

A Comparative Study using Different Techniques for reattaching Fractured Tooth Fragment in Maxillary Incisors: An *ex vivo* Study

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ABSTRACT

Introduction: Anterior tooth fracture due to trauma is the most common traumatic injury. It not only damages the dentition, but also affects the patient psychologically. If the original tooth fragment is retained following fracture, reattachment of the fractured fragment to the remaining tooth can provide better and long-lasting esthetics along with improved function.

Aim: This *ex vivo* study evaluated the fracture strength of maxillary central incisors after restoring it with three reattachment techniques (chamfer, overcontour, and bonded only) and direct composite buildups.

Materials and method: A total of 40 anterior teeth were sectioned and randomly assigned into four groups, each group consisting of 10 teeth. Teeth were restored using adhesive systems and nanocomposite. Restored teeth were subjected to load at a specific point on the buccal surface. Statistical analyses used were one-way analysis of variance and Tukey's tests to evaluate differences between techniques.

Results: The result revealed that the average force was significantly higher in overcontour and composite buildup as compared with chamfer and bonded only.

Conclusion: Over contoured preparation and the composite buildup were found better techniques for restoration of a fractured incisor as compared with the chamfer preparation and the bonded fragment.

Within the parameters of this *ex vivo* study, we can conclude that fragments reattached with additional preparation are a realistic alternative for restoring esthetics and function to traumatized teeth, under which overcontoured and composite buildup techniques have the highest strength recovery.

Keywords: Crown fracture, Esthetics, Reattachment, Tooth fragment, Trauma, Traumatized teeth.

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INTRODUCTION

Tooth fracture accounts for up to 92% of all traumatic injuries to the permanent dentition, particularly incisors.¹ It is due to their anterior position and protrusion.² They are oblique fractures more often affecting enamel and dentin.³ Males have a predominance.⁴ In the past, techniques used included stainless steel crowns, basket crowns, orthodontic bands, porcelain-bonded crown, and composite resin. Recent advancements have allowed clinicians to reattach a tooth fragment to the remaining tooth structure mechanically and chemically. It offers advantages like excellent esthetics, natural brightness and texture, maintains original tooth contours, is conservative and an economical technique, and less time consuming.⁵⁻¹³

MATERIALS AND METHOD

A total of 40 sound human maxillary central incisors extracted due to periodontal disease were selected. Only teeth free from cracks or other structural defects were chosen. The teeth were disinfected and stored in 0.9% saline solution. The selected teeth were randomly distributed into four groups, i.e., group I (Chamfer), group II (Overcontour), group III (Composite buildup), and group IV (Bonded Only). Each group had 10 teeth.

The labial surface of each tooth was divided into transversal and longitudinal thirds (Fig. 1A). The sectioning was carried out under continuous jet of water using a diamond disk (# P-129, Engler Engineering Corp., USA) at 200 rpm, from the proximal to the incisal edge (Fig. 1B).^{5,14} Both, the fragment and the remaining tooth were kept in 0.9% saline solution until restored. For groups I, II and III, acid etching of both fragment and remaining tooth was done using 37% phosphoric acid gel (Total etch, Ivoclar Vivadent,

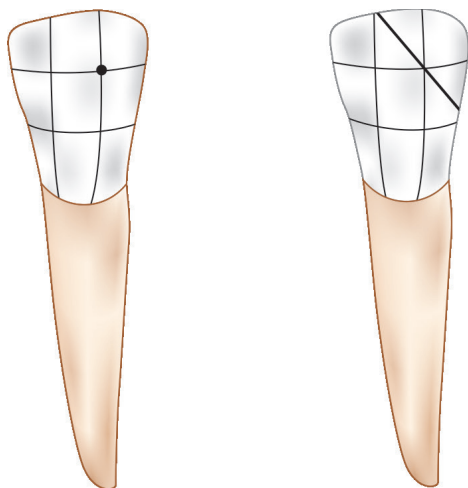
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Figs 1A and B: (A) Standardized area for load application to cause the fracture of the teeth. (B) Direction of the diamond disk used for sectioning the proximal edge of the teeth

Schaan/Liechtenstein, Germany) followed by rinse with water and drying. Adhesive system (Prime and Bond NT, Dentsply, USA) was applied on both the fractured surfaces and the remaining tooth. The fragment was reattached to the remaining tooth by a thin layer of nanocomposite (Z-350, Filtek Supreme, 3M ESPE, St. Paul, MN, USA).

After rebonding, in group I, a 1 mm depth chamfer was placed in the fracture line using a round diamond bur (#1016, KG Sorensen, São Paulo, Brazil). In group II, a preparation was placed in the buccal surface (at the junction of fragment and remaining tooth structure) using a cylindrical diamond-finishing bur (#2135F, KG Sorensen, São Paulo, Brazil) extending about 2.5 mm coronally and apically from the fracture line with a depth of 0.3 mm. In group IV, no additional preparation was made. The prepared areas in groups I and II were then restored with nanocomposite after applying the adhesive system.

In group III, no reattachment was done; 45° bevel extending 1 mm on the labial surface was prepared using a cylindrical diamond-finishing bur (#2135F, KG Sorensen, São Paulo, Brazil) at the fractured margin and composite build-up with nanocomposite using incremental technique was performed. Finally, all of the restored teeth were finished using Soflex polishing disks (3M ESPE, St. Paul, MN, USA).

The specimens were then loaded in the universal testing machine (Fig. 2). The load was applied to each tooth in buccal to lingual direction by means of a sharp-edged steel scalpel with a 45° chamfer inserted at the end of a pin held in the crosshead of the universal testing machine at a speed of 5 mm/minute (Fig. 3). The force required to detach each fragment was measured in Kgf and recorded for all samples of the four groups (Table 1). Statistical tools like one-way analysis of variance and Tukey’s test ($\alpha = 0.05$) were performed. A comparison of the fracture strength was evaluated by a Student’s t-test ($\alpha = 0.05$).

Table 1: Observed force required to detach each fragment (in Kgf)

Group I (chamfer)	Group II (overcontour)	Group III (composite buildup)	Group IV (bonded only)
98.5	221.57	191.30	170.23
151.50	274.30	214.33	138.18
207.95	274.89	325.85	124.56
157.58	269.30	265.87	73.20
227.94	211.28	154.76	137.06
135.26	294.58	294.59	143.86
135.24	161.40	219.23	146.26
169.24	198.74	252.55	109.07
182.37	177.77	178.06	172.48
233.82	157.09	295.78	129.91



Fig. 2: Specimens being loaded in the universal testing machine

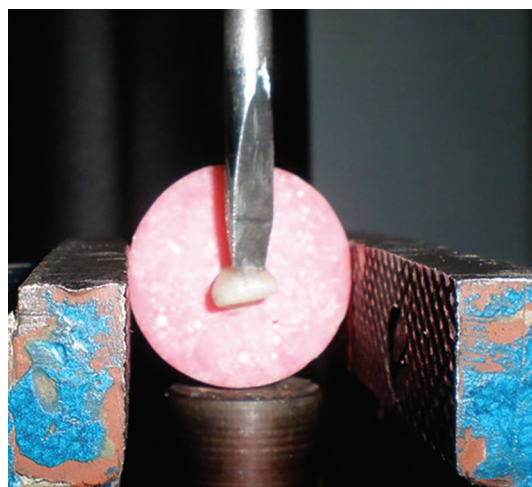


Fig. 3: The load being applied to each tooth in buccal to lingual direction in universal testing machine

Table 2: Mean force and standard deviation for each group

Sample identification	Group (sample size)	Force (Newton)		
		Mean	SD	Range
Chamfer	I (n = 10)	169.9	43.5	98.5–233.8
Overcontour	II (n = 10)	224.1	51.1	157.1–294.6
Composite	III (n = 10)	239.2	56.6	154.8–325.9
Bonded only	IV (n = 10)	134.5	28.8	73.2–172.5

SD: Standard deviation

Table 3: Statistical comparison of groups by p-values

Group comparison	p-value
I vs II	0.041
I vs III	0.013
I vs IV	0.331
II vs III	0.784
II vs IV	0.022
III vs IV	0.020

RESULTS

Based on the statistical analysis (Tables 2 and 3), the study revealed that the average force was significantly higher in groups II and III compared with group I ($p = 0.041$ and $p = 0.013$ respectively) and group IV ($p = 0.022$ and $p = 0.020$ respectively). The average force was not significantly different between groups II and III ($p = 0.784$). Similarly, no significant difference was seen between groups I and IV ($p = 0.331$). Hence, we can conclude that the overcontoured preparation (group II) and the composite buildup (group III) were significantly better techniques for restoration of a fractured incisor.

DISCUSSION

The incidence of dental trauma is on the rise due to an increase in dangerous activities and sports that involve children.¹⁵ These injuries have physical, psychological, and social impacts on the young minds.¹⁶

The first published case of reattachment was reported in 1964 by Chosack and Eildeman.¹⁷ Since then, several successful case reports using a variety of techniques and materials have been published. The best technique in the present study was found to be when teeth restored with direct buildups, followed by reattachment with overcontour. The least favorable was the chamfer group. These results are in agreement with the study conducted by Reis et al⁵.

Reis et al⁵ highlighted that chamfer increased the fracture strength of restored teeth from 37% (found in bonded only) to 60.6%. However, this difference was not considered statistically significant. Also, here the stresses are concentrated in the fracture line.

Overcontour technique utilizes external tooth preparation on facial surface and, thus, can take care of any misfit or unesthetic fracture line. Its good performance can be attributed to enlargement of the adhesion area provided by tooth preparation around the fracture site.¹² According to Andreasen et al, the greater the extension of material on the surface, the better is the force distribution over a large enamel area, contrary to what occurred in the chamfer group. However, exposure of the composite to the oral environment using both chamfer and overcontour techniques may diminish the long-term esthetics due to

process of abrasion and discoloration that occur over time with composite. Polishing at recall appointments may solve this problem. This drawback does not occur when bonding is performed without additional preparation (group IV).

For composite buildup group, the high toughness of resin composite is likely to be responsible for absorbing the load used to fracture the tooth before its failure, which may explain the good results obtained in this group. This is the most popular way to restore a fractured tooth when the fragment is not available. But the esthetic problems, wear resistance, achievement of correct contours, and establishment of interproximal contacts are more complex, requiring longer chair time.

The low fracture strength found in bonded only may be partly due to the smaller bonded area. Even in the study done by Loguercio et al,¹⁸ the bonded only group showed fracture strength recovery ranging between 36.9 and 44.3%. Munksgaard et al¹⁹ also concluded that reattachments without preparation and with the use of dental bonding agents exhibited about 50% of the fracture strength displayed by intact teeth. Reis et al¹⁴ also reached similar conclusions. So, one can conclude that this technique should be avoided because of its low fracture strength and consequently the greater vulnerability to future fractures.

For *in vitro* studies, specimens can be obtained by fracturing and sectioning. Regarding the method used to obtain the fragments, Loguercio et al¹⁸ have evidence that different results were obtained when teeth were fractured rather than cut with a thin diamond saw. When sectioning with a diamond saw, the reattachment techniques showed similar performance. In fact, most techniques presented a fracture strength recovery of approximately 60%.¹² However, different fracture strengths were observed among the techniques when fractured instead of sectioned.

As emphasized by Badami et al, the surface anatomy produced by sectioning is likely different from that produced as a result of fracture.²⁰ A fractured surface tends to run parallel to the main direction of enamel prisms, while orientation of the sectioned surface is dictated by alignment of the diamond saw used to section the incisal edge. Sectioning loses the fit between the fragment and

remaining teeth, and strength of the reattached tooth relies only on the bonding of material to the sectioned interfaces and the mechanical properties of the materials employed.²¹

CONCLUSION

According to the methodology used, within the parameters of this *ex vivo* study, we can conclude that fragments reattached with additional preparation are a realistic alternative for restoring esthetics and function to traumatized teeth. Of the preparations employed in the present study, groups II and III (overcontoured and composite buildup) techniques have the highest strength recovery. On the contrary, group I (chamfer group) has the least strength recovery.

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