Influence Of Dentin Dryness On The Adhesive Strength Of Reattached Tooth Fragments. An In Vitro Study

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Background: Reattachment of the fractured fragment is an efficient, quick and cheap treatment option for noncomplicated crown fractures.
Objective: The aim of this study was to evaluate the variation of adhesive strenght of reattached tooth fragments in two instances: first when the dentin surface was dried out and second when, after being dried out, the surface was rewetted.
Methods: One-hundred sixty-nine extracted lower incisors were fractured and divided in two groups. In the first group, before being fractured again, the teeth were dried for different periods of time. In the second group, after being dried for 24 hours the teeth were stored in water for different periods of time and then fractured again. In all groups, the energy needed to fracture the teeth was measured and compared with the energy needed to fracture the intact teeth.
Results: After 3 hours of dehydration the resistance to fracture decreased significantly. Fragments that were rehydrated for 6 hours after 24 hours of dehydration showed an increase in fracture resistance.
Conclusions: Fractured tooth fragments that are to be reattached should be stored in water or, if already dried should be rehydrated.

Keywords: crown fracture, fragment reattachment, storage environments

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Introduction

The maxillo-facial territory is highly exposed to the action of external mechanical and physical factors therefore the frequency of dental trauma among children and adolescents is very high [1].

Most of the times, the teeth that are involved in such incidents are the upper incisors and the most frequent type of lesion is the coronal (dentino-enamel) fracture without pulpal involvement [2].

The treatment of dental fractures consists of sealing off dentinal tubules and restoring the tooth functionally and aesthetically. Steel or acrylic crowns belong to the past. Currently, the sealing of the dentinal tubules is achieved with bonding agents while the crown is reconstructed either of composite or by re-attaching the fractured tooth fragment. Of these two methods, the latter has three main advantages: it grants a more natural aspect than the composite restoration, wearing occurs at the same rate as the homologue, natural tooth and finally, working time is much shorter [3,4,5]. Nevertheless, for this method to be successful, it is important that the broken fragment is kept wet before the reattachment.

This study focused on re-attaching of tooth fragments, namely on the influence of dehydration of the fragments on the adhesive strength. Hence, the effect of different periods of dehydration and re-hydration of fragments was assessed.

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Material and methods

One-hundred sixty-nine mandibular incisors, extracted due to periodontal disease were used. Prior to the experiment the teeth were stored in saline. On the palatal surface, parallel to the incizal edge, a groove was prepared using a 0.5 mm torpedo diamond bur in order to establish the future line of fracture.

The teeth were embedded in acrylic self-curing resin (Duracryl, Spofa) in a 1.5 by 1.6 cm PVC tube in such a manner that only the crown of the tooth was left exposed.

All teeth were fractured using the Charpy/Izod impact test [6]. The PVC tube containing the teeth was secured in the Charpy pendulum (VEB Werkstoff Prüfmaschinen, Leipzig) vertically, in such a way that in its curve movement the Charpy hammer hit the incizal third of the teeth and fractured them along the notch that we created with the bur. The energy needed to fracture the teeth was measured on the scale of the instrument. The weight of the Charpy hammer used in this experiment was 10 kg.

After the fracturing, the teeth were divided in two groups. The first group of fractured teeth was used to demonstrate the effect of dehydration on the bond strength of reattached dental fragments and the second to verify whether or not, already dried tooth fragments can achieve a stronger adhesive bond if re-wetted before being reattached. The radicular, embedded fragments were kept in water throughout the experiment.

Dehydration group

The teeth were divided in 6 subgroups of 13 teeth each and the fractured fragments were kept dry for 30 minutes,

Table I. Ratio values and standard deviation for the two experimental groups

All groups	Mean	SD	Median	95% CI	
				Upper bound	Lower bound
0.5 hr dry	0.77	0.01	0.78	0.77	0.78
1 hr dry	0.72	0.04	0.70	0.70	0.74
3 hrs dry	0.58	0.03	0.58	0.56	0.60
9 hrs dry	0.57	0.03	0.56	0.55	0.59
12 hrs dry	0.55	0.03	0.56	0.53	0.56
24 hrs dry	0.52	0.07	0.54	0.48	0.56
1 hr wet (no drying)	0.79	0.02	0.78	0.78	0.80
24 hrs wet (no drying)	0.77	0.02	0.78	0.76	0.78
24 hrs dry + 1 hr rewetting	0.53	0.03	0.54	0.51	0.56
24 hrs dry + 2 hrs rewetting	0.61	0.04	0.60	0.59	0.63
24 hrs dry + 6 hrs rewetting	0.77	0.04	0.77	0.75	0.80
24 hrs dry + 12 hrs rewetting	0.74	0.02	0.74	0.73	0.75
24 hrs dry + 24 hrs rewetting	0.76	0.04	0.77	0.74	0.79

1, 3, 9, 12 and 24 hours respectively. In order to reattach the corresponding radicular fragments, both surfaces to be reattached were beveled along the enamel margins with a flame shaped diamond bur.

Both fragments (corono-radicular and incizal) were acid-etched using 37% phosphoric acid for 30–40 seconds on enamel and 10 seconds on dentine. After thoroughly rinsing the acid and lightly drying, the bonding agent was applied (Optibond Solo Plus, Kerr) for 15 seconds, using an applicator with a light brushing motion and then was air-thinned for a few seconds and light cured for 20 seconds. The two parts were not in contact while the bonding agent was cured, only afterwards they were assembled and soldered together with a not too heavy bodied composite (Grandio, Voco). While holding the parts together by hand, the composite was light cured for 30 seconds both from the oral and buccal.

Following the reattachment the teeth were installed again in the Charpy pendulum and the impact test was performed again.

Rehydration group

Two control subgroups were formed, one (n=13) in which immediately after being broken in the Charpy instrument the teeth were introduced in water and hold there for one hour prior to being reattached and fractured again and the another similar to the first, but in which the teeth were hold in water for 24 hours instead of one hour (n=13).

In the experimental subgroups, after being broken in the Charpy testing machine, all teeth were kept dry for 24 hours. Then re-wetting followed, for 1, 2, 6, 12 and 24 hours respectively (n=13 for each subgroup). Afterwards, the procedure was identical to that used in all the other subgroups that is, reattaching and then fracturing with the testing instrument. To express the variation of the force needed to fracture the reattached versus the teeth intact, the value of the ratio between the values of the energy measured in the two instances was used (for example if the energy needed to fracture the reattached teeth is 90 Joules but for the intact tooth it was 100, than the ratio is 0.9 or, more conveniently, expressed in percent, 90%).

Statistical analysis was performed using SPSS Statistics 15.0.

Results

The variation of ratio in the two main experimental groups with their subgroups is illustrated in Table I.

In the dehydration group, after a dehydration of only half an hour, the ratio decreased to 77%.

After a dehydration of 3 hours the ratio dropped to 57% and after 24 hours the ratio reaches 51%.

In the two groups which were immediately stored in water for 1 and 24 hours respectively before being reattached the differences between the values of ratio (0.79 vs. 0.77) were statistically but not clinically significant (Student test, p=0.20) (Table II).

In the rehydration group, the evolution of ratio is seen in Table I.

After 6 hours of rehydration the ratio became 76%, the same as after 24 hours of rehydration (Figure 1).

After 12 hours of rehydration the ratio was 73%.

Table II. Ratio values for the groups where the fractured fragment was kept in water until reattachment

Group statistics					
Ratio	All groups	N	Mean	Std. Deviation	Std. Error Mean
	1w	13	0.790	0.02	0.006
	24w	13	0.772	0.017	0.005

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Significance (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Upper	Lower
Ratio	Equal variances assumed	0.591	0.449	2.490	24	0.020	0.018	0.007	0.003	0.034
	Equal variances not assumed			2.490	23.279	0.020	0.018	0.007	0.003	0.034

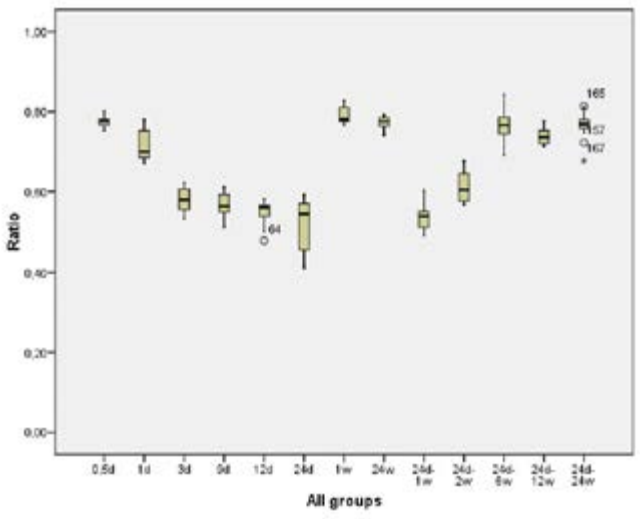

Fig. 1. Ratio values for all experimental groups

Discussion

Sudden physical impact with the head or face can lead to dental trauma. One of the most frequent and less severe form of dental trauma is the uncomplicated tooth fracture [7,8]. The easiest way to restore such teeth is to reattach the fractured fragment [9,10].

Certainly, the reattached fragment will be more vulnerable to a future trauma but the strength of the adhesive bond can, to a certain extent, be improved [11,12,13]. As well as choosing a high quality material and a proper technique, another element that changes the adhesive strength is the degree of desiccation of the dental tissues that are going to be bonded to each other [14,15]. To demonstrate this, two experiments were conducted. In the first experiment the fractured fragments were leaved exposed to the air for different periods of time before being bonded, thus proving the detrimental effect of drying on adhesion. In the second experiment the aim was to find out whether rewetting of already dried fractured fragments could lead to regaining the adhesive strength when reattaching these fragments.

By testing the fracture strength of the intact versus reattached fragment on the very same tooth, an objective comparison could be made and each tooth served as its own control.

Dental fractures usually affect young individuals; therefore this in vitro study was somewhat disadvantaged since the most obvious source of extracted front teeth is in periodontally involved patients, which usually are over 50 years of age.

As expected, in the dehydration group, a continuous decrease of ratio was noted. Already after thirty minutes ratio went under 80% (77.53%). The next measurement was made after an hour but the difference was not statistically significant (70.00%). The greatest and statistically significant decrease was noted after 3 hours of dehydration (57.89%). Ratio continued to drop through the groups of 9, 12 and 24 hours of dehydration but the change occurred uniformly and the differences were not statistically significant. At 24 hours, the last measurement revealed a decrease of ratio to almost half (54.44%) meaning that the energy needed to fracture such a reattached fragment is only half of the energy needed to fracture the intact tooth.

Our results compare well with data from the literature, which also notes a decrease in the resistance to fracture of teeth keep dry for more than one hour [16]. The longer the fragment remains dehydrated, the weaker the adhesion will be. This is due to the fact that in the process of drying out, the dentinal collagen fibers collapse thus blocking of the penetration of the bonding agent and resulting in poor adhesion [17].

One can try to compensate this phenomenon by either removing a layer of dentin or by rehydrating it. Capp & co. (2009) tried both methods and concluded that removing the surface layer of dentin compromised by 48 hours of dehydration can lead to a twice fold increase in resistance to fracture of the bonded fragment whereas a 30 minute rehydration of the fragments leads to total recovery of the resistance to fracture [18]. In contrast, other studies report that longer rehydration periods are needed. Thus, in a similar study, Farik et al (2002) fractured several groups of incisive teeth and dried the fractured fragments for different periods of time, ranging from 5 seconds to 24 hours and after reattaching them, fractured them again [19]. Comparing the force needed to fracture the intact versus the reattached fragments, they concluded that when the desiccation period exceeded one hour, the bonding strength dropped dramatically. However, when after a 24 hours period of drying the fragments were rewetted for another 24 hours, the resistance to fracture improved significantly.

In this study two groups served as positive controls and the fractured fragments were not dehydrated but stored in water immediately after the intact teeth were fractured. In the first control group the teeth were fractured again after one hour of storage in water and the ratio had the greatest value of the whole experiment (78.13%). In the second control group the teeth were fractured again after 24 hours of storage in water but the ratio showed a slight decrease (77.53%), probably due to the excessive moistening, thus becoming less favorable for the adhesion. Even so, the value of ratio is close to that obtained after 24 hours of dehydration and 6 hours of rewetting.

Conclusions

– Keeping a fractured tooth fragment dry can worsen its chances of adhesively being reattached to the tooth.
– A fractured tooth fragment that has dried out must be rewetted before trying to bond it to the remaining tooth structure.
– Rewetting of dried tooth fragments longer than one hour appeared to worsen the adhesive bond with the remaining tooth structure.

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