Journal for ReAttach Therapy and Developmental Diversities
eISSN: 2589-7799
2023 Jan; 6(1): 2038-2045

"In-Vitro Comparative Evaluation of Different Rewetting Agents in Success of Tooth Fragment Reattachment"

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Abstract

Aims & Background: Fractured teeth can cause significant damage and psychological impact. Reattachment, using appropriate storage media for fragment hydration, ensures optimal aesthetics and strength. This study evaluates various rewetting solutions.
Materials and Methods: Fifty permanent maxillary central incisors were mounted in acrylic resin. Standardized crown fractures were simulated and the fractured teeth were divided into five groups (n=10) based on immersion solutions: Group A (Control- Intact), Group B (Dry Fragment), Group C (Rice Water), Group D (Rose Water) and Group E (Coconut Water). Fractured fragments were reattached using light-curable flowable composite. The specimens were stored, thermocycled, and tested for fracture resistance.
Results:
Group A (Intact teeth) (372 ±17.3) showed highest fracture resistance followed by Group C (Rice Water) (266 ± 39), Group E (Coconut Water) (232 ± 23), Group D (Rose Water) (170 ± 28) and least was observed in Group B (Dry Fragment) (148 ±32).
Conclusion:
None of the storage media used for the reattachment could help the reattached teeth to match the natural tooth in its fracture resistance. Rice Water, a novel inclusion in this research, demonstrated remarkable improvement in fracture resistance when used as storage media for fractured fragment.
Clinical significance:
This study included widely available household rewetting solutions to provide patients with practical options for preserving fractured tooth fragments during dental emergencies before seeking professional care.

Keywords: Fracture resistance; Tooth Reattachment; Dry Fragment, Rice Water, Coconut Water, Rosewater and Universal Testing Machine.

Introduction:

The World Health Organization recognizes dental trauma (DT) as a public health concern due to its high prevalence (7.4% to 58%) and negative impact on functional, cosmetic, and psychological well-being. It predominantly affects children aged 9-11, with simple coronal fractures (enamel or enamel and dentin) being the most common injury, particularly in the maxillary central incisors, followed by the maxillary lateral and mandibular central incisors.[1]
Treating coronal fractures poses challenges for dental professionals, as they must achieve an aesthetic result that closely matches the original tooth's shape, size, opacity, and translucency. Various methods are available for restoring damaged teeth, including ceramic crowns, steel crowns, orthodontic bands, resin composite restorations, and resin crowns.[2]
These treatments can be expensive, though they may fully or partially restore the tooth's mechanical strength. Long-term clinical care and removal of healthy tooth structure might be required. Additionally, replicating the original tooth's color, shape, surface texture, and translucency can be challenging.[1,3]

Reattachment is a good option because the success of reattaching a fragmented tooth depends upon how the fragment is stored immediately after trauma and its adherence to the tooth. De Sousa et al. emphasized that one important aspect that can impact bond strength upon reattachment is the drying of tooth pieces caused by insufficient storage.[4] Most case studies highlight the importance of wetting fractured segments. The hydrophilic nature of adhesive systems ensures that hydration supports strong bonding. However, research on hydrating mediums is limited. Hydration is crucial for maintaining the tooth's vitality and original aesthetic appearance.[3] Since delays in reattachment are common, keeping the fragment in a moist environment is recommended.[5]

Many authors recommend rewetting the fragment for at least 24 hours following a 24-hour dehydration period. Some studies suggest that 30 minutes of rehydration is sufficient after 48 hours of drying.[6] However, research on various storage solutions, such as saliva, water, saline, milk, and recently coconut water, is limited, similar to the storage of avulsed teeth. There is still no consensus on the best storage medium for hydrating the fragment over time to enhance bond strength.[1]

By incorporating Rose water and Rice water as storage media, this study explores their potential to enhance the preservation and reattachment of fractured tooth fragments. Both materials are commonly found in households, making them practical choices for immediate use in dental emergencies. The inclusion of these novel media is intended to expand the range of effective and accessible options available for patients, particularly in situations where traditional storage solutions may not be readily available.

The success of reattaching a fragmented tooth depends on how the fragment is stored immediately after trauma and its adherence to the tooth. Hydration is crucial for maintaining vitality, appearance, and bond strength, making the choice of storage medium important. However, there is limited research on the exact role of different hydrating mediums.[7]

Micro-hybrid composites and light-cured flowable nanocomposites are commonly used for bonding fractured tooth pieces.[8] This method offers high success rates and advantages such as cosmetic and functional recovery with minimal restorative material, enhanced security, conservatism, simplicity, lower cost, and a positive emotional outcome. Takeyama et al. highlighted the importance of moisture in adhesive dentistry, noting that it facilitates bonding agent penetration into dentinal tubules and enamel, leading to tag formation that helps the composite resin integrate effectively.[9,10]

Hence, the purpose of this study was to assess the effect of various readily available rewetting solutions on the fracture strength of reattached fragment of fractured teeth.

Methods:

Teeth selection:

A total of fifty extracted sound permanent maxillary central incisor teeth selected for the study were cleaned of any debris, deposits and calculus using ultrasonic scaler and were stored in distilled water until use. After cleaning, all the teeth were examined under stereomicroscope to exclude teeth with any defects.

Specimens grouping and specimen’s sectioning:

Fifty permanent maxillary central incisors were mounted in acrylic resin and divided into five groups (n=10) based on immersion solutions: Group A (Control- Intact), Group B (Dry Fragment), Group C (Rice Water), Group D (Rose Water) and Group E (Coconut Water). Root of each tooth was embedded in a mass of acrylic resin so as to leave only the crown of the tooth exposed. Experimental teeth (except Group A) were sectioned 3 mm from the incisal edge parallel to it, using a diamond disc (Fig.1). The fractured fragments from the experimental groups (Group B, Group C, Group D and Group E) were stored in respective rewetting agents in separate marked containers. The remaining structure of the tooth was stored in artificial saliva till reattachment, while the control group i.e. of intact teeth were stored in artificial saliva as storage media.

Specimens reattachment procedures:

After removing from the storage media, the fragments were washed with distilled water.

The fragments and the remaining tooth structure were etched for 15 s on enamel with 37% phosphoric acid (ActinoPlus), followed by washing for 30-40s using distilled water, and was blot dried gently. The Bonding Agent (Prime & Bond, Dentsply) was applied carefully on both, i.e the fractured fragments and the remaining tooth structure using a microbrush and left undisturbed for 10–15 s. After that, the bonding agent was gently rubbed for 20 seconds. To remove any remaining solvent, the adhesive layer was air thinned using oil-free compressed air for 5 seconds, ensuring a thorough evaporation process. The adhesive layer was light cured (1000 mW/cm 2) for 10 s according to the manufacturer’s instruction using LED light curing light (Satelec) without the fragment and tooth being in contact. Afterwards a thin layer of the flowable composite (Filtek Supreme Flowable, 3M ESPE) was applied on both fractured fragment and tooth**.** The fragment was positioned back to the remaining tooth structure by means of light finger pressure. Excess material was removed from the buccal and lingual aspect. After ascertaining the correct position light curing was carried out for 20 s on palatal and labial surface both respectively. During light curing, the incisal dental fragment was kept in place under slight finger pressure (Fig. 2).

Reattached teeth were then finished and polished with the flexible polishing disc (Super Snap, SHOFU) immediately after the reattachment to remove excess composite material if left. The disc's were used from coarse to superfine.

Aging of the specimens:
The finished and polished specimens were incubated for 24 hrs at 37°C and 100% humidity. Following incubation, the specimens were subjected to thermo-cycling between 5°C and 55°C (±5°C) for 500 cycles with 30 s dwell time.

Evaluation of Fracture resistance:
A universal testing machine was used for testing the fracture resistance of reattached specimen and intact tooth. The acrylic block with specimen was mounted on lower plate of universal testing machine, one at a time such that the incisal edge was perpendicular to the chisel. The upper plate of machine enclosed a chisel which was used to deliver the force so that contact was achieved 2 mm from the incisal edge as per mentioned by Nagi SM and Khadr SM in their study. (Fig.3)

Statistical analysis:
Fracture resistance of each reattached fragment was determined using Universal Testing Machine. The load required to dettach each specimen fragment was recorded. The values obtained were then subjected to stastical anlysis and analyzed using SPSS software V.21.0. Post Hoc Tukey's tests was used.

Results:

Among the Various Groups, Group A (Intact teeth) (372 ±17.3) showed highest fracture resistance followed by Group C (Rice Water) (266 ± 39) ,Group E (Coconut Water)(232 ± 23), Group D(Rose Water) (170 ± 28) and least was observed in Group B (Dry Fragment) (148 ±32) , indicating that Intact teeth had maximum fracture resistance followed by reattachment using fractured fragment immersed in Rice Water, Coconut Water, Rosewater as storage media. Dry Fragment exhibited least fracture resistance. (Table-1)

There was a statistically significant difference between the groups with different rewetting solutions. Among the experimental groups, Group C (Rice Water) showed highest fracture resistance, though no statistical significant difference was observed between group E (Coconut Water) and Group C (Rice Water), and also between Group B (Dry Fragment) and Group D (Rose Water). (Table-2)

Discussion:

Orofacial trauma represents 5% of all bodily injuries, with traumatic dental injuries (TDI) globally affecting 15.2% of the population. Despite their growing significance, TDIs are often overlooked by public health organizations and policymakers. Uncomplicated crown fractures are the most common type, accounting for 17% to 48% of cases. It's estimated that one in three adolescents has an untreated crown injury, primarily due to lack of awareness and limited access to care, particularly in developing countries.[4]
Nowadays, Parents seek natural and aesthetically pleasing treatments for their children's dental traumas. Fragment reattachment is considered a minimally invasive and physiologically sound approach that not only meets current standards but also fulfills these expectations.[7]
This technique preserves the tooth's natural look and shape, is highly conservative, matches adjacent teeth wear, is straightforward with minimal chairside time, restores patient confidence quickly, and is cost-effective.[12]
The inclusion of Dry fragments, Rice Water, Coconut Water, and Rose Water in this study was deliberate, as each represents distinct storage conditions for fractured tooth fragments. These choices were made based on their ready availability in order to ensure practical applicability to real-world scenarios.
Dry fragments in this study is likely grounded in the practical consideration that teeth fractures often occur in real-world scenarios where the broken fragments may be exposed to air, leading to desiccation.
Takeyama et al. emphasized moisture's role in adhesive dentistry, showing that it aids bonding agent penetration into dentinal tubules and enamel, forming tags that enhance composite resin integration.[10]
Rice water was selected as a storage medium for fractured tooth fragments in this study due to its rich composition of essential nutrients, including amino acids, vitamins, and minerals, which are known to support cell vitality and hydration. These properties suggest that rice water may help maintain the moisture and structural integrity of the fractured fragments, potentially preserving their viability for reattachment.
Rice (*Oryza sativa*) is a fundamental food for almost half of the world's population, supplying nearly all the daily calories especially in Asia. Rice water retained after soaking or boiling rice is commonly consumed.[13]
Additionally, rice water is easily accessible, cost-effective, and has been traditionally used in various health and beauty applications, indicating its safety and biocompatibility. By exploring the potential of rice water as an alternative storage

medium, this study aims to contribute to the development of practical and readily available solutions for managing dental trauma in a clinical setting.

Prabhakar AR et al. established through their study that Coconut water kept PDL cells significantly more viable than HBSS or milk in simulated avulsed teeth.[7] Hence, it was logical on our part to testify if coconut water gave similar results if used as a storage medium for fragment reattachment as well.[7]

Dabur Gulabari Rose Water, a popular and widely used product in India, is known for its skincare and cosmetic applications. It contains ingredients like rose water, fragrance, rose oil, and preservatives that may aid in hydrating fractured tooth fragments.

This study included permanent maxillary central incisors due to their high trauma frequency. Maxillary central incisors are affected in up to 96% of cases.[2,5]

Common storage mediums for sectioned teeth include distilled water, formalin, 0.9% saline, and 5.25% sodium hypochlorite. Lee et al. found that residual chlorine from saline and sodium hypochlorite can reduce bond strength. This study used distilled water because of its neutral pH and purity.[3]

Artificial saliva was used in this study to store the remaining tooth structure as it mimics the natural oral environment, preserving moisture, pH balance, and salivary enzymes, thus maintaining tooth health and integrity.

The intact teeth group (Group A) (373 ± 17.3) exhibited superior fracture resistance, likely attributed to its natural structure, absence of prior damage, uniform composition, lack of material interface issues, and preservation of natural occlusion. The inclusion of an intact teeth group in this study serves as a baseline or control for comparison with the experimental groups involving fractured teeth fragments.

Among the experimental groups, Group C (Rice Water) (266 ± 39 N) demonstrated the highest fracture resistance, Several factors could contribute to these superior results. Rice water is rich in starch, which may help maintain moisture and provide a protective coating on the fractured fragment, preventing dehydration and preserving the structural integrity of the tooth. Additionally, rice water contains antioxidants like ferulic acid, which can reduce oxidative stress and potentially limit the activation of matrix metalloproteinases (MMPs).

Group E (Coconut Water) achieved a fracture resistance almost similar to Rice water (232 ± 23 N). This effectiveness can be attributed to several factors. Coconut water's higher osmolality and water content improve dentin wetting and collagen preservation, which enhances resin tag formation. Its nutrient-rich profile, including potassium and calcium, supports tooth vitality and stability. The electrolyte balance maintains optimal pH conditions, while natural antioxidants help combat oxidative stress.[7]

Group D (Rosewater) showed poor fracture resistance (170 ± 28 N) compared to Rice Water, Coconut Water and Intact teeth, but better than the dry fragment group. Rosewater's water content and Rose Oil likely aid hydration, while Propylene Glycol helps retain moisture. However, preservatives like Propyl Paraben, Methyl Paraben, and Bronopol may affect overall hydration. Detailed role of each component's of Rose water needs to be studied further.

The study revealed that the Group B (Dry Fragment) (148 ± 32 N), where the tooth fragments were kept dry before reattachment, exhibited significantly lower fracture resistance compared to the other experimental groups which was in accordance with studies previously conducted by Poubel et al and Farik et al. [14,17,18]

After the reattachment procedure, the specimens were subjected to thermo-cycling between 5 °C and 55 °C (±°C) for 500 cycles with 30 s dwell time. This was done because previous studies have shown that hydrophilic resin monomers tend to absorb water gradually, leading to the disintegration of resin-dentin interfaces and a decrease in bond durability.[15] Nonetheless, thermocycling is widely recognized as an essential method for simulating the aging of restorative materials.[15,16]

Advancements in adhesive systems have led many to use them exclusively for fragment reattachment. While self-etching adhesives are popular, phosphoric acid-based systems remain the gold standard for enamel bonding. Self-etching adhesives can match or exceed the bond strengths of etch-and-rinse systems. Enamel etching followed by a self-etch dentin bonding agent (Dentsply Prime & Bond Universal) was used in the study.[17]

This study offers valuable insights into effective storage media and their impact on fracture resistance. Intact teeth set the standard for optimal resistance, highlighting the importance of preserving natural structure. None of the storage media matched the fracture resistance of natural teeth. However, Rice Water showed notable improvement in fracture resistance. The use of common rewetting solutions enhances the findings' practical relevance, connecting laboratory research with clinical practice.

Conclusion: It can be concluded that reattachment of fractured fragment is simple, pocket friendly and faster method. Fragment reattachment with proper use of storage media, presents a viable option for the restoration of both aesthetics and functionality to teeth that have been traumatized rather than going ahead with crowns or veneer preparation which require extensive loss of tooth structure. Rice Water, a novel inclusion in this research, demonstrated remarkable improvement in fracture resistance, marking a pioneering stride in this area of study.

Clinical significance: Understanding the most effective reattachment techniques is essential for dental practitioners to ensure optimal functional and aesthetic outcomes for patients with fractured anterior teeth. By evaluating common household solutions like coconut water, rose water, and rice water, the research provides practical insights into their effectiveness in maintaining the structural integrity of the tooth until professional treatment is available. Notably, rice water demonstrated significant potential in preserving fracture resistance, making it a valuable option for managing dental trauma. These findings offer clinicians and patients practical strategies for improving the outcomes of tooth reattachment, bridging the gap between clinical practice and accessible, everyday resources.

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Figures:

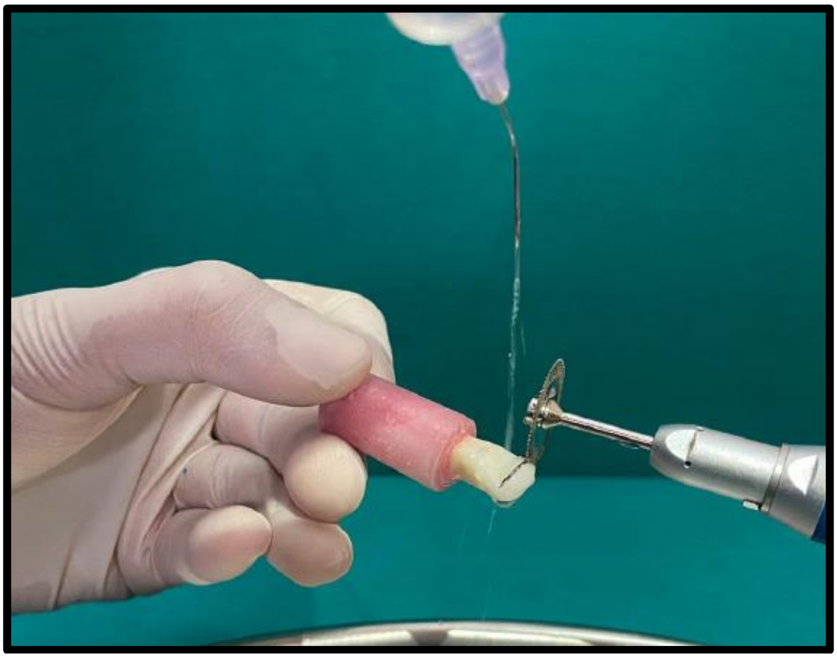

Fig.1) A line traced 3mm from incisal edge, crown fracture simulated using diamond disc under water coolant.

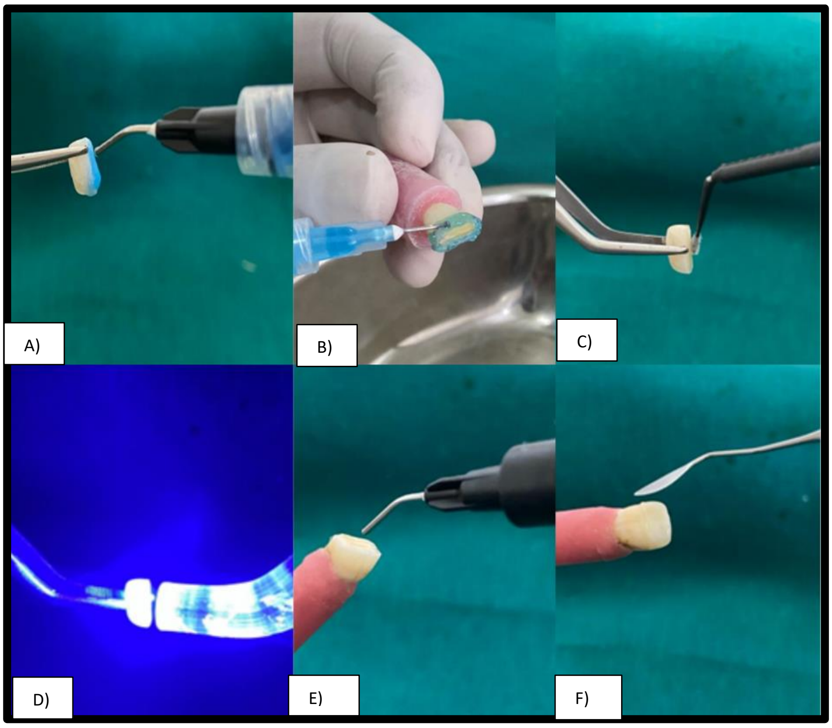

Fig.2 :(A) Etching of the fragment and (B) the fractured tooth done. C) Bonding agent applied, D) Curing done, E) Flowable nanocomposite used for the reattachment of the tooth and fractured fragment, F) Fragment repositioned and excess composite material removed with the help of composite placement instrument.

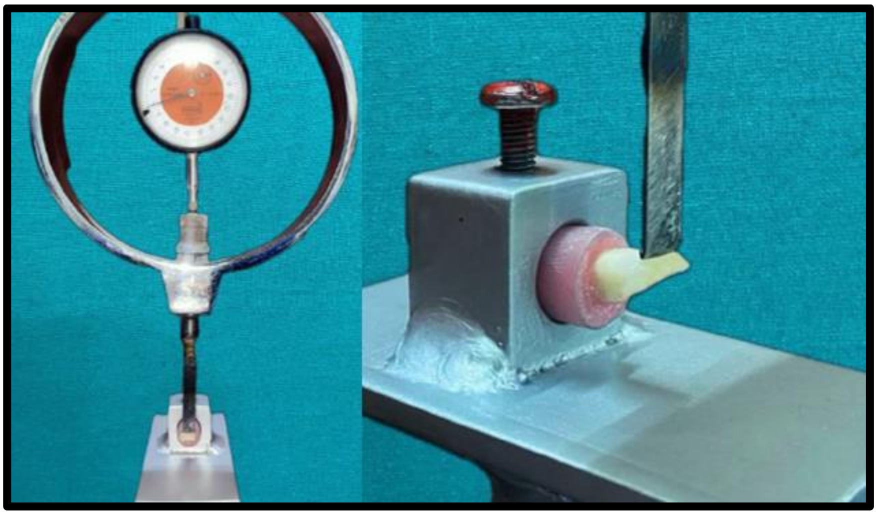

Fig.3 Fracture resistance evaluation using Universal testing machine.

Table 1: Descriptive statistics of fracture load values of reattached fragments rewetted using different solutions.

Groups	N	Mean (N)	S.D.
Group A: Control Group	10	372.600	17.309
Group B: Dry Fragment	10	148.500	32.837
Group C: Rice Water	10	266.000	39.398
Group D: Rose Water	10	170.200	28.397
Group E: Coconut Water	10	232.600	23.330

Table 2: Intergroup comparison using Post Hoc Tukey's test of fracture load values for reattached fragments rewetted using different solutions.

Group		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Group A: Intact Teeth (Control Group)	Group B: Dry Fragment	224.10	14.436	0.000	180.134	268.066
	Group C: Rice Water	106.60	14.436	0.000	62.634	150.566
	Group D: Rose Water	202.40	14.436	0.000	158.434	246.366
	Group E: Coconut Water	140.00	14.436	0.000	96.034	183.966
Group B (Dry Fragment)	Group A: Control Group	-224.10	14.436	0.000	-268.066	-180.134
	Group C: Rice Water	-117.50	14.436	0.000	-161.466	-73.534
	Group D: Rose Water	-21.70	14.436	0.742	-65.666	22.266
	Group E: Coconut Water	-84.10	14.436	0.000	-128.066	-40.134
Group C (Rice Water)	Group A: Control Group	-106.60	14.436	0.000	-150.566	-62.634
	Group B: Dry Fragment	117.50	14.436	0.000	73.534	161.466
	Group D: Rose Water	95.80	14.436	0.000	51.834	139.766
	Group E: Coconut Water	33.40	14.436	0.254	-10.566	77.366
Group D (Rose Water)	Group A: Control Group	-202.40	14.436	0.000	-246.366	-158.434
	Group B: Dry Fragment	21.70	14.436	0.742	-22.266	65.666
	Group C: Rice Water	-95.80	14.436	0.000	-139.766	-51.834

	Group E: Coconut Water	-62.40	14.436	0.001	-106.366	-18.434
Group E (Coconut Water)	Group A: Control Group	-140.00	14.436	0.000	-183.966	-96.034
	Group B: Dry Fragment	84.10	14.436	0.000	40.134	128.066
	Group C: Rice Water	-33.40	14.436	0.254	-77.366	10.566
	Group D: Rose Water	62.40	14.436	0.001	18.434	106.366
*The mean difference is significant at the p < 0.05 level.						