was evaluated using 3 different resin composites. This was done in maxillary central incisors as these teeth account for the maximum occurrence of the fracture due to dental trauma. The teeth selected for the study were extracted for periodontal reasons and the patients who donated the teeth were of older age group due to the same reason. But in an actual clinical scenario, trauma usually happens in the younger age group. However, literature shows no significant differences in the micro tensile bond strength of composite resins to the adult and young teeth.[1] Samples with similar external crown lengths were selected because other parameters such as internal geometry (pulp chamber), enamel tissues and structure of dental tissues could not be controlled. The crown of all the teeth was cut at 3mm from the incisal edge to equalize the exposed area. Thus a consistent and duplicable condition can be attained with the sectioned fragment which is highly necessary for an in vitro study.[9]

The result of this study demonstrated that the intact teeth have the highest fracture resistance than all the other restorative materials used for reattachment. Group A which were used as control and the mean fracture resistance of intact teeth was found to be 487.41 N. Among the experimental groups, Group D i.e; teeth reattached with fibre reinforced nanocomposite showed highest resistance to fracture with a mean fracture resistance than Group C and Group B.

Higher fracture resistance provided by fibre reinforced nanocomposite could be attributed to the presence of polyethylene fibres, which can improve the impact strength, modulus of elasticity and flexural strength of composite materials. High toughness and strength are the two important properties of FRC materials. The addition of polyethylene fibres in nanocomposite used to rebuild the incisal edge enhances its mechanical properties by sharing the forces to a wider surface area. Bonding area is increased and the stress at the interface is diminished which became beneficial under repeated loading. In a study done by Kumar P et al, permanent maxillary central incisor's edge was reattached with glass fibre composite and load-bearing capacity was tested. The study concluded that by using fibre reinforced composite substructure under conventional composites in the repair of fractured incisors, the load-bearing capacity can be increased substantially.[15] Among Group C and Group B i.e; the fibre reinforced microhybrid composite and fibre reinforced nanocomposite, the microhybrid composite reattached fragment failed at a lower load of 324.41N as compared to nanocomposite, in spite of reinforcing it with fibre. This may be due to the higher contact surface area of nanofiller particles with the organic phase in nanocomposite resin which improves its material strength when compared with microhybrid composite. Concentration of the inorganic filler and its particle size contributes to the mechanical behavior of the composites. Due to the increased filler content, reduced filler particle dimension and its wide size distribution which can be obtained without an increase in the viscosity gives nanocomposite higher compressive strength than microhybrid composite.

Experimental group reattached with nanocomposite i.e; Group B alone failed at the least load ie; at 240.75 N. Nanocomposite in spite of having better properties than microhybrid, proved inferior to the latter as fibre addition enhanced the mechanical properties of the latter. Additionally in the other two experimental groups, grooves were placed in palatal surface and this provided increased surface area for adhesion of reattachment material.

One of the limitations of this study was cutting the incisal edge with a diamond disk as the fracture pattern thus obtained differs from the natural fracture patterns. As the anatomy of the sectioned surface of the tooth and natural fracture varies, the fit of the sectioned fragment over the remaining tooth will not be as exact as that of a natural fracture. Also with the cut, smear layer is produced which is usually not present in fracture surface. In an actual in vivo situation the speed at which trauma occurs also influences the anatomy of the involved tooth surfaces. Loguercio et al studied the fracture strength recovery of fractured or sectioned tooth fragments reattached with different techniques and showed that force that caused detachment of sectioned fragment was significantly less.[10] In spite of all these shortcomings, we resorted to sectioning with a disc in this study as fracture stimulated by impact load may lead to unpredictable fracture surface with dissimilar surface area, location, and direction. Even though fracturing using impact load provides better stimulation of clinical condition with smear free surfaces, there will be difficulty in standardizing the fragment dimensions and surface area. Another limitation is the use of a static load instead of a dynamic load which mimics the intraoral situation more precisely. Further studies using dynamic loading should be done to confirm the present result.

Group B, nanocomposite in spite of having superior material properties failed at a lower load when compared with Group C and Group D because in this group no fibre was used and no grooves were placed.

In vitro results cannot be directly applied to an in vivo study. Further clinical trials should be conducted to establish the hypothesis proved in the present study.

CONCLUSION

Within the limitations of the study the following conclusions can be drawn

1. Fragment reattached teeth had lower fracture resistance when compared sound natural teeth.
2. Polyethylene reinforced nanocomposite is proven to be the best reattachment material when compared with other materials used for reattachment with statistically significant result.
3. Polyethylene reinforced microhybrid composite proved to be the next best material to be considered as a choice of reattachment.
4. Reattachment with nano composite was demonstrated to have the least fracture resistance among the tested materials.
5. Measuring fracture resistance using Universal Testing Machine may be a reliable method to study about the strength of restorative materials.

Further in vivo studies have to be undertaken to prove in vivo significance.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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