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To Evaluate The Effect Of Storage Medium On Fracture Resistance Of Reattached Tooth Fragments By Using Flowable Composite Resin

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Abstract

AIM: To compare the fracture resistance of fractured incisor tooth fragments stored in four different storage media after reattachment.

Materials and methods: Sixty freshly extracted human maxillary incisors were included in this study, Teeth were then sectioned, and fragments were stored in four groups of 15 teeth as, Group I - Stored in Open container, Group II - Stored in Tap water, Group III - Stored in Artificial Saliva and Group IV - Stored in Milk. The fragments were reattached using simple reattachment technique and tested on the Universal Testing Machine. Statistical analysis was performed using one-way analysis of variance and *post hoc* Tukey's test.

Results: There was statistically significant difference ($P < 0.05$) in fracture resistance values between the groups. The highest fracture resistance value was demonstrated by Group IV (milk), whereas least fracture resistance values were observed in Group I (open container) dry storage.

Conclusion: Hydration of the fragment improve its fracture resistance significantly. Milk offers the highest fracture resistance values among the tested media.

Keywords: Fracture resistance; fragment reattachment; flowable composite; storage medium

Introduction

There is greater involvement of peoples in contact with the sports, automobile accidents and outdoor activities which led to an increased incidence of dental trauma. [1] Trauma to the permanent teeth is common, crown fractures almost presents 92% of all traumatic injuries of the permanent teeth. Maxillary incisors are most commonly affected, 80% central incisors and 16% lateral incisors. [2]

Fig. 1 sample stored in glass container

Many techniques have been used to restore such traumatically injured teeth by usage of resin, stainless steel and ceramic crowns, orthodontic bands and composite restorations with and without pins. However, all these techniques required lot of scarification of healthy natural tissue. [3] Now a days significant advances in recent years have led to the development of dentin bonding system with relatively high bond strength with enamel and dentin. [4] Hence, tooth's own fragment reattachment can be considered a minimally invasive biological option for restoring such injuries. [5]

Tooth fragment reattachment offers a conservative, esthetic and cost effective restorative option. Reattachment of a fragment to the fractured tooth can provide good and long lasting esthetic i.e tooth's original anatomic form, color and surface texture. [6] In addition incisal edges of reattached fragment tends to wear similar that of adjacent natural tooth. This technique can be less time-consuming and provide more predictable long-term results. [6,7] The prognosis of the reattached fragment is depends on the firmness of its attachment to the tooth and also on the storage medium immediately following trauma. [5] Storage medium acts as hydrating media. Hydration maintains the vitality, esthetic appearance, and the bond strength of the tooth. [8,9,10] Hence, the aim of present study was to compare the fracture resistance of fractured incisor tooth fragments stored in four different storage media namely dry air, tap water, artificial saliva and milk, which were reattached using a flowable composite resin.

Materials and Methods

Sixty freshly extracted human permanent maxillary incisors with intact crown structures were collected.

Extrusion criteria- Teeth with defects such as fractures, decalcification, or caries were extruded.

Cleaning and removal of tissue remnants on the root surfaces were carried out using curettes and ultrasonic tips. The teeth were disinfected using 0.2% thymol and stored in distilled water until the time they were intentionally fractured.

The selected teeth were randomly divided into four groups of 15 teeth each based on the storage medium used.

- Group I: Open container (Dry storage)
- Group II: Tap water
- Group III: Artificial saliva (E-saliva)
- Group IV: Milk.

The cervicoincisal distance was measured on the labial surface of all teeth. One-third of this distance was marked from the incisal edge. The tooth was then cut on the marked line perpendicular to its long axis with a low-speed diamond disk. Immediately after fracturing, the fragments were stored in separate marked containers with appropriate storage media (dry, tap water, artificial saliva and milk) for 2 hours and the remaining tooth structure was stored in distilled water. The fragments and the remaining tooth structure were then rinsed in distilled water. Fragments were reattached after 2 hour by simple reattachment technique. The fragment and the tooth were etched by 37% phosphoric acid for 15 s and rinsed. After drying, bonding agent (Bond Force, TOKUYAMA, Japan)) was applied in two consecutive coats and surfaces were dried for 5 s to allow solvent evaporation. The bonding agent was then light cured for 15 s in the fractured fragment and 15 s in the tooth remnant.

Flowable composite BEAUTIFIL Injectable (Shofu INC, Japan) was applied on the surface of the fragment and tooth remnant. The fragment was then positioned back to the tooth remnant. After ascertaining the correct position, light curing was carried out 30 s for both labial and lingual half.

After reattachment, all the samples were kept in distilled water at room tempreture for 2-3 days. Each sample was then embedded in a self-cure acrylic resin block till cemento-enamel junction.

All the samples were then subjected to testing for fracture resistance using Universal Testing Machine (TUF-C-1000 SERVO). The rod of universal testing machine was held perpendicular to the long axis of the tooth at the incisal third of the crown near the bonding line on the labial surface. The load was applied at a crosshead speed of 1 mm/min. The load was increased progressively and the value at which the reattached fragment debonded was recorded in kilograms and converted into Newton (N) using the relationship, 1 kg = 9.81 N. This load represented the fracture resistance of the reattached tooth. The fracture resistance of all the samples was recorded similarly.

Statistical Analysis

The data were compiled and put to statistical analysis using one-way analysis of variance and *post hoc* Tukey's test were performed. $P \leq 0.05$ was considered statistically significant.

Results

The values for each group were tabulated, and the mean and standard deviation were calculated for each of the groups [Table 1]. Statistical tests were then applied. The Highest fracture resistance value was demonstrated by Group IV (Milk), followed by Group III (saliva), followed by Group II (Tap water) and least fracture resistance values were observed in Group I (open container) Dry storage.

It was seen that there was a statistically significant difference in fracture resistance values between Group IV and Group I; Group IV and Group II ($P < 0.05$) There was no statistically significant difference found between Group II and Group III ($p > 0.05$).

Table-1

GROUPS	N	MEAN (N)	SD
GROUP I	15	108.26	20.3339
GROUP II	15	187.63	35.1848
GROUP III	15	203.54	31.6339
GROUP IV	15	264.50	33.7431

The f-ratio value is 883.66969. The p-value is 0.0001 the result is significant at $p < 0.05$.

Discussion

Coronal fractures of anterior teeth are common, which mainly affects children and adolescents. [1, 6] Parents want a esthetic, economic and natural restoration for such traumatic injuries. Fragment reattachment can be considered a biologically viable and minimally invasive option. [5,11]

A study by Farik *et al*. showed that additional drying of fractured fragment beyond 1 hour decreases the fracture resistance significantly, thus giving the importance of hydrating the fragment. [12] It is found that bond strength can be preserved by rehydrating dry fragment. [8]

Permanent maxillary incisors were selected for this study because of its greater involvement in traumatic episodes. [2] Patient can bring fractured fragment in the form of dry or wet, which affects the viability of fractured fragment.

Tap water is the most convenient medium due to its easy availability but it causes rapid cell lysis similar to dry storage due to its hypotonicity, unphysiological pH of 7.4 to 7.79, osmolality of 30 mosmol/kg and microbial contamination. **Saliva** can also used as storage medium.

But it also has an unfavorable characteristics such as hypotonicity, unphysiological pH of 5.6 to 7.9, osmolality of 60-70 mosmol/kg and microbial contamination. So tap water and saliva can be considered as better storage media in comparison to dry storage, but they provides minimal efficacy. [13,14,15] Previous studies have stated that milk was better in enhancing the fracture resistance of the reattached tooth fragment than dry air. [16] Milk is an excellent medium for storage due to its properties of a physiological neutral pH of 6.5 to 7.2, osmolality of 270 mosmol/kg isotonicity, minimal bacterial content due to pasteurization and with easy availability at the site of accidents. [13,14,15] Thus, the test groups comprised these four media which are natural as well as readily available. Distilled water was used as the storage medium for freshly extracted teeth in the present study, instead of saline and sodium hypochlorite as it can affect the bond strengths when used as storage medium. [17] In this study the teeth were cut in a standardized manner using diamond disk, as the aim was to evaluate the storage media. [8] Fracturing a tooth *in vitro* could be of uneven dimensions, so the fitting between the fragment and the tooth was not always perfect. As a result, the amount of material required for reattachment will vary and can give inconclusive results. Hence, with this limitation to simulate the natural fracture forces, this procedure of sectioning using a diamond disk was followed as it allows the standardization of the fragment size. The storage time was taken as 2 hour to simulate a clinical scenario and the reattachment procedure is carried out in the same appointment. The technique of simple reattachment was used as the aim of this study was to evaluate the hydration media. Dehydration of human dentin leads to a brittleness of dentin. [18] Hence in the present study the samples were not allowed to dry except for the fragments of Group I. All of the samples were tested within 2–3 days to prevent any major variation from occurring in the values between the samples. To simulate a clinical scenario for fracturing the reattached teeth the direction of load kept perpendicular to the long axis of tooth at incisal third, wherein a tooth restored using fragment reattachment encounters the second episode of trauma. However, one potential drawback of this study was the amount of load which was applied using the universal testing machine at a crosshead speed of 1 mm/min did not simulate a natural traumatic scenario. [19] In this study, the fracture resistance value for Group IV was recorded highest being statistically significant over Group I and Group II. It can be attributed to the isotonicity of milk with high water content which allowed adequate rewetting of the dentinal tubules. [19,20] Group II and Group III gave the lower fracture resistance values due to the low osmolality which might have prevented uniform wetting of dentin.[13,14,15] Group I gave the least fracture resistance values due to the dryness which causes dehydration and collapsed collagen fibers of dentin. [8,18] Hence, this study has the potential to the fact that the mode of storage of a fractured fragment before its reattachment significantly affects the prognosis. Thus, there is a need of public awareness about the manner of storage of such fragments.

Conclusion

Within the limitations of this study, it can be concluded that:

- Fracture resistance of the fractured fragment can be significantly improved by the hydration of the fragments.
- Milk gives the highest fracture resistance values among the tested storage medium.

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