Original Article

Comparative Evaluation of Fracture Resistance of Incisor Fragments Using Simple, Bevel, Internal Groove Preparation Designs and Reattached with Nanocomposites: An In Vitro Study

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Aim: The aim of this in vitro study was to evaluate the fracture resistance of anterior crown fragments using three different preparation designs and reattached using two different nanocomposites. Materials and Methods: A total of 120 sound human permanent incisors were selected and divided into six groups. The teeth were sectioned and reattached using different preparatory designs and nanocomposites. Group A (simple reattachment with G-aenial Universal Flo), Group A2 (bevel preparation reattached with G-aenial Universal Flo), Group A3 (internal groove preparation reattached with G-aenial Universal Flo), Group B1 (simple reattachment with Polofil NHT Flow), Group B2 (bevel preparation reattached with Polofil NHT Flow), and Group B3 (internal groove preparation reattached with Polofil NHT Flow). The teeth were sectioned and reattached using different preparatory designs and nanocomposites. These teeth were then subjected to thermocycling, and fracture resistance of the reattached fragments was recorded using Instron machine. Results: Group A3 showed the highest fracture resistance. The least fracture resistance was seen in Group B1. Conclusion: The fracture resistance of reattached incisor fragments depends mainly on the preparation design incorporated and also the material used to restore. Fragments where internal groove preparatory design was done and reattached with G-aenial Universal Flo, showed greater fracture resistance. Simple reattachment preparatory design showed the least fracture resistance, and hence must be avoided.

Keywords: Fracture resistance, fragment reattachment, in vitro study

INTRODUCTION

Dental trauma is on a rise in children and teenagers due to involvement in contact sports, domestic fights and fall, risk taking activities, and increased traffic accidents.[1,2] Research has shown that fracture of anterior teeth is common among 8–11-year-old children.[1,2] Coronal fractures of permanent incisors represent 18%–22% of all traumas of hard tissues. Of these, 96% involve maxillary incisors (80% central incisors and 16% lateral incisors).[1-4]

Simple techniques that are fast, restore aesthetics, and improve long-term success rates are therefore of potential value. Reattachment of fractured tooth fragments is one valid alternative for conservative treatment where anterior teeth are involved.

The first published case of fragment reattachment was reported in 1964 by Chosack and Eidelman[5] at Hebrew School of Dentistry, and they termed this treatment as “temporary restoration.”[6]

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The resistance to fracture of the reattached tooth will not be the same as the intact tooth. However, by using the proper technique and material, the resistance to fracture can be matched with intact teeth.[7]

Nanocomposites have been successfully used since few years for fragment reattachment, as they offer high mechanical properties in terms of fracture toughness, wear resistance, and decreased polymerization shrinkage as compared to conventional composites. G-aenial Universal Flo (GC, Tokyo, Japan) and Polofil NHT Universal Flow (VOCO, Cuxhaven, Germany), are two flowable nanocomposites, which the manufacturers claim that they can be used as universal injectable composites.

The aim of this in vitro study was to determine the fracture resistance of anterior crown fragments using simple reattachment, bevel, and internal groove preparation designs, reattached with G-aenial Universal Flo and Polofil NHT Universal Flow nanocomposites.

**Materials and Methods**

A total number of 120 human permanent maxillary central and lateral incisors extracted due to periodontal disease, which were non-caries, free from cracks, devoid of developmental defects, and with intact incisal edges were selected. Soft tissue remnants and calculus were removed, and specimens were stored in artificial saliva.

The selected teeth were randomly divided into six groups of 20 samples each.

- **Group A1**—Simple reattachment + G-aenial Universal Flo
- **Group A2**—Bevel preparation + G-aenial Universal Flo
- **Group A3**—Internal groove preparation + G-aenial Universal Flo
- **Group B1**—Simple reattachment + Polofil NHT Flow
- **Group B2**—Bevel preparation + Polofil NHT Flow
- **Group B3**—Internal groove preparation + Polofil NHT Flow

All teeth were embedded in color-coded self-cure acrylic resin with anatomical crowns exposed. The samples were then numbered and stored in artificial saliva.

**Intentional fracture of sound teeth**

The tooth was measured on the labial side from the cervical to incisal edge using a vernier caliper, and was divided into three segments. The incisal third of the tooth was then sectioned perpendicular to the long axis of the tooth using a diamond disk in lathe with distilled water as a coolant. The fractured fragments and the remaining tooth structure were stored in artificial saliva.

**Preparation of the fractured fragments**

The tooth and the fragment were prepared using the following techniques:

- Simple reattachment: No preparation done on the tooth and the fragment
- Bevel preparation: A bevel with 45° inclination was prepared on the labial cavo-surface margin of the tooth, extending 2 mm cervically. This bevel was prepared both on the tooth and the fragment by means of a water-cooled high-speed tapering fissure right angle (RA) 700 bur.
- Internal groove preparation: An internal groove was prepared on the tooth and the fragment, measuring 1 mm in depth and 1 mm wide, by means of a water-cooled high-speed straight fissure bur #558 RA.

**Reattachment of the fragments**

*Ortho*-phosphoric acid 37% (S.S. White, S.S. White Dental, Lakewood, NJ, USA) was applied to the fragment and the tooth surface for 15 s and rinsed for 10 s followed by air drying for 5 s. Bonding agent (Adper Single Bond, 3M ESPE, St. Paul, MN, USA) was applied on the surfaces and air dried for 5 s. The samples were then light cured for 20 s each on the fractured fragment and on the tooth.

G-aenial Universal Flo and Polofil NHT Universal Flow were applied on both the fractured surfaces and then reattached and light cured on the buccal and palatal surface for 30 s each in Group A and Group B. The reattached specimens were then stored in artificial saliva.

**Thermocycling**

All restored specimens were subjected to 150 cycles of thermocycling at 5–55°C + 20°C. The samples were then placed in hot water bath for 30 s at 55°C + 20°C and cold water bath for 30 s at 5°C + 20°C with a transfer time of 10 s.

**Fracture of the restored teeth**

All the samples were subjected to fracture strength test using Instron Universal Testing Machine (LR-100K, Lloyd Instrument Ltd., UK) at a speed of 0.5 mm/ min. The load was applied in a buccolingual direction, and the breaking load was tabulated and subjected to statistical analysis.

Statistical analysis was performed using the program Statistical Package for the Social Sciences (SPSS) software, version 22.0 (IBM SPSS, IBM Corporation,
New York, USA). Mean, median, and standard deviation were estimated for each study group by one-way analysis of variance (ANOVA). Median test was used for the data comparison as some outliers were present in the data. Intragroup comparisons were done using ANOVA and post hoc analysis. Intergroup comparisons were done using Student’s independent t test. $P < 0.05$ was considered as the level of significance.

### RESULTS

Table 1 shows the fracture resistance in Newton in the range of mean, median, and standard deviation in all the six groups.

The highest fracture resistance was seen in Group A3, reattached with internal groove preparation and G-aenial Universal Flo. The least fracture resistance was seen in Group B1.

On intragroup comparison, fracture resistance of Group A3 was higher than A2 and A1 [Figure 1]. Fracture resistance of Group B3 was higher than B2 and B1 [Figure 2]. Statistically significant difference was seen between Groups A1 and A2, A1 and A3, and B1 and B3.

On intergroup comparison, statistically significant difference was seen between A1 and B1.

### DISCUSSION

Fragment reattachment technique offers several advantages over other techniques. It is a conservative procedure, and also provides color stability over time and wears at a similar rate as the other teeth. The clinical procedure is safe and simple, therefore less chairside time is required.\(^{[8]}\)

In this study, three designs are compared, that is, simple reattachment, beveling, and internal groove preparation, and two flowable nanocomposites (G-aenial Universal Flo and Polofil NHT Universal Flow). The highest fracture resistance was observed with internal groove preparation when used with both the composites. The greater adhesion area and the placement of an internal groove, which acts as an opponent to the compression load applied on buccal surface could be responsible for the excellent results obtained in this group.\(^{[9]}\)

Beveling has resulted in good fracture resistance compared to simple reattachment. This could be because of increased surface area for bonding of adhesive.\(^{[7]}\)

The least fracture resistance was seen with simple reattachment. This could be because of lack of surface area for bonding of adhesive.\(^{[9]}\)

Nanocomposites can be used for reattachment of the fractured anterior teeth as they offer high mechanical properties in terms of increased fracture toughness, wear resistance, and decreased polymerization.
shrinkage as compared to conventional composites. The higher mean fracture strength of nanocomposites could be attributed to their superior mechanical properties on account of the nano-fillers present in them.\textsuperscript{[10]} Hence, in this study, we have compared two nanocomposite resins, G-aenial Universal Flo and Polofil NHT Universal flow, which the manufacturers claim that they can be used as a universal restorative material.

Better fracture resistance was seen with G-aenial Universal Flo nanocomposite. Statistical significance was seen between Groups A1 and B1. This could be manufacturer dependent.

Numerous other factors that can influence the fracture resistance of a reattached tooth in \textit{in vitro} studies are: type of teeth selected, selection of root embedment material, selection of storage media, storage period, mode of fracture, presence of smear layer, acid etching pattern, dentin bonding agent used, polymerization of composite, and amount of load applied to fracture the reattached fragments.\textsuperscript{[10]}

All the samples were stored in artificial saliva till sectioning to simulate the natural condition in the oral cavity.\textsuperscript{[11]}

To simulate the fracture, the teeth were sectioned using a diamond disc bur. However, sectioning implies some disadvantages: (1) The necessary force to detach the reattached dental fragment cannot be compared to the force required to fracture the intact tooth; (2) the surface of the two sectioned dental halves are radically different from the surfaces that result from fracturing; (3) the sectioning technique produces a cut surface of coronal dentin that incorporates a smear layer, whereas the fracturing generates smear-free fractured surfaces; (4) a fractured surface runs parallel to the main direction of enamel prisms, whereas the orientation of a sectioned surface is dictated by the alignment of the diamond saw used to section the incisal edge; and (5) the lack of substance arising from the tooth sectioning makes it impossible to perfectly reassemble the two dental fragments.\textsuperscript{[6,12]}

The teeth and dental fragments were kept in artificial saliva following fracture by diamond disc because the dehydrated dental surfaces may adversely affect the adhesion of the reattached fragments.\textsuperscript{[6,13]}

During testing of specimens in Instron Universal Testing Machine, lingual side was chosen for the application of loading force to simulate oral conditions. The results in this study have shown that there is a significant difference in fracture resistance between Groups A1 and A3 and B1 and B3, which concludes that incorporation of a bevel or internal groove improved the fracture resistance. Simple reattachment has shown poor fracture resistance using both the materials. Hence, simple reattachment should be avoided because of its highest vulnerability to future fractures.

Statistical significant difference was also observed on intragroup comparison between A1 and B1, which shows that in spite of the preparation design, fracture resistance is material dependent as well.

Group A3 and B3 showed the best fracture resistance compared to other groups. This revealed that both G-aenial Universal Flo and Polofil NHT Universal Flow nanocomposites can be successfully used with internal groove preparation for fragment reattachment to provide better fracture resistance. Hence, this study implies that the fracture resistance of reattached incisor fragments depends mainly on the preparation design incorporated and also the material used to restore.

The loss of tooth structure during sectioning with diamond disk and the inability to adequately reproduce actual intraoral forces in a laboratory simulation are notable limitations to the external validity of the present findings. Trials should be conducted to confirm the hypothesis presented by laboratory investigations.

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**Conflicts of interest**
There are no conflicts of interest.

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