Research Journal of Biological Sciences 2 (6): 682-686, 2007
ISSN: 1815-8846

Microtensile Bond Strength of Fragment Reattachment Vs. Resin Composite Restoration in Crown Fractures

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Abstract: The materials placed between the tooth and its fragment affect treatment of fractured part of the crown. The aim of this controlled in vitro trial study was to compare the microtensile bond strength of three different restorative techniques including composite restoration, fragment reattachment with bonding agent (Excite DSC) and resin cement variolink II. Thirty extracted caries- free human permanent incisors were selected. Each tooth was sectioned buccolingually perpendicular to the long axis at 3 mm from the incisal edge and restored in normal saline. Then samples were divided into three groups randomly, as follow: Fragment reattachment with bonding agent Excite DSC (Ivoclar/ Vivadent), fragment reattachment with resin cement Variolink II (Ivoclar/Vivadent) and restoration with resin composite Tetric Ceram (Ivoclar/Vivadent). After 24 h, the teeth were vertically sectioned into approximately 1 mm^2 beams for microtensile evaluation, by using Microtensile Tester (Bisco USA). Data were anzlyzed using ANOVA (p=0.05) and tukey,s post hoc. Failure modes were examined by stereomicroscope. The mean value of microtensile bond strength in group 1 (fragment reattachment with bonding agent) was 20.55±2.36Mpa,group 2 (fragment attachment with resin cement) 34.64±2.99 Mpa and group 3 (composite restoration) 38.23±1.95 Mpa. The ANOVA analysis showed significant differences microtensile bond strength values in three groups (p<0.001). The dominant failure mode was mixed in all groups. Composite restored teeth show higher MTBS compared with the reattached ones. Using Variolink II for fragment reattachment has higher bond strength than Excite DSC.

Key words: Fragment reattachment, crown fracture, microtensile bond strength,bonding agent

INTRODUCTION

Coronal fractures of the permanent dentition dentition are the most frequent type of dental injuries (Douglas, 2003) that mainly affects children and adolescents (Reis *et al.*, 2004). A majority of the studies agree in the respect that the most common injuries are uncomplicated crown fractures (Reis *et al.*, 2004). The major challenge for the clinician is to re-establish the natural aesthetics of the traumatized tooth, thus its form and dimensions, shade, opacity and translucency, fluorescence and opalescence (Opsburgh *et al.*, 2002). Common restorative treatments such as laminate veneers or full-coverage restorations tend to sacrifice healthy tooth structure and challenge clinicians to match the adjacent unrest red teeth with composite restorations, there will be difficulties to match the color and they will present higher wear than the enamel structure (Demarco *et al.*, 2004).

Incisal edge fragment reattachment is a restorative option that offers the advantages of simplicity, immediate esthetics and conservation (Murchison and Worthington, 1998), psychological effects for the patient and/or parents, enact restoration of morphology and texture and use of a tissue that abrades the same as the antagonist tooth (Opsburgh *et al.*, 2002). However, once restorations are placed, they are likely to be prematurely replaced with additional loss of tooth structure and increased number of restore tine surfaces. Therefore, a durable interfacial adhesion between tooth and biomaterial is essential (Armstrong *et al.*, 1998).

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Chosack and Eildman published the first case report on reattachment of a fractured incisor fragment in 1964 (Reis *et al*., 2004). After endodontic treatment, they used a cast post and core and conventional cement to reattach an anterior crown segment (Douglas, 2003; Reis *et al*., 2004). Anterior tooth fragments have since been reattached using composite, interlocking minipins and light-cured resins (Andreasen *et al*., 1992).

In 1995 andreasen, Noren and Engelhardtsen observed, in a clinical study, the good fragment retention, acceptable esthetics and pulpal vitality in reattached teeth. This study indicate that reattachment of the coronal fragment is a realistic alternative to placement of conventional resin-composite restorations (Andreasen *et al*., 1995).

Pagliarini *et al*. (2000) showed that in the reattachment of fractured tooth fragments, fourth-generation adhesives can guarantee a bonding force stronger than fifth-generation adhesives. A study by Sengun and Ozer (2003) showed that when the composite resin material was used to restore the fractured incisors, their shear bond strength went down about half of the intact teeth. Nevertheless, no statistical deferens were seen between the fracture strength of in tact teeth and the reattached teeth with the dual-cure bonding agents and dual-cure luting resin cement.

In a study in 2004, Demarco and Fay observed the presence of a bevel increased the resistance to fracture of the reattach teeth. The adhesive materials provided different levels of fracture resistance with the worst fracture resistance obtained with the bonded specimens with adhesive system alone.

As the prevalence of crown fracture is high, especially among children and adolescents, much effort has been made to techniques which can restore the lost part of the crown. These techniques are mainly based on restoration with composite resin and few articles deal with fragment reattachment with adhesive materials. Because of the controversy exists in various studies regarding the bond strength of reattached fragments. The purpose of this study was to compare microtensile bond strength of composite restoration with fragment reattachment with bonding agent and with luting resin cement.

MATERIALS AND METHODS

Thirty excreted sound permanent incisors were selected. The teeth were cleaned and stored in physiological saline until testing. Standardized fragments were obtained by cutting the incisal edge with a diamond saw, mounted in Thin Sectioning machine (Homes Machine, Ine Rochester), perpendicular to the long anis of the tooth. The fragments measured 3 mm from the incisal edge. Once sectioned, both tooth and its fragment were stored in physiologic saline. The teeth were divided into three groups randomly. The teeth in the first two groups were restored with fragment reattachment and in the 3rd group with composite resin.

The fragments of teeth in the first group were reattached to their main part by using dual-cure bonding system, Excite DSC (Ivoclar / Vivadent). Both tooth and fragment were etched with 37% phosphoric acid for 15s. After washing and gently drying, maintaining the dentine moist, The one-bottle dental adhesive (Excite DSC), Was applied in two coats onto cut surfaces of main teeth and fragments for 10s and was thinned gently with air steam for 5s; the cut fragments were seated onto their respective teeth and light-cured for 20s from buccal and lingual directions.

In the second group, dual-cure adhesive resin cement Variolik II (Ivoclar/Vivadent) was used for the reattachment. Both fragment and remaining tooth structure were conditioned with 37% phosphoric acid for 20s. Following washing and gently drying, keeping the dentine moist, Excite DSC was applied followed by the placement of a thin layer of mixed base and catalyst pastes of the cement. The coronal fragment was adapted to the remaining dental structure and reattached using hand pressure. The excess material was removed before polymerization. The resin cement was polymerized for 20s in each surface.

In the third group, instead of fragment reattachment, resin composite restoration was used. After etching, the adhesive system (Excite DSC) was applied on the moist dental surface and was cured for 10s from the incisal direction. Photo-activated Tetric Ceram composite (Ivoclar/Vivadent) was built up, in two 2 mm increments, on to the bonding applied surface. Each increment was photo-activated for 40s, and each restored tooth was cured additionally for 20s in buccal and lingual directions. The restored specimens were stored in physiologic saline for 24 h.

For microtensile testing, the roots of teeth were cut down 2 mm below CEJ with a diamond saw.

Using Thin Sectioning machine, the specimens were cut occlusogingivally and perpendicular to the bonding surface, so that 1 ± 0.1 mm thick sticks could be made. Another transverse cut was made in the sticks in order to obtain sticks of approximately 8-9 mm high and a rectangular cross-sectional area of 1 mm^2.

The thickness of each stick was determined by measurement with a digital caliper (Mittoyo Corp, Japan). Microtensile testing was performed in a universal testing machine at a crosshead speed of 0.5 mm^2/min. The force in Newton at which the tooth was fracture was recorded and the fracture strength calculated in MPa using the area of the measured fracture surface of each specimen.

Table 1: Microtensile bond strength in MPa of three crown restorative techniques

Restorative technique	Sample size	Mean	SD	Max	Min
Fragment reattachment with bonding agent	30	20.55	2.36	22.36	17.55
Fragfment reattachment with resin cement	30	34.64	2.99	37.21	31.92
Composite restoration	30	38.23	1.95	41.54	34.58

Table 2: Failure mode in three restorative techniques

Failure mode	Adhesive	Cohesive	Mixed
Fragment reattachment with bonding agent	6 (23.1%)	2 (7.7%)	18 (69.2%)
Fragment reattachment with resin cement	5 (19.2%)	6 (23.1%)	15 (53.7%)
Composite restoration	4 (16%)	4 (16%)	17 (68%)

After the specimens were tested and removed from the testing apparatus, the fracture site was observed using a stereomicroscope at 40X magnification to identify the mode of failure.

Statistical analysis was carried out using one way ANOVA and Tukey's post hoc test.

RESULTS

The microtensite bond strength data and the data on modes of failure are shown in Table 1 and 2, respectively. The results can be summarized as follow: The mean value of microtensile bond strength in group 1 (fragment reattachment with bonding agent) was 20.55±2.36 MPa, while it was 34.64±2.99 and 38.23±1.95 MPa in group 2 (fragment reattachment with resin cement) and group 3 (Composite restoration), respectively.

The analysis of variance showed that the microtensile bond strength values obtained in three groups were significantly different ($p<0.001$).

The analysis of failure mode revealed that, in all groups, mixed failures were more common than adhesive and cohesive failures. Specimens sustained 64.2% mixed failures in group 1, 57.7% in group 2, 68% in group 3. X^2 testing showed that there was no significant difference in failure modes among the three groups ($p>0.05$).

DISCUSSION

Recent developments in restorative materials, Placement techniques, and adhesive protocols facilitate restoration of fractured incisors. If the tooth fragment is maintained, natural tooth structure can be reattached using adhesive techniques, which allows for esthetics and enhanced durability of the restoration (Douglas, 2003).

Strong bonding to enamel and dentin, is a desirable characteristic of a restorative material (Fruits and Dumzan, 1996; Peutzfelt and Ruolet, 2000). *In vitro* studies, usually measure the adhesion with shear and tensile bond strength tests (Peutzfelt and Ruolet, 2000).

To increase the scatter of results and increase the probability of achieving failures within the adhesive, most of the studies recommend testing a surface area of 0.25-1 mm^2 (Armstrong *et al*., 1998; Schreiner *et al*., 1998; Zafer *et al*., 2003). Sano explain that the small adhesive interface used in the micro-tensile test contains less defects compared with large specimens, such as those used in shear and tensile tests. Fewer defects would increase bond strength and reduce the variation (Sano *et al*., 1994). Moreover, the microtensile method may result in better estimates of the true bond strength of a material. Because clinical failures result primarily from tensile forces and microtensile testing utilizes tensile rather than shear forces, the microtensile methodology should more closely approximates clinical applications (Schreiner *et al*., 1998). On the other hand, the results of the study of Shreiner provide support for the superiority of the microtensile test method over the shear bond method in evaluating the comparative strengths of dentinal adhesive systems (Schreiner *et al*., 1998).

Considering the above reasons, in this study microtensile bond strength test was applied to compare the bond strength of three restorative techniques with each other, including: fragment reattachment with bonding agent, fragment reattachment with resin cement and composite resin restoration. As being recommended in most studies, the specimens prepared for microtensile test had surface area of 1±0.3 mm^2. Since one-bottle adhesive systems and resin cements are among the materials used in various studies of fragment reattachment and sometimes fractures involve large areas of dentine, use of chemical and dual-cure materials is desirable in order to overcome the attenuation of light intensity that occurs when light activation is performed through the teeth (Reis *et al*., 2004).

In this study, Excite DSC bonding agent and Variolink II resin cement, which both are dual- cure materials, were used.

For the measurement of bond strength in reached teeth, microtechniques have been less used so far and in different studies, shear bond strength has been measured or fracture strength of reattached teeth with various restorative materials has been compared with that of sound teeth (Sengun *et al*., 2003; Busato *et al*., 1998; Farik *et al*., 2002).

Therefore, this study is unique in respect of the technique used for the measurement of bond strength in these teeth. In this study, the highest bond strength observed in teeth restored with composite, followed by the teeth reattached with Variolink II cement and those reattached with Excite DSC. This is in agreement with the results of Fay and Demarco. Nevertheless, in their study, bovine incisors have been used and they measured fracture resistance (Zafer *et al.*, 2003). However, Reis *et al.* (2002) has shown that the sole use of an adhesive system or it's combination with higher mechanical property materials such as flowable resins, resin coments and resin composites have led to similar results when the fragment was reattached with no additional preparation. Dean and Minutillo showed no difference in fracture strength when fractured teeth had their fragments reattached with only an adhesive system or when the adhesive system was associated with a ligh-cured resin composites a light-cured liner and base of glassionomer cement (Reis *et al.*, 2004). These results are different from those of the present study, since different bond strength values were obtained where bonding system was used solely or it combined with resin cement or composite.

The controversy among laboratory studies may result from methodological differences, for example, the mechanical test chosen, teeth origin, the method used to obtain tooth fragments and the fracture pattern and extension (Reis *et al.*, 2004).

In this study as other similar studies, one of the reasons of higher mean of bond strength value in composite restoration compared to reattachment with luting cement is its more complete polymerization than dual-cure resin cement. Since a higher degree of conversion of monomers can lead to higher bond strength of composites to the dental structure (Demarco *et al.*, 2004). Therefore, despite the use of high-intensity light unit along with long exposure time, it seems reaching of light to each 2 mm composite increment might be better than curing through the tooth structure for the polymerization of the cement in the reattachment interface.

In this study, incisal fragment was cut with a diamond saw which is methodologically different from the studies promote tooth fracture. Not only, is the direction of enamel prisms different, but also the precise fit between the remnant and the fragment is lost. In this situation, it's difficult to use sole bonding agents for reattachment because a thicker layer of adhesive material is required to fill the gaps between the parts (Reis *et al.*, 2002). Therefore, the results of our study confirm Farik *et al.* (2002) hypothesis. It says fifth-generation bonding agents (total-etch, one-bottle), which are a combination of primer and adhesive, may contain insufficient amount of resin for reattachment. Similarly, Pagliarini has recommended that in reattachment of fractured tooth fragments multi-step adhesives can guarantee a bonding force stronger than one-bottle adhesives, due to higher resin content.

Supported by various studies, luting cements have performed well in small luting spaces. On the other hand, their higher cohesive strength and filler content, compared to bonding agents, allow higher bond strength (Rosnestiel *et al.*, 1998; Schmalz *et al.*, 1998).

Another difference between fragments obtained by tooth fracture and by sectioning, is the presence of smear layer created by cutting a tooth (Oliverira *et al.*, 2003). The smear layer reduce dentin permeability wich could affect bond strength of the adhesive negatively (Rosenstiel *et al.*, 1998). Some studies, which report similar resistance between sound and reattached teeth (Farik *et al.*, 2002; Rosenstiel *et al.*, 1998) obtain fragments by tooth fracture. As a result, the creation of bond interfering smear layer can be avoided.

In the present study, mixed failure mode was the most prevalent, but there is no difference in failure distribution among the groups. In general, the difference in failure modes is attributed to the material properties of all components of the bonded joint, i.e, dentine and adhesive system as well as the mechanics of the test assembly (Armstrong *et al.*, 1998).

As this study is the sole one that is conducted to determine the microtensile bond strength of fragment reattachment and composite restoration, it is recommended using other adhesive systems, as well as reattachment with the fragments obtained by various fracture patterns.

CONCLUSION

Microtensile bond strength of composite restored teeth is higher than the reattached ones. Reattachment with resin cement Variolink II produce a higher microtensile bond strength than with bonding agent Excite DSC.

ACKNOWLEDGEMENT

We are grateful to Dr.K.Alavi for performing the statistics and we express our thanks to the manufacturers who provided the materials.

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