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ANALYZING THE IMPACT OF REMINERALIZATION ON FRACTURE RESISTANCE OF REATTACHED FRACTURE FRAGMENT USING CONVENTIONAL AND FLOWABLE COMPOSITE – AN IN VITRO STUDY

Conservative Dentistry

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ABSTRACT

Aim To evaluate the effect of remineralization pretreatment and different composite resins on the fracture resistance of reattached anterior tooth fragments. **Materials and Methods** This in vitro study was conducted on 40 extracted human maxillary central incisors. Standardized crown fractures were created and samples were divided into four groups (n=10): Group 1 – remineralizing agent + flowable composite, Group 2 – remineralizing agent + packable composite, Group 3 – flowable composite, and Group 4 – packable composite. Reattachment was performed using an adhesive protocol followed by light curing. Fracture resistance was evaluated using a Universal Testing Machine and analyzed using one-way ANOVA and Tukey's post hoc test. **Results** Group 1 demonstrated the highest mean fracture resistance (260.4 N), followed by Group 2 (218.8 N), Group 3 (186.8 N), and Group 4 (156.6 N). Significant differences were observed among all groups ($p<0.01$). Remineralization pretreatment and use of flowable composite significantly improved fracture resistance. **Conclusion** Pretreatment with remineralizing agents enhanced fracture resistance of reattached fragments. Flowable composite resin showed better performance compared to packable composite resin

KEYWORDS

Fragment reattachment, remineralization, CPP-ACP, fracture resistance, flowable composite, packable composite.

INTRODUCTION

Traumatic dental injuries (TDIs) commonly affect anterior teeth, particularly in children and young adults, resulting in functional, esthetic, and psychological consequences. Crown fractures are among the most frequent dental injuries and often require immediate treatment to restore esthetics and function.[1]

Tooth fragment reattachment has emerged as a conservative and esthetic treatment modality when the fractured fragment is available. The procedure preserves natural tooth structure, translucency, contour, and surface texture while providing a cost-effective treatment option. However, restoration of fracture resistance comparable to intact teeth remains a challenge.[2]

Several factors influence the fracture resistance of reattached fragments, including adhesive systems, restorative materials, bonding techniques, and hydration status of the fractured fragment. Dehydration negatively affects bonding effectiveness, whereas proper hydration improves adhesive penetration and fracture resistance.[3]

Recently, remineralizing agents such as CPP-ACP have gained attention because of their ability to enhance mineral content and improve surface characteristics of enamel and dentin. These agents may improve wettability and bonding effectiveness, thereby increasing fracture resistance.[4] In addition, the type of composite resin used during reattachment also affects mechanical performance. Flowable composites possess low viscosity and superior adaptability, while packable composites provide greater filler content and strength.[5] Limited literature is available regarding the combined effect of remineralization pretreatment and different composite resins on fracture resistance of reattached tooth fragments. Therefore, the present in vitro study was conducted to evaluate fracture strength recovery of reattached anterior tooth fragments following remineralization pretreatment using flowable and conventional packable composite resins.

MATERIALS AND METHODS

Study Design

The present study was designed as an in vitro experimental study to evaluate fracture resistance of reattached tooth fragments with and without remineralization pretreatment using different composite resins.

Sample Selection

A total of 40 extracted human maxillary central incisors were selected.

Inclusion Criteria

- Sound maxillary central incisors extracted for periodontal reasons
- Teeth free from restorations and caries

Exclusion Criteria

- Extensively carious teeth
- Endodontically treated teeth
- Teeth with resorption or developmental anomalies

The samples were cleaned and stored in distilled water until use.

Sample Preparation

Standardized crown fractures were created using a diamond disc under water cooling. Fractured fragments were preserved in distilled water until reattachment.

Grouping of Samples

Samples were randomly divided into four groups (n=10):

- Group 1 – Remineralizing agent + adhesive + flowable composite
- Group 2 – Remineralizing agent + adhesive + packable composite
- Group 3 – Adhesive + flowable composite
- Group 4 – Adhesive + packable composite

Reattachment Procedure

Fragments in Groups 1 and 2 were treated with a remineralizing agent for a standardized duration. Both fractured surfaces were etched using 37% phosphoric acid for 15–20 seconds, rinsed, and gently air dried.

Bonding agent was applied to both surfaces and light cured for 10 seconds. Flowable composite resin was used in Groups 1 and 3, whereas packable composite resin was used in Groups 2 and 4.

Fragments were repositioned accurately and excess material was removed. Light curing was performed from labial, lingual, and incisal surfaces for 40 seconds. Finishing and polishing procedures were subsequently carried out.

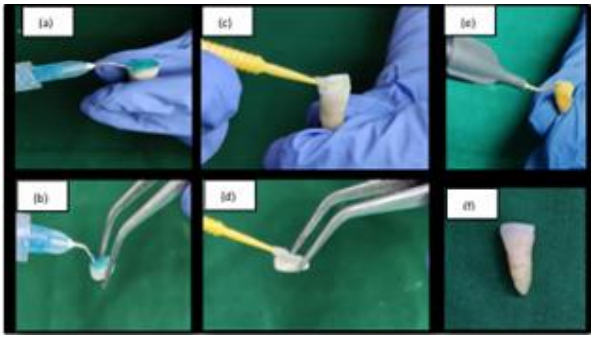


Fig (a) and(b) – Etching of tooth fractured fragment. FIG (c) and (d) –application of bonding agent to tooth and fractured fragment. Fig (e)-composite placement. Fig (f) reattached tooth after finishing and polishing

Fracture Resistance Testing

Fracture resistance was evaluated using a Universal Testing Machine. Load was applied at a constant crosshead speed until fracture occurred, and maximum fracture load was recorded in Newtons (N).

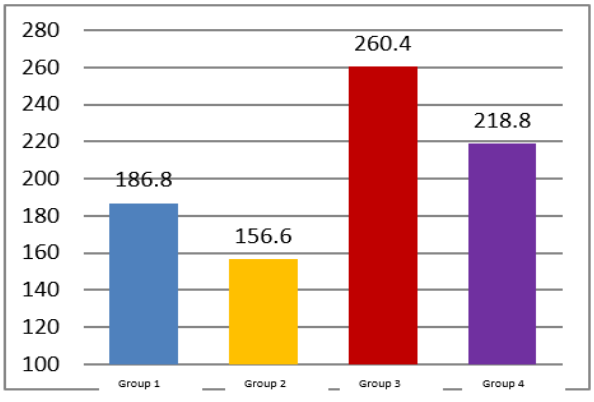
The data were analyzed using one-way ANOVA followed by Tukey's post hoc test. A p-value ≤0.01 was considered statistically significant.

RESULTS

Among all groups, Group 1 (Remineralization + Flowable Composite) demonstrated the highest mean fracture resistance (260.4 N), followed by Group 2 (218.8 N), Group 3 (186.8 N), and Group 4 (156.6 N).

Table 1. Mean Fracture Resistance Values

Group	Experimental Condition	Mean Fracture Resistance (N)
Group 1	Remineralization + Flowable Composite	260.4
Group 2	Remineralization + Packable Composite	218.8
Group 3	Flowable Composite	186.8
Group 4	Packable Composite	156.6



The graph demonstrates that Group 3 showed the highest fracture resistance, whereas Group 2 demonstrated the lowest fracture resistance among all groups

Table 2. Tukey's Post Hoc Test

Intergroup Comparison	p-value
Group 1 vs Group 2	p=0.008*
Group 1 vs Group 3	p<0.001**
Group 1 vs Group 4	p=0.005**
Group 2 vs Group 3	p<0.001**
Group 2 vs Group 4	p<0.001**
Group 3 vs Group 4	p<0.001**

p<0.01 = Statistically significant
** p≤0.001 = Highly statistically significant

The results indicated that remineralization pretreatment significantly improved fracture resistance. Flowable composite resin also demonstrated superior performance compared to packable composite resin.

DISCUSSION

The present study evaluated the effect of remineralization pretreatment and different composite resins on fracture resistance of reattached anterior tooth fragments. Fragment reattachment is considered a conservative and esthetic approach for management of crown fractures; however, achieving adequate fracture resistance remains challenging.

The results demonstrated that groups treated with remineralizing agents showed higher fracture resistance than non-treated groups. Group 1, in which remineralization pretreatment was combined with flowable composite resin, exhibited the highest fracture resistance, while Group 4 showed the lowest values. These findings suggest that remineralization pretreatment improves bonding effectiveness and reinforcement of fractured fragments.

Hydration of fractured fragments is essential for successful adhesion. Previous studies have shown that dehydration adversely affects bond strength, whereas rehydration improves fracture resistance by facilitating adhesive penetration.[6] In the present study, remineralization pretreatment may have contributed to enhanced uptake of calcium and phosphate ions, thereby improving enamel and dentin surface characteristics.

The improved fracture resistance observed in remineralized groups may also be attributed to the action of CPP-ACP, which increases surface roughness and wettability of enamel and dentin. Increased surface roughness provides greater surface area for adhesive bonding and promotes micromechanical retention.[7]

The duration of application of the remineralizing agent may also influence fracture resistance. Studies evaluating different remineralization time intervals have reported that application for longer durations such as 2 hours and 12 hours resulted in significantly greater fracture resistance compared to shorter durations such as 30 minutes.[8] Increased application time enhances mineral deposition and improves bonding at the fracture interface. In the present study, a standardized remineralization duration was used to maintain uniformity among samples.[9]

The type of composite resin also influenced fracture resistance. Flowable composite resin demonstrated superior performance compared to packable composite resin. This may be attributed to its low viscosity and better adaptability, which enable improved penetration into microscopic irregularities and reduce void formation at the fracture interface.[10]

Although packable composites possess higher filler content and mechanical strength, their higher viscosity may reduce adaptation at the fracture interface, thereby lowering fracture resistance. Similar findings have been reported in previous studies.[11]

The findings of the present study are consistent with previous investigations by Firouzmandi et al. and Sangal and Goswami, who reported improved fracture resistance following remineralization pretreatment and use of flowable composite resin.

Despite the valuable findings obtained, certain limitations should be considered. Since this was an in vitro study, it did not completely simulate oral conditions such as saliva contamination, thermal fluctuations, and cyclic loading. Long-term durability and fatigue resistance were also not evaluated. Further in vivo studies are recommended to determine the optimal remineralization duration and evaluate long-term clinical performance.

CONCLUSION

Within the limitations of the present in vitro study, the following

conclusions were drawn:

- Pretreatment with remineralizing agents increased fracture resistance of reattached tooth fragments.
- Flowable composite resin demonstrated higher fracture resistance compared to packable composite.
- The combination of remineralization pretreatment and flowable composite may improve the durability and clinical success of fragment reattachment procedures.

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