Dental Traumatology

Dental Traumatology 2013; **29**: 99–102; doi: 10.1111/j.1600-9657.2012.01143.x

Evaluation of the effect of storage medium on fragment reattachment

David Ditto Sharmin, Eapen Thomas

Department of Pedodontics and Preventive Dentistry, Meenakshi Ammal Dental College, Chennai, India

Key words: fragment reattachment; fracture resistance; bond strength

Correspondence to: D. Ditto Sharmin, Department of Pedodontics and Preventive Dentistry, Meenakshi Ammal Dental College, Chennai, India
Tel.: +91 9486190456
Fax: +91 44 23781631
e-mail: dr.dittosharmin@gmail.com

Accepted 17 March, 2012

Abstract – *Background/Aim*: Fragment reattachment is a conservative and a valid alternative to a direct composite restoration. The aim of this study was to evaluate the effect of commonly available storage media on the fracture resistance of reattached fragments. *Material and methods*: Sixty sound human maxillary incisors were divided into three groups, the teeth were then sectioned and the fragments were kept dry (Group A), stored in milk (Group B) and in saline (Group C) for 24 h. The fragments were then reattached using simple reattachment technique with flowable composite resin. These teeth were then subjected to thermocycling and the fracture resistance of these reattached fragments were recorded. The mode of fracture was also recorded. *Results*: Group C (saline) recorded the highest mean fracture resistance (76.9 N) followed by Group B (milk) and Group C (dry), (38.7 N and 27.2 N, respectively). Most of the samples in Group A (65%) and Group C (70%) showed adhesive fracture, whereas 50% of the samples in Group B showed adhesive fracture. *Conclusions*: Fragments stored in saline and milk showed greater fracture resistance than those kept dried.

Coronal fractures of anterior teeth are the most frequent form of acute dental injury that mainly affects children and adolescents. Coronal fractures of permanent incisors represent 18–22% of all traumas to dental hard tissues; of these 96% involve maxillary incisors (1).

The treatment of coronal fracture is a considerable challenge for the dentist because it has to fulfill many parameters like necessity to obtain an esthetic result that nears itself to a natural form and dimension, opacity and translucence of the original tooth to obtain a successful restoration (2).

Over time, numerous techniques have been developed for the reconstruction of injured teeth: resin crowns, steel crowns, orthodontic bands, ceramic crowns and resin composite restorations with and without pins (3). With the development of adhesive dentistry, came the concept of 'Fragment Reattachment.'

Fragment reattachment may offer several advantages over conventional acid etch composite restoration. Improved esthetics is obtained because enamel's original shape, color, brightness, and surface texture are maintained. In addition, incisal edge will wear at a similar rate to that of adjacent teeth, whereas composite restoration will likely wear more rapidly. Furthermore, this technique can be less time-consuming and provide more predictable long-term appearance (4).

Chosack and Eidelman (5) published the first case report on reattachment of fractured fragment in 1964. In the late 1970s, Tennery (6) and Simonsen (7) reported cases of fragment reattachment using enamel etching and resin composites. The first follow-up examination (2 years and 6 months later) was overwhelmingly positive in terms of retention.

The prognosis of the fragment reattachment depends on the firm attachment of the fragment on the tooth with impervious margins, strong bonding between the two segments and the tooth preparation. Various studies have been carried out using different materials, tooth preparation designs employed for the union of fractured segments (2, 4, 8).

One of the factors that play an important role in the success of fragment reattachment is the mode of storage of the fragment following trauma. Most of the case reports have highlighted the importance of hydrating the fractured segments (9–11). Hydration maintains the vitality and original esthetic appearance of the tooth (12, 13). The hydrophilic characteristic of adhesive systems also means that hydration acts to ensure adequate bond strength (14); however, very limited studies have been performed on the hydrating medium (15).

The aim of this study was to evaluate and compare the fracture resistance of reattached fragments kept dry or stored in milk or saline and the mode of fracture of reattached fragments.

Materials and methods

A total number of 60 permanent human maxillary central and lateral incisors, extracted for periodontal reasons were selected. The teeth were free from cracks, caries or any other kind of structural defects. The teeth were autoclaved for 40 min and the tissue remnants on the root surface of the teeth were removed with curettes and ultrasonic tips. They were then stored in distilled water until experimentation.

The study consisted of following steps:

1 Intentional fracture of sound teeth
2 Storage of fractured fragments in appropriate storage medium for 24 h
3 Reattachment of fractured teeth using flowable composite resin
4 Thermocycling of the reattached specimens
5 Fracture of the restored teeth using Universal Testing Machine (INSTRON LLOYD)
6 Evaluation of the type of fracture

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

Group A – 20 (dry storage)
Group B – 20 (milk as storage medium)
Group C– 20 (saline as storage medium)

All teeth were embedded in self-cure acrylic resin and were numbered separately. The anatomical crowns were exposed and the samples were stored in distilled water until sectioning of the crown.

Intentional fracture of sound teeth

The teeth were measured on the labial side from the cervical to incisal edge with a digital caliper. The measurement was then divided by three after which the tooth was marked at one-third from the incisal edge. The tooth was cut on the marked line perpendicular to the long axis of the tooth using saline as a coolant with a low-speed diamond disk.

Storage of fractured fragment

Immediately after fracturing, the fractured fragments were stored in separate marked containers with appropriate storage medium (dry, milk, and saline) for 24 h and the remaining tooth structure along with acrylic blocks were stored again in distilled water until reattachment.

Reattachment of the fragments

Fragments were reattached after 24 h by means of simple reattachment technique without any additional preparation. Thirty-seven percent phosphoric acid (H3PO4) (D-tech; Sakhi Chem Tech Pvt. Ltd, Pune, India) was applied to the fragment and the tooth for 15 s and rinsed for 10 s followed by air drying for 5 s to remove excess water. Bonding agent (Adper Single Bond 2, 3 M ESPE, St. Paul, MN, USA) was applied in two consecutive coats. Then, the surfaces were dried for 5 s using an air syringe to allow solvent evaporation. The bonding agent was light cured for 20 s in the fractured fragment and 20 s in the tooth remnant. The flowable composite (Filtek flowable Z350, 3M ESPE, USA) was applied in the fractured surface of 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 positioning, light curing was proceeded in four stages:

a 20 s mesio buccal half
b 20 s disto buccal half
c 20 s mesio lingual half
d 20 s disto lingual half

After reattachment, specimens were stored again in distilled water.

Thermocycling

All restored specimens were kept in distilled water at 37°C and were subjected to 100 cycles of thermocycling at 5–55°C with dwell time of 15 s and transfer time of 10 s. After thermocycling, the specimens were again stored in distilled water until testing.

Fracture of restored teeth

All the samples were then subjected to fracture strength test using universal testing machine (Instron Lloyd, LR100; London, UK) at a speed of 0.6 mm min^{-1} (4).

The force application was always at 90° with respect to the buccal surface and the force required to fracture each tooth was recorded in Newtons (N). The data collected were tabulated accordingly and were subjected to statistical analysis.

Evaluation of type of fracture

The fractured specimens were examined under a compound microscope (45×) for adhesive and cohesive fracture and the results were tabulated.

Statistical analysis

Statistical analysis was performed using the program Statistical package for the Social Sciences (Version 16; SPSS Inc, New York, USA). Mean and standard deviation were estimated from the sample for each study group by one-way ANOVA. Intergroup comparison was made using Student's independent *t*-test. In this study, $P \leq 0.05$ was considered as the level of significance.

Results

Results were expressed as Mean ± Standard Deviation. One-way ANOVA analysis was used for multiple group comparison (Table 1). The *P* value was calculated for statistical significance.

Table 1. Mean fracture resistance and the standard deviation among the groups

Group	*N*	Mean Newtons (*N*)	SD	*P* value
Dry	20	27.282	7.9528	<0.001
Milk	20	38.778	14.4696	
Saline	20	76.917	15.2033	
Total	60	47.659	24.8975	

* *P* value $\leq$ 0.05 is statistically significant.

The results showed that Group C (saline) demonstrated the highest fracture resistance (76.917 N) followed by Group B (milk) (38.778 N) and Group A (dry) which had the least fracture resistance of (27.282 N).

Independent Student's *t*-test was performed for group wise comparison that had statistically significant difference between Group A and Group B ($P \leq 0.05$). Comparison between Group A and Group C, and Group B and Group C revealed that there was a high statistically significant difference ($P \leq 0.001$).

The adhesive fracture at tooth–restoration interface when fragments were left dry or stored in milk or saline was 65%, 50%, and 70%, respectively (Table 2).

Discussion

In the present study, only maxillary incisors were included because in natural conditions these teeth are most prone to trauma. The extracted teeth had periodontal disease.

Commonly used storage media for extracted teeth and sectioned teeth are 0.9% saline, 5.25% sodium hypochlorite solution, distilled water, and formalin. Lee et al. (16) reported that residual chlorine from saline and sodium hypochlorite can negatively influence the bond strengths when used as storage medium.

In this study, distilled water was used as the universal storage medium because it has a neutral pH and does not contain any contaminants.

Various methods to obtain tooth fragments *in vitro* are as follows:

1 Sectioning of the tooth
2 Placing small notches on two proximal surfaces and fracturing by using narrow forceps
3 Using a blunt instrument without notches (17).

In this study, the teeth were cut in a standardized manner, as the aim was to compare hydration techniques. The specimens were sectioned with a saw rather than fractured. Badami et al. (18) and Reis et al. (4) have shown that the surface of a sectioned tooth is different from a naturally occurring fractured one, as the fracture produces fragments with a good fitting. A fractured surface also tends to run parallel to the main direction of the enamel prisms, whereas the orientation of the sectioned surface is dictated by the alignment of the diamond saw used to section the incisal edge (19). Therefore, the fitting in this study, between the tooth and the fragment, was not perfect and sometimes even presented a gap. But fracturing a tooth *in vitro* has its own disadvantages in that, the fracture line produced can be uneven and the resultant fragment obtained would be of unequal dimensions. Hence, the amount of material used for reattachment will vary leading to inconclusive results. Using the diamond saw allows standardization of the fragment size.

Table 2. The mode of fracture among various samples of groups

	Type of fracture					
	Adhesive		Cohesive		Total	
Group	*n*	%	*n*	%	*n*	%
Dry	13	65.0	7	35.0	20	100.0
Milk	10	50.0	10	50.0	20	100.0
Saline	14	70.0	6	30.0	20	100.0
Total	37	61.7	23	38.3	60	100.0

One of the factors that play an important role in the success of fragment reattachment is the mode of storage of the fragment following trauma. If the coronal fragment has been allowed to dry out prior to bonding, the fragment will whiten and *in vitro* tests have shown a decreased bonding strength of such a fragment. Therefore, in the interim period between fragment retrieval and reattachment, the fragment should be kept moist (20).

For the reattachment procedure, an adhesive agent is required that keeps the union of tooth and the fragment intact and also has enough fracture toughness to bear the masticatory load. Although various techniques are available for fragment reattachment, a simple reattachment technique was used in this study as the aim was to compare the effect of hydration of the fragments. Moreover, it was a less time-consuming and simple procedure. Among the tested groups, fragments stored in Group C (saline) gave the highest mean fracture strength values followed by Group B (milk) and the least mean fracture strength values were found among the samples in Group A (dry). These results are consistent with a study carried out by Capp et al. (15) whose results showed that the strength of the hydrated and rehydrated bonded fragments was greater than that of the dehydrated fragments. Keeping the fragments in a moist environment ensured that there is no or minimal collapse of the collagen fibers in the dentin leading to a better bond strength. Moreover, it prevents the whitening of the fragment leading to a better esthetic result.

Yilmaz et al. concluded from their study that the storage medium in which the fragment is kept prior to its reattachment has no effect on the survival, color, and bond strength of restored teeth after fragment reattachment. The color disharmony encountered initially resolves on its own accord within 12 months (21).

In our study, the fracture resistance of the samples stored in saline was higher compared with those stored in milk. This can be due to the amount of water content in milk, which is less than saline. The hydration of the collagen fibers could have been better achieved in saline leading to better fracture resistance.

In the present study, the tooth fragments were kept in the medium for 24 h. If the storage time was more than 48 h, even the samples stored in milk could have obtained similar fracture resistance as stored in saline.

Comparing the mode of fracture, most of the samples in Group A and Group C showed adhesive fracture at tooth surface and restoration interface, whereas 50% of the samples among Group B showed adhesive failure. All the specimens failed at the weakest point, which in this case proved to be the reattachment line, more precisely the interface between the tooth and the repairing material. Another possible explanation for this type of failure is not having a perfect fitting: a discrepancy between the fragment and the tooth will act as a stress raiser. The third possibility would be that, having the force applied incisal to the reattachment line; the weakest point would be the interface (22).

These results must be observed with care, as they indicate that the bonding capacity of the adhesive system alone is not sufficient in the success of fragment reattachment but also the hydration of the fragment.

Conclusion

Within the limitation of the study, the following conclusions were drawn:

1 Group C (Saline) has recorded the highest fracture resistance among the test groups, followed by Group B (Milk) and Group A (Dry).

2 Fracture resistance among the test groups were statistically significant ($P \leq 0.05$).

3 Most of the samples in Group A (65%) and C (70%) showed adhesive failure at tooth surface and restoration interface, whereas 50% of samples among Group B showed adhesive failure and the remaining samples showed cohesive failure.

References

1. Andreasen JO, Ravn JJ. Epidemiology of traumatic dental injury to primary and permanent teeth. Int J Oral Surg 1972;1:235–9.
2. Fernando Demarco F, Fay RM, Pinzon LM, Powers JM. Fracture resistance of reattached coronal fragments-influence of different adhesive materials and bevel preparation. Dent Traumatol 2004;20:157–63.
3. Buonocore MG, Davila J. Restoration of fractured anterior teeth with ultraviolet light polymerized bonding materials: a new technique. J Am Dent Assoc 1973;86:1349–54.
4. Reis A, Francci C, Longuerco AD, Carrilho MRO, Rodrigues Filho LE. Re- Attachment of anterior fractured teeth: fracture strength using different techniques. Oper Dent 2001;26:287–94.
5. Chosack A, Eildeman E. Rehabilitation of a fractured incisor using the patient's natural crown: case report. J Dent Child 1964;31:19–21.
6. Tennery TN. The fractured tooth re-united using the acid-etch bonding technique. Tex Dent J 1978;96:16–7.
7. Simonsen RJ. Traumatic fracture resistance: an alternative use of the acid-etch technique. Quintesscence Int Dent Dig 1979;10:15–22.
8. Prabhakar AR, Kurthukoti AJ, Kayalvizhi G. A comparison of impact strength of fragment-bonded anterior teeth using 3 different restorative materials: an invitro study. J Indian Soc Pedod Prev Dent 2007;25(2):88–92.
9. Agarwal A, Manwar NU, Chandak MG. Reattachment of anterior teeth fragments with two different treatment techniques: report of two cases. Int J Dent Clin 2011;3:107–8.
10. Valceanu AS, Loan S, Stratu l. Multidisciplinary approach of complicated crown fractures of both superior central incisors: a case report. Dent Traumatol 2008;24:482–6.
11. Heda CB, Heda AA, Kulkarni SS. Multidisciplinary approach in the management of atraumatized tooth with complicated crown root fracture: a case report. J Indian Soc Pedod Prev Dent 2006;24:197–200.
12. Simonsen RJ. Restoration of a fractured central incisor using original tooth fragment. J Am Dent Assoc 1982;105: 646–8.
13. Baratieri LN, Monteiro S Jr, Andrada MAC. The "sandwich" technique as a base for reattachment of dental fragments. Quintessence Int 1991;22:81–5.
14. Perdigao J, Van Meerbeek B, Lopes MM, Ambrose WW. The effect of a re-wetting agent on dentin bonding. Dent Mater 1999;15:282–95.
15. Capp CI, Roda MI, Tamaki R, Castanho GM, Camargo MA, de Cara AA. Reattachment of rehydrated dental fragment using two techniques. Dent Traumatol 2009;25:95–9.
16. Lee JJ, Nettey-Marbell A, Cook A Jr, Pimenta LAF, Leonard R, Ritter AV. Using extracted teeth for research: the effect of storage medium and sterilization on dentin bond strength. J Am Dent Assoc 2007;138:1599–603.
17. Reis A, Francci C, Loguerico AD, Carrilho MRO, Rodregues LE. Reattachment of anterior fractured teeth: fracture strength using different materials. Oper Dent 2002;27:621–7.
18. Badami AA, Dunne SM, Scheer B. An in vitro investigation into the shear bond strengths of two dentine-bonding agents used in the reattachment of incisal edge fragments. Endod Dent Traumatol 1995;11:129–35.
19. Chazine M, Sedda M, Ounsi HF, Paragliola R, Ferrari M, Grandini S. Evaluation of the fracture resistance of reattached incisal fragments using different using different materials and techniques. Dent Traumatol 2011;27:15–8.
20. Farik B, Munksgaard EC, Kreiborg S, Andreasen JO. Adhesive bonding of fragmented anterior teeth. Endod Dent Traumatol 1998;14:119–23.
21. Yilmaz Y, Gulier C, Sahin H, Eyuboglu O. Evaluation of tooth-fragment reattachment: a clinical and laboratory study.. Dent Traumatol 2010;26:308–14.
22. Bhargava M, Pandit IK, Srivastava N, Gugnani N, Gupta M. An evaluation of various materials and tooth preparation designs used for reattachment of fractured incisors. Dent Traumatol 2010;26:317–20.