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Reattachment of rehydrated dental fragment using two techniques

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Abstract – The reattachment of dental fragments is a conservative treatment and should be considered in the restoration of anterior tooth fractures. This study compared the fracture strength of dehydrated and rehydrated tooth fragments submitted to two different bonding techniques. *Materials and Methods:* Sixty human central and lateral mandibular incisors were divided into six groups and sectioned 3 mm from the incisal edge, using a diamond disk. Two reattachment techniques were applied: (a) bonding, using the Single Bond adhesive system and FiltekZ250 composite resin, followed by placement of a chamfer on the fracture line that was filled with composite resin (Groups 1, 3 and 5); and (b) use of the same bonding technique after dentin removal from the tooth fragment (Groups 2, 4 and 6). The following hydration treatments were applied to the fragments before bonding: (a) 48-h hydration (Groups 1 and 2); (b) 48-h dehydration (Groups 3 and 4); (c) 48-h dehydration followed by rehydration 30 min before bonding (Groups 5 and 6). The reattached teeth were mounted in acrylic resin cylinders and stored in distilled water for 24 h. The specimens were fractured at a speed of 1 mm min^{-1} in a universal testing machine. *Results:* The following mean fracture strengths (kgf) were recorded: (G1) 12.9 ± 0.6; (G2) 18.8 ± 4.8; (G3) 7.3 ± 1.5; (G4) 15.2 ± 2.4; (G5) 13.4 ± 2.2; and (G6) 17.1 ± 3.2. Analyses using two-way ANOVA and the Tukey test ($P < 0.01$) revealed significant differences between the restorative techniques and the hydration treatments. *Conclusions:* The bonding technique that incorporated dentin removal from the fragment before bonding showed greater fracture strength across all groups. Fragment dehydration for 48 h caused a reduction in fracture strength, which was recovered by a 30-min rehydration.

Dental trauma is a common occurrence, and attending to patients with fractured teeth is an important component of clinical dentistry. According to clinical research (1) in the USA, 25% of individuals between 6 and 50 years of age suffer some type of tooth injury during their lifetime. Complete coronary fracture involving the enamel and dentin is a frequent occurrence; the most common type of fracture being uncomplicated enamel fractures (2–5) that usually involve the maxillary incisors (3, 5, 6).

Although composite resin restoration is indicated in the management of fractured anterior teeth, reattachment is an excellent option when the fragment is available (3, 7–11). Tooth fragment bonding offers the advantage of being a highly conservative technique that promotes preservation of natural tooth structure, good aesthetics and acceptance by patients, who receive a psychological benefit from amelioration of the mutilation (2).

Clinical reports have indicated the application of additional preparations, on both the fractured tooth and the fragment, before and after bonding, with the aim of improving bond strength (2, 7, 12, 13). Reis et al. (9) demonstrated that composite over contouring of the fracture line, as well as the creation of an internal grove on the both fragment and on the fractured tooth, provided strength similar to that of sound teeth. In contrast, bonding without additional preparations produced restored teeth with only 50% of the strength of intact teeth (8, 14–17).

Another important factor is the maintenance of adequate hydration while the fragment is outside the mouth. Hydration maintains the vitality and original aesthetic appearance of the tooth (18, 19). The hydrophilic characteristic of adhesive systems (20) also means that hydration acts to ensure adequate bond strength.

The aim of this study was to compare dehydrated/rehydrated crown fragments submitted to two bonding techniques: simple reattachment with reattachment plus complete removal of dentin from the fragment before bonding, to see if the second procedure could influence the fracture strength.

Materials and methods

Sixty intact human, central and lateral mandibular incisors of similar dimensions were used in this study. The teeth were selected under optical magnification (2×), and those with cracks or structural defects were eliminated. The teeth were disinfected with a 0.5% chloramine solution for 15 days and kept in a 0.9% saline solution, under refrigeration at 5°C, until the beginning of the experiment.

With the aim of standardizing the fragment bonding areas on the vestibular and lingual faces of each tooth, a line was traced at a distance of 3 mm from the incisal edge. Based on this line, and with the aid of a thickness metre, the mesio-distal and vestibular-lingual dimensions (in the centre of both faces) of each incisor were measured. Based on these measurements, the teeth were randomly divided and distributed into six groups (n = 10).

Tooth fracture simulations

The tooth crowns were sectioned with a 0.1-mm thick cooled steel diamond disk (ref no. 983.104.008, Komet Brasseler, Germany) mounted in a device specially constructed for dental preparations (21), which allowed a precise cut to be made on the traced line, perpendicular to the long axis of the tooth and parallel to the incisal surface. After the teeth were sectioned, the fragments were stored in individual flasks filled with distilled water.

Two restoration techniques were studied:

(1) Groups 1, 3 and 5: bonding of the fragment, after which a chamfer was generated along the fracture line and filled with composite resin;

(2) Groups 2, 4 and 6: complete removal of the dentin from the fragment before filling it with composite resin; fragment bonding was then followed by creation of a chamfer along the fracture line and restoration with composite resin.

Three hydration treatments were performed before bonding:

(1) Groups 1 and 2: the fragments and remaining tooth structures were immersed in distilled water for 48 h at ambient temperature;

(2) Groups 3 and 4: the remaining tooth structures were immersed in distilled water for 48 h at ambient temperature, while the fragments were kept dry for 48 h at ambient temperature, packed in paper towels;

(3) Groups 5 and 6: the remaining tooth structures were immersed in distilled water for 48 h at ambient temperature. The fragments were kept dry for 48 h, packed in paper towels, also at ambient temperature. The fragments were immersed in distilled water 30 min before the bonding procedures (Table 1).

Table 1. Reattachment techniques and hydration treatments

Group	Restorative technique	Hydration
1	Reattachment	Hydrated fragment
2	Reattachment plus fragment dentin removal	
3	Reattachment	Fragment dehydrated for 48 h
4	Reattachment plus fragment dentin removal	
5	Reattachment	Fragment dehydrated for 48 h and rehydrated for 30 min
6	Reattachment plus fragment dentin removal	

Fragment reattachment

Groups 1, 3 and 5: After etching the tooth fragments and remaining structures of with 37% phosphoric acid gel, the Single Bond (3M, St. Paul, MN USA, batch no. 1FL) adhesive system was applied in accordance with the manufacturer's instructions. A small layer of composite resin, shade A2, FiltekZ250 (3M, USA, batch no. 1KW) was then applied to the fractured area of the tooth remnant to which the fragment was reattached. The excess was removed from buccal and lingual surfaces before curing for 40 s. A chamfer was placed on the fracture line of the buccal and lingual surfaces with a spherical diamond bur (ref no. 1013, KG Sorensen, São Paulo, Brazil). After acid etching, the chamfer was filled with composite resin FiltekZ250 shade A2 and Single Bond adhesive was applied in accordance with the manufacturer's instructions.

Groups 2, 4 and 6: With the purpose of simulating a clinical situation and to minimize vibration, the entire dentinal portion was removed from the fragments using a high speed spherical carbide steel bur (ref no. H1.204.010, Komet Brasseler, Germany). During this procedure, the fragments were hand held also to absorb vibration. No fragment fractured. Preparation was done under intense cooling and the bur was replaced by a new one after every three fragments. After Single Bond was applied to the fragments and tooth remnants, the area where dentin had been removed was filled with composite resin FiltekZ250 (batch no. 1KE) shade Universal Dentin (UD). The fragments were fitted to the tooth remnants, and excess resin was removed from the buccal and lingual surfaces before curing for 40 s. As in groups 1, 2 and 3, a chamfer was placed on the fracture line and restored. A light-curing unit, an Optilux 400 (Demetron Research Corp., Danbury, CT, USA) set at 450 mW cm^{-2}, was used for polymerization. The teeth were finished and polished with abrasive disks (Super-Snap; Shofu Dental, Kyoto, Japan). The root portions of the reattached teeth were mounted in chemically activated acrylic resin cylinders 1 mm from the cement–enamel junction. The specimens were stored in distilled water for 24 h.

Fracture test

The specimens were loaded on a universal testing machine (Riehle Testing Machine; FS-5, Philadelphia, PA, USA) (9). Load was applied using a device with a conical shaped stainless steel tip measuring 2 mm in diameter. The force application tip was positioned exactly on the fracture line, at 90 degrees on the buccal surfaces of the crowns (Fig. 1), and the machine was activated at a speed of 1 mm min^{-1} until the specimens fractured. The force required to fracture each fragment was recorded. Two-way ANOVA and the Tukey test (P < 0.01) were used to verify the differences between the bonding and hydration treatments.

Ethical approval

Research protocol approved by the Ethical Committee on Research, School of Dentistry, University of São Paulo – Opinion Report No. 90/00.

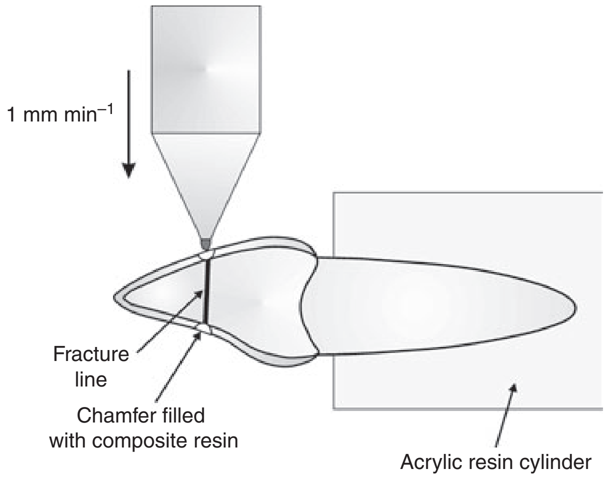

Fig. 1. Universal test machine with specimen in position.

Results

The mean fracture strength values and the standard deviations are shown in Table 2. The two-way ANOVA showed significant differences in strength between the two bonding techniques (reattachment and dentin removal) and the hydration treatments (hydration, dehydration and rehydration). However, there was no significant interaction between bonding and hydration. The mean strength of the fragments with bonding was lower than that of dentin-free fragments in all of the hydration categories.

In view of the differences between fracture strengths obtained in the hydration treatments for the two restored groups, the Tukey test was performed ($P < 0.01$) to determine, if there were significant differences between the treatments. The results showed that in all groups, the strength of the hydrated and rehydrated bonded fragments was greater than that of the dehydrated fragments.

Discussion

Fracture patterns obtained in the laboratory do not necessarily simulate clinical occurrences. One experimental model (14–16) consisted of fracturing the teeth with spherical diamond tipped forceps while it was supported on previously made niches. Others studies (8, 22–26) compared the fracture strength of intact teeth fractured in a test machine with teeth fractured in a lathe with cutting blades. In another method, the fracture strength of sound teeth was compared with the same specimen after reattachment (9, 27, 28).

In this study, the teeth were cut in a standardized manner, as the aim was to compare restorative and hydration techniques. Sengun et al. (11), Badami et al. (16) and Worthington et al. (17) used the cut to study fragment bonding, although, as affirmed (16), the loss of structure and the bonding surface resulting from the cut differ from those of fractured teeth. The micromechanical overlap between the fragment and the remnant tooth is fundamental to fragment adaptation (29). Although this observation should be affirmed in tooth fractures, there is also loss of structure, which is frequently not detected clinically.

Clinical reports were analysed for improving fragment retention. Restorative techniques were performed using pre- and postbonding preparations, such as the application of the vestibular and lingual prebonding bevel and groove or double postbonding chamfer along the fracture line (2, 18). The application of an internal groove and a bevel on the tooth remnant, both on the fractured crown and the fragment, allows the use of a greater volume of resin, which would increase the bond strength (9).

Teeth bonded without any additional retentive mechanism attained 50% of the fracture strength of intact teeth (8, 14–16, 25). Otherwise, the application of a chamfer and composite over the contour on the fracture line, and grooves in the fragment and tooth remnant before bonding, produced excellent fracture strength (9, 29). The material or the combination of materials used for the reattachment is less important, but the choice of a reinforcement technique that improves fracture strength is essential (30).

Strength is not the only consideration when using pre- and postbonding preparations. The fracture line is visible on the bonded fragment, which lowers the aesthetic quality of the restoration. Therefore, the goal of applying a postbonding chamfer would be to 'mask' this line (2). Clinical experience with dental fragment reattachment has shown that the postbonding chamfer plays a decisive role in final aesthetic appearance. In this study, in addition to making the chamfer, all of the dentin was removed from the fragment as part of the bonding preparation. Complete dentin removal from the fragment before bonding would be to increase the bond strength and prevent the eventual darkening of the devitalized dentin fragment.

Under all the experimental conditions, dentin removal from the fragment produced better fracture strength than simple bonding because of an increase in bonding area

Table 2. Fracture strength means and the standard deviations (kgf)

Reattachment technique	Group 1 Reattachment	Group 2 Dentin removal	Group 3 Reattachment	Group 4 Dentin removal	Group 5 Reattachment	Group 6 Dentin removal
Mean	12.9[a]	18.8[b]	7.3[c]	15.2[d]	13.4[a]	17.1[b]
Deviation	0.6	4.8	1.5	2.4	2.2	3.2
Hydration	Hydrated		Dehydrated		Rehydrated	

*Different letters mean statistical difference.

and direct adhesion to the fragment enamel. These results are consistent with those of Reis et al. (9), who obtained 90.54% of the fracture strength of intact teeth with an internal groove on both the fragment and the tooth remnant, forming an internal 'bar' of resin that opposed the force applied to the buccal surface.

The strength of the final restoration is dependent on correct hydration of the dentin fragment. Hydration was originally indicated maintenance of the original tooth colour and consequent aesthetic quality of the restoration (18, 19, 31). However, fragments are not always kept hydrated after an accident until the moment of restoration. It was believed that in a majority of patients, the fragment could be completely rehydrated within a week, although this may never occur in actual practice (12).

Bond strength is diminished by drying the dentin fragment surface. Rehydrating the dry dentin for 2 s with a moisturizing agent was not sufficient to moisturize the collapsed collagen fibres, as was indicated by the decreased fracture strength (8). Fragments kept in a dry environment for over an hour had a lower bond strength compared with fragments kept in a humid environment (24). Bond strength can be preserved by rehydrating dry fragments in water for 24 h prior to bonding (24).

In this study, it is notable that although bond strength diminished drastically in Group 3 (dehydrated 48 h), the same did not happen in Group 4 (dehydrated 48 h plus dentin removal). These data suggest that for the adhesive system used, the moisture necessary for proper functioning of the adhesion mechanism was more critical in the dentin than in the enamel. That is, removal of the dentin doubled the strength in the group of fragments dehydrated for 48 h (Group 4). Therefore, fragment dehydration would not be so critical when dentin is removed from the fragment before restoration.

In contrast to previous findings (8, 24), strength recovery was observed after only 30 min of rehydration before both reattachment techniques. These data were encouraging, as a 30-min rehydration would be clinically convenient. However, it should be remembered that the fragment is hydrated not only for the purpose of increasing fracture resistance, but it is also of fundamental importance for preservation of the original tooth colour.

There was no interaction between the bonding techniques and the hydration treatments. Even with the loss of strength caused by dehydration, the groups in which the dentin was removed always presented a better performance. It is possible that the proposed technique of dentin removal from the fragment acts as a mechanical retention agent. These results must be observed with care, as they indicate that the bonding capacity of the adhesive system alone is not sufficient in the specific case fragment reattachment.

The aim of this study was to evaluate the fracture strength of reattachment techniques and hydration treatments. Thus, methods to improve strength were analysed rather than the type of the bonding failure. Further studies should be conducted to evaluate the effect of fracture type – adhesive, cohesive or mixed – on fracture strength after the reattachment of dental fragments.

Conclusions

Tooth fragments reattached by bonding, after previously having dentin entirely removed from the fragment, exhibited better fracture strength than teeth with dentin not removed. Fragment dehydration for 48 h before bonding diminished fracture strength. However, fracture strength was recovered when tooth fragments were rehydrated for 30 min following the 48-h dehydration.

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