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COMPARATIVE EVALUATION OF VARIOUS STORAGE MEDIA ON FRACTURE RESISTANCE OF REATTACHED CROWN FRAGMENT: - AN IN VITRO - STUDY

Dental Science

Dr. Shivani Bhatia* PG Student, Department Of Conservative Dentistry And Endodontics, Bharati Vidyapeeth (Deemed To Be) University Dental College And Hospital , Pune , Maharashtra.
*Corresponding Author

Dr. Anupam Sharma Head Of Department, Professor And PG Guide, MDS, Department Of Conservative Dentistry And Endodontics, Bharati Vidyapeeth (Deemed To Be) University Dental College And Hospital , Pune , Maharashtra.

Dr. Rajlaxmi Patil Assistant Professor, MDS, Department Of Conservative Dentistry And Endodontics, Bharati Vidyapeeth (Deemed To Be) University Dental College And Hospital , Pune , Maharashtra.

Dr. Anirudha Sharma PG Student, Department Of Conservative Dentistry And Endodontics, Bharati Vidyapeeth (Deemed To Be) University Dental College And Hospital, Pune , Maharashtra.

Dr. Esha kedia PG Student ,Department Of Conservative Dentistry And Endodontics, Bharati Vidyapeeth (Deemed To Be) University Dental College And Hospital , Pune , Maharashtra.

ABSTRACT

Background-Episodes of dental trauma, more commonly coronal fractures of anterior teeth are being increasingly reported in children over the past few years. Fragment reattachment can be considered as a valid treatment option in such situations. However, ideal medium for storage of fragments before reattachment needs to be explored.
Aim-The aim of the study is to compare effect of various storage media on the strength of reattached fragment of the tooth bonded to the remaining tooth.
Materials and Methods: Forty freshly extracted maxillary incisors were divided into four groups. Teeth were then sectioned, and fragments were stored in dry storage (Group I), milk (Group II), coconut water (Group III), and artificial saliva (Group IV). 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 II, whereas least fracture resistance values were observed in Group I).
Conclusion- Along with milk, coconut water can be considered a viable alternative.

KEYWORDS

Fracture Resistance, Reattachment , Storage Media

INTRODUCTION

Anterior crown fractures are a common form of injury that mainly affects children and adolescents. The position of maxillary incisors and their eruptive pattern carries a significant risk for trauma

The incidence of trauma to anterior teeth in children is on a rise. In the 6–12-year-old children, it has been reported to range from 2.1% to 4%. The prevalence of dental trauma has also shown considerable variation. It has been shown to range from 6% to 34%. [1]

The major cause for dental trauma to the deciduous dentition has been found to be accidents within and around the home, and in case of permanent dentition, most injuries were due to accidents in school and at home.[2]

The most common dental injury to the permanent dentition is uncomplicated crown fracture without any pulp exposure. The maxillary central incisors are the most commonly affected teeth, followed by the maxillary lateral incisors.[1]

In the pre-adhesive era, fractured teeth needed to be restored either with pin-retained inlays or cast restorations followed by full-coverage crowns that sacrificed healthy tooth structure and were a challenge for the clinicians to match in aesthetics with the adjacent teeth.[1]

Although composite resin restoration is indicated in the management of fractured anterior teeth, reattachment is an excellent option when the fragment is available. With the development of adhesive dentistry came the concept of "fragment reattachment." Reattachment offers the advantages of being a highly conservative technique and does not involve any kind of preparation that promotes the preservation of natural tooth structure, good aesthetics, maintaining the original anatomy and translucency. The rate of incisal wear also matches that of original tooth structure,[1] and acceptance by the patient who receives the treatment. Prognosis of the fragment reattachment depends on the firm attachment of the fragment to the tooth with strong bonding between the two segments and the tooth preparation. Various studies have been carried out using different materials and tooth preparation designs employed for the union of fractured fragments[3]

One of the factors that play an important role in the success of fragment reattachment is the type of storage of the fragment following trauma. Most of the case reports have highlighted the importance of hydrating the fractured segments[4].

Unlike the well-established protocols of how to treat the avulsed tooth before treatment, recent guidelines do not mention how a tooth fragment should be preserved, even though most reports support the idea that the fragment should be kept hydrated. Although many of the storage media used are water based, the question arises as to whether storage of the fragment in different storage media would influence the quality of hydration and, as a result, the bond strength between the tooth and the restoration[5]

Very few studies have been reported on the kinds of environments like saliva, water, or normal saline, in which patients may store fractured parts of teeth, similar to various storage media for avulsed teeth.[6] The focus of the study was to examine the influence of different storage media on the fracture resistance of the reattached fragment of teeth.

MATERIALS AND METHODS

Forty human maxillary single-rooted central incisors extracted for periodontal reasons were selected for this in vitro study. After extraction, the soft tissues, dental calculus, and stains was immediately removed from teeth. Teeth with defects such as fractures, decalcification, or caries were discarded. 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 10 each

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based on the storage medium used. Immediately after fracturing, the fragments were stored in separate marked containers with experimental storage media (dry, milk, coconut water, artificial saliva) for 2 hours.

Group I: Dry storage
Group II: Milk as storage medium
Group III: Coconut water as storage medium
Group IV: Artificial saliva as storage medium

The procedural steps were as follows:
1. Intentional fracture of freshly extracted sound teeth: The tooth was divided into nine equal quadrants by drawing 2 horizontal and 2 vertical lines at equal distance on the labial surface of the tooth. The fracture line was traced on the mesial side, from the middle quadrant of the incisal row obliquely upward to the mesial quadrant of the middle row. The tooth was cut on the marked line with a low-speed diamond disk.

2. Storage of the fractured fragments in appropriate storage media for 2 h: The selected teeth were randomly divided into four groups of 10 each based on the storage medium used. Immediately after fracturing, the fragments were stored in separate marked containers with experimental storage media (dry, milk, coconut water, artificial saliva) for 2 hours.

3. Reattachment of fractured teeth using flowable composite resin: The remaining tooth structure was kept in artificial saliva. The fragments and the remaining tooth structure was rinsed in distilled water. Fractured fragments were reattached after 2 hours by means of simple reattachment technique. About 37% phosphoric acid was applied to the fragment and the tooth for 15 s, rinsed for 10 s followed by air drying for 5 sec (Etch – Rite (PULPDENT). Bonding agent(Solare Universal Bond (GC) was applied in two consecutive coats and surfaces were dried for 5 s using an air syringe to allow solvent evaporation. The bonding agent was then light cured for 20 s in the fractured fragment and 20 s in the tooth remnant. Nanohybrid flowable composite(Filtek Z350) was applied on the surface of the fragment and tooth remnant. The fragment was then positioned back to the tooth remnant by means of a sticky wax (to carry the fractured fragment). After ascertaining the correct position, light curing was carried out:

1. 40 s labial half
2. 40 s lingual half.

4.Incubation of prepared samples at 37°C in artificial saliva: After reattachment, all the samples were kept in artificial saliva and incubated at 37°C for 24 h. Each sample was then embedded in a self-cure acrylic resin block such that only the coronal portion of the tooth was exposed.

5. Fracturing the samples using Universal Testing Machine: All the samples were subjected to testing using Universal Testing Machine. The rod of universal testing machine was held perpendicular to the long axis of the tooth at the incisal third of the crown at 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 deboned was recorded in kilograms and converted into Newton (N) using the relationship, 1 kg = 9.81 N. This load represents the fracture resistance of the reattached tooth. The fracture resistance of all the samples was recorded similarly

RESULTS

The values for each group were tabulated, and the mean and standard deviation were calculated for each of the groups . Statistical tests were then applied. Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups (Inter group analysis). Further post hoc analysis was carried out if the values of ANOVA test were significant.

The highest fracture resistance value was demonstrated by Group II(Milk), followed by Group III(coconut water), followed by Group III(artificial saliva) and group I(dry storage)

Table 1- ***Comparison of various storage media on the strength of reattached fragment bonded to the remaining tooth in terms of mean (SD) using ANOVA test***

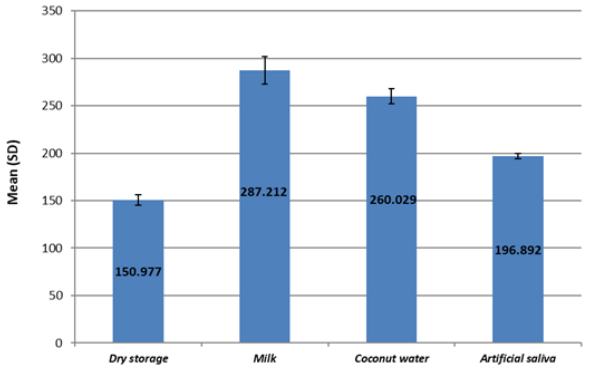
Group	N	Mean	Std. Deviation	F value	P value
Dry storage	10	150.9770	5.5044	473.695	<0.001**
Milk	10	287.2120	14.6622		
Coconut water	10	260.0290	8.1911		
Artificial saliva	10	196.8920	2.7208		
Total	40	223.7775	54.6519		

(p < 0.05 - Significant*, p < 0.001 - Highly significant**)

Table 2 – Comparison of various storage media on the strength of reattached fragment bonded to the remaining tooth using post hoc Tuckey's test.

	Dry storage	Milk	Coconut water	Artificial saliva
Dry storage	-	<0.001**	<0.001**	<0.001**
Milk	<0.001**	-	<0.001**	<0.001**
Coconut water	<0.001**	<0.001**	-	<0.001**
Artificial saliva	<0.001**	<0.001**	<0.001**	-

Graph 1 - Comparison of various storage media on the strength of reattached fragment bonded to the remaining tooth in terms of {Mean (SD)} using ANOVA test



DISCUSSION

Over a period of the past few years' episodes of dental trauma more commonly coronal fractures of anterior teeth are being increasingly reported due to the changing lifestyle of children and teenagers in the modern era.[1] The current generation of parents want a very esthetically pleasing and natural remedy for such traumatic injuries. Fragment reattachment can be considered a biologically viable option which not just meets the current expectations but is minimally invasive as well. The philosophy behind this approach dates back to the early 1960's.[7] However, the interest in this concept got renewed after it was found that the mode of fragment storage following trauma was a key prognostic determinant.[4] A study by Farik et al. showed that additional drying of fractured fragment beyond 1 h decreases the fracture resistance significantly, thus emphasizing the importance of keeping the fragment moist.[8] However, the present study is one of the very few interventions which has solely evaluated the effectiveness of the storage media per se. Permanent maxillary incisors were selected for this study because of their greater involvement in traumatic episodes.

Previous studies have stated that dehydrating the fragments resulted in least fracture resistance. Hence dry air, i.e. Group 1 was taken as a control group. In Group 2 milk was chosen as a storage media. As in this study a major importance was given to public accessibility of the media, milk being the most easily available was chosen.[9] In a previous study, it was also concluded that coconut water kept PDL cells significantly more viable than HBSS(Hanks balanced salt solution) or milk in simulated avulsed teeth.[10] Hence, it was used to testify if coconut water gave similar results if used as a storage medium for fragment reattachment as well. When the tooth is avulsed, parents are advised to store it in milk or saliva [11] Thus artificial saliva was chosen as one of the storage media, as it simulates the environment of the oral cavity. Therefore, the test groups comprised these four media which are natural as well as readily available.

In this study, the teeth were cut in a standardized manner using a low-speed diamond disk. The tooth was divided into nine equal quadrants by drawing 2 horizontal and 2 vertical lines at equal distance on the labial surface of the tooth according to reis and others [7] this procedure of sectioning using a diamond disk was followed as it allows the standardization of the fragment size since the dimensions of each fractured fragment were in proportion to the dimension of the whole crown structure. [9]

The storage time was taken as 2 hrs to simulate a clinical scenario wherein the reattachment procedure is carried out in the same appointment. [12] (such as the patient has met with a traumatic episode. He/ she stores the fractured fragment in the storage media and reports to the dental clinic on the same day. Reattachment procedure is carried out in the same appointment.) The technique of simple reattachment was followed as the point of contention here was the hydration media.[3,5,11,12]

If the coronal fragment is been allowed to dry out prior to reattachment, the fragment will desiccate and in vitro tests have shown decreased bond strength of such reattached fragment. Hence, at no point in the entire study was the samples allowed to dry except for the fragments of Group 1.

In our study, the fracture resistance value for Group II(milk) was recorded as the highest being statistically significant over Group I(dry storage) III(coconut water) and Group IV (artificial saliva). It can be attributed to various factors. 1) it has physiologic pH, (2) has low bacterial count and (3) commonly available.[13]The chemical compositions, pH, hydrophility, etc. maybe some of the related factors that are responsible for higher fracture resistance in this Group. It has been proved that milk elements such as calcium and phosphate can harden and stiffen both demineralized and healthy dentin by permeating the surface.[14] This is probably the reason why enhancement of bond strength was observed in the milk which was rich in calcium and phosphates. Calcium and phosphate sedimentation can also affect the surface topography of dentin and the degree of its dissolution during acid etching, which may also explain the better bond strength in the milk group.[12] It is also said that milk has high water content which allowed adequate rewetting of the dentinal tubules. This is in accordance to previous studies.

The second highest fracture resistance was seen in Group 3 i.e. coconut water. Coconut water is biologically pure and sterile.[1] It is rich in amino acids, minerals and vitamins. [15]The predominant cations are potassium, calcium, and magnesium. Sodium, chloride, and phosphate are found in much lower concentrations.[10]It can be said that the water content of coconut water being high might have allowed better wetting of the dentin preventing the collapse of the collagen fibers which play a role in resin tag formation[12] When measured in an osmometer, the osmolality of coconut water was found to be 372 mOsm/L, respectively. Physiologic osmolality required for storage media is 230 to 400 mOsm/L. [10] If The water permeability of a cell is high, in a hypotonic solution, the cells swell and rupture, whereas in a hypertonic solution they shrink because of water movement out of the cell. Thus, it is important to maintain the physiologic osmolality of the media. [10] Coconut water being hypotonic solution, can also be a reason for higher fracture resistance shown by this group.

According to the results of this study the artificial saliva had the third highest fracture resistance. Its osmolality is much lower than the physiologic (60-70 mOsm/kg),). [13] Lindskog et al in an in vivo study with monkeys compared saliva with milk and concluded that saliva was less suitable than milk because of its low osmolality and higher risk for bacterial contamination. [16] this may be attributed as a reason for low fracture resistance when compared to milk and coconut water.

Dry storage that is Group 1 showed the least fracture resistance. (150.97 N) Keeping the tooth dry leads to loss of moisture from the dentinal tubules due to loss of dentinal fluid. Dehydration of dentin makes it brittle. And because of this there is reduction in the fracture resistance. This result is similar to all previous studies highlighting the importance of hydration of the fragment before reattachment.[3,5,9,11,12,13]

Considering the Indian scenario for the problem in question, there is a greater probability of coconut water being readily available at the site of trauma such as a typical school playground. Hence, this study has the potential to be the eye opener to the fact that the mode of storage of a fragment before its reattachment significantly affects the prognosis. Thus, there is a need to catalyze public awareness about the manner of preservation of such fragments such as their avulsed counterparts.

CONCLUSION

Within the limitations of this in vitro study following conclusions were made

1. Hydration of the tooth fragment prior to reattachment is important as it increases the fracture resistance.
2. Among the storage media which were tested milk showed the most superior results followed by coconut water, artificial saliva lastly dry storage.
3. Thus milk should be the first choice of storage media for storing the fractured fragment. Coconut water can also be used as an alternative to milk.

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