

FRACTURE RESISTANCE OF WEAKENED TEETH RESTORED WITH CONDENSABLE RESIN WITH AND WITHOUT CUSP COVERAGE

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ABSTRACT

Objectives: This *in vitro* study evaluated the fracture resistance of weakened human premolars (MOD cavity preparation and pulp chamber roof removal) restored with condensable resin composite with and without cusp coverage. Material and Methods: Thirty human maxillary premolars were divided into three groups: Group A (control), sound teeth; Group B, wide MOD cavities prepared and the pulp chamber roof removed and restored with resin composite without cusp coverage; Group C, same as Group B with 2.0 mm of buccal and palatal cusps reduced and restored with the same resin. The teeth were included in metal rings with self-curing acrylic resin, stored in water for 24 h and thereafter subjected to a compressive axial load in a universal testing machine at 0.5 mm/min. Results: The mean fracture resistance values \pm standard deviation (kgf) were: group A: 151.40 ± 55.32 , group B: 60.54 ± 12.61 , group C: 141.90 ± 30.82 . Statistically significant differences were found only between Group B and the other groups ($p < 0.05$). The condensable resin restoration of weakened human premolars with cusp coverage significantly increased the fracture resistance of the teeth as compared to teeth restored without cusp coverage. Conclusion: The results showed that cusp coverage with condensable resin might be a safe option for restoring weakened endodontically treated teeth.

Key words: Composite resins. Nonvital tooth. Compressive strength.

INTRODUCTION

Posterior teeth, particularly maxillary premolars, have an anatomic shape that makes them more likely to fracture the cusps under occlusal load¹⁴. Additionally, these teeth when treated endodontically can be easily fractured because of pulp chamber roof removal^{19,20}, mainly when the marginal ridge is thin or totally removed²⁸.

Sound teeth rarely fracture under normal masticatory function. Several studies have emphasized the importance of maintaining dental structure to preserve the strength of remaining tooth. Generally, the wider the involvement by caries or cavity preparation, the weaker the tooth^{19,20}. These teeth are usually restored by indirect restoration to protect the cusps. Other authors have suggested an alternative cusp coverage with amalgam to restore the weakened teeth, with satisfactory long-term results²⁰. This alternative therapy is

economically more accessible, easy to perform and has no cement line as conventional cast restorations, which are more costly and time consuming. However, esthetics is compromised harm.

It has been stated that remaining tooth structure restored with adhesive technology presents higher fracture resistance²⁹. However, the hypothesis that direct cusp coverage is still necessary even when adhesive procedures are used in large cavities must be confirmed. This study compared the fracture resistance of weakened human premolars restored with direct condensable resin composite with and without cusp coverage.

MATERIAL AND METHODS

Tooth Selection

Thirty sound human maxillary first and second premolars extracted for orthodontic reasons were used. The freshly extracted teeth were cleaned, stored in tymol solution at 0.1% and used within 1 month after extraction. After selection, teeth dimensions remained between 8.06 and 10.7 mm. Every tooth was examined under a 10x magnification and those presenting visible enamel cracks or fractures were rejected. The selected teeth were embedded in cold-cure plastic resin in metal rings¹, with the resin limit at 1.0 mm below the cemento-enamel junction.

Tooth Preparation and Restoration

The specimens were divided into three groups with 10 teeth each: group A (control) included sound teeth, group B included restored teeth without cusp reduction and group C had teeth restored with cusp coverage. Cavity preparation was initiated by occlusal approach with a spherical diamond bur towards the pulp chamber. Removal of the pulp chamber roof and reduction of the mesial and distal walls were done with a cylindrical diamond bur, creating a 4-mm-deep slit cavity design. The buccolingual isthmus was approximately half the intercuspal distance, as well as the mesial and distal boxes. The cavity dimensions were carefully assessed with a digital caliper for proper standardization. Teeth of group C received a further 2.0-mm-high reduction of both buccal and palatal cusps (Figure 1). In those teeth, before cavity preparation and cusp reduction, a silicone matrix was prepared by taking an impression of the original cusp height and inclined planes. The matrix was sectioned into mesial and distal parts and used as a guide to facilitate posterior restoration with resin to the original shape (Figure 2).

The floor of the exposed pulp chambers received a layer of glass ionomer cement (Vitrebond, 3M ESPE). In Group B, the cavity was etched with 37% phosphoric acid for 30 seconds enamel and 15 seconds dentin, rinsed, and dried

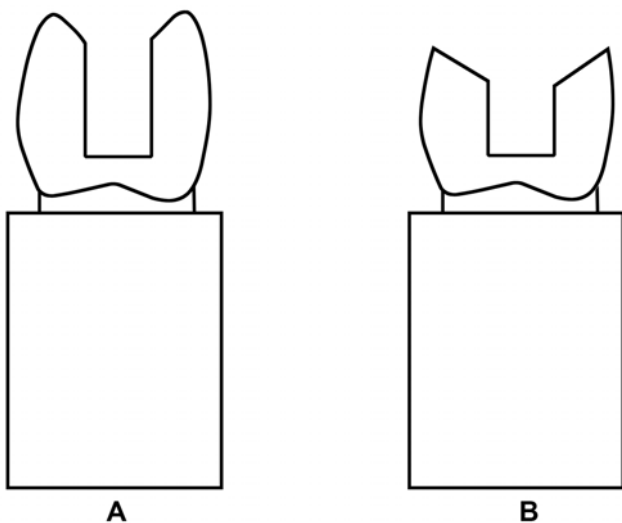


FIGURE 1- MOD cavities: A- 4.0-mm deep, slit cavity design (group B); B- 2.0-mm reduction in cusps height (group C)

(moist technique) with an absorbing paper. The adhesive (Prime& Bond NT, Dentsply) was applied and light-cured by 20s. Circumferential metal matrix was adapted to the cervical margins with low fusion impression material (Aquasil, Dentsply). Surefil resin composite (SureFil, Dentsply) was inserted in 2.0 mm thick, oblique increments and light-cured for 40 s each at 600 mW/cm² (Gnatus, Ribeirão Preto, São Paulo, Brazil).

In group C, tooth restoration was performed in the same way as in group B, with the aid of the matrix to reconstruct the cusp height and slopes (Figure 3). The restored specimens were stored in distilled water at 37°C. After 24 hours, all surfaces of the restorations were polished with rubber points and were stored again in distilled water at 37°C until testing.

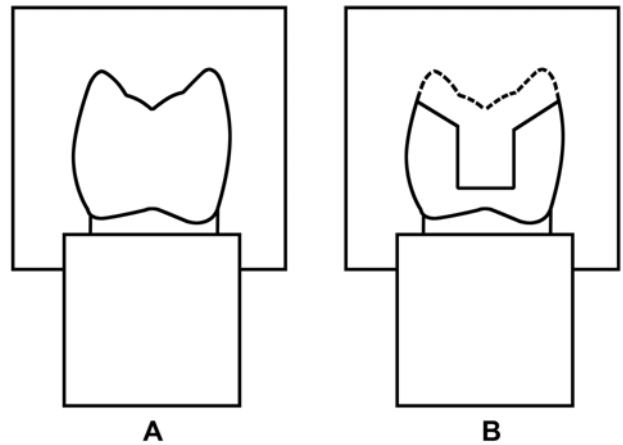


FIGURE 2- A) Half of the silicone matrix was placed on the tooth before cavity preparation; B) view after cavity preparation

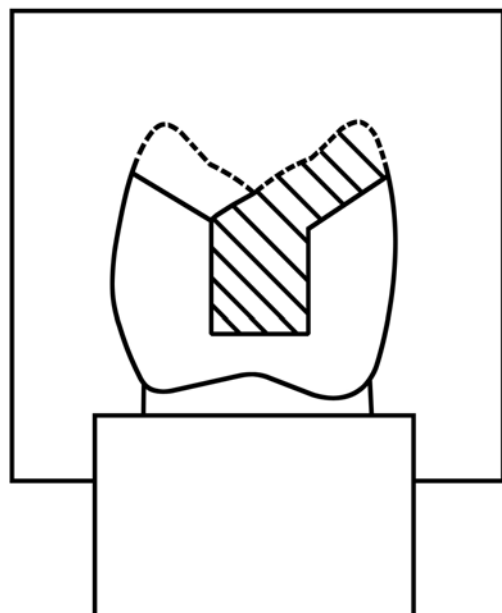


FIGURE 3- Restoration of group C with the aid of the matrix to reconstruct the cusps height and slopes

Testing Procedures

After 48 hours of storage, the specimens were mounted in an universal testing machine (EMIC DL500; São José dos Pinhais, PR, Brazil) and subjected to an axial compression load applied parallel to the long axis of the tooth and to the slopes of the cusps by means of a round-end steel device (8.0 mm in diameter) running at a crosshead speed of 0.5mm/minute (Figure 4). A flame-shaped bur was used to create small contact points on the buccal and lingual cusps for preventing lateral deflection of the sphere. The load required to cause fracture of the specimens was expressed in kgf as registered by the machine. The mode of fracture was recorded. The results were analyzed by one-way ANOVA and Tukey's test at 5% significance level.

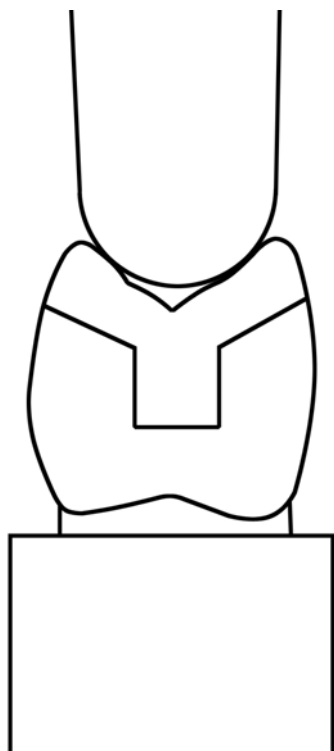


FIGURE 4- Specimen attached to the universal testing machine. Load was applied to pre-demarcated sites on cusp slopes

RESULTS

The mean fracture resistance values for each group are shown in Table 1. Teeth restored with condensable resin composite without cusp coverage presented a significant decrease in strength as compared to sound teeth. Restorations with cusp coverage recovered the strength of the teeth to values similar to the sound teeth ($p < 0.05$).

All teeth of Group C showed fractures that occurred only within condensable resin, without fracture of the remaining structure. Teeth of Group B presented cusp fracture mostly at cusps base level, starting in the adhesive interface towards the apical third.

DISCUSSION

The natural and drastic consequence of dental weakness is cusp fracture, and the study of this pathology is relevant because it is considered a common occurrence in clinics^{3-5,7,15}. Some authors have investigated the incidence of these dental fractures in oral cavity and found that is more concentrated in upper premolars^{5,7,15}.

Sedgley and Messer²⁶ studied the biomechanical properties of non-vital teeth in tests of tenacity, microhardness and shear and fracture resistance. They concluded that these properties do not change, suggesting that cumulative loss of dental structure by caries, trauma, restorative and endodontic procedures lead susceptibility to fracture. It has been suggested that cusp elongation due to cavity preparation may be the major factor in fracture susceptibility, mainly in endodontically treated upper premolars whose anatomy tends to separate the buccal and palatal cusps under occlusal load^{7,19}.

Some authors have emphasized that endodontically treated premolars with class II MOD cavity designs have a drastic decrease in fracture resistance. After receiving an indirect metallic restoration with cusp protection, these teeth recover the lost resistance with higher fracture resistance values than those of sound teeth^{11,22}. Similar results were found with cusp coverage with amalgam²⁰. Placement of amalgam restorations in weakened premolars with cusp coverage significantly increased the fracture resistance of the teeth (63%) as compared to teeth restored without cusp coverage²⁰.

TABLE 1- Mean fracture resistance (Kgf) and standard deviation of sound teeth and weakened teeth (MOD cavity preparation and pulp chamber roof removal) with and without cusp coverage with condensable resin composite (Surefil - Dentsply)

Groups	Fracture Resistance Mean ± SD (kgf)	ANOVA ($p = 0.05$)*
Group A: Sound Teeth	151.40 ± 55.32	a
Group B: Without cusp coverage	60.54 ± 12.61	b
Group C: With cusp coverage	141.90 ± 30.82	a

n = 10 *Different letters indicate statistically significant difference

Although metallic restorations with cusp coverage are a reference in the rehabilitation of weakened teeth and cracked tooth syndrome¹⁰. The esthetics is compromised. Some authors^{12,13,16,23,24,32} have confirmed that resin composite could be a viable alternative to amalgam, with better results in posterior endodontically treated teeth with MOD preparations². However, in larger cavities, cusp reduction and posterior restoration with direct or indirect procedures seems to be a more secure option^{8,25}.

Although cusp reduction promotes more dental tissue reduction²⁷, this procedure leads the restoration margins to buccal and palatal surfaces, protecting the adhesive interface from early marginal discrepancies³⁰. In a previous finite element analysis, it was stated that stress value in the restorative material and remaining tooth structure was mainly influenced by the restorative material itself (95.49%) and cavity design (>80%). When cuspal-coverage treatment is considered, the cuspal height should be reduced in at least 1,5mm to significant reduce the stress values¹⁷. The present study confirm these results showing that 2.0-mm cusp reduction and posterior restoration with direct resin composite can restore the fracture resistance of weakened teeth. These results seems to be also confirmed clinically⁶.

As seen in Table 1, the results of the present study do not agree with those of previous investigations^{2,9,13,18,21,23} that found fracture resistance of weakened teeth restored with resin composite without cusp coverage been similar of sound teeth. This probably occurred because the cavity size used in the present study was larger than those of other studies. The anchorage promoted by resin composite, protecting the buccal and lingual cusps of Group C specimens, recovered the fracture resistance in similar values of sound teeth. The adhesive procedure was clearly not the only responsible for this resistance, but also cusp protection that avoided the separation in consequence of the wedge effect caused by cusp elongation^{14,19,20}. No cusp fracture was seen in Group C. However, Group B presented some fractures indicating that only the adhesive interface may be insufficient to avoid these fractures.

Despite failures mentioned by different authors, resin composites improved and are now indicated for posterior teeth as an alternative to amalgam, especially condensable resins, which have higher wear resistance³¹. The results of the present study showed that cusp coverage with condensable resin might be an option for restoring weakened endodontically treated teeth because cusp coverage resulted in similar fracture resistance to that sound teeth.

CONCLUSIONS

Cusp coverage with condensable resin might be a safe option for restoring weakened endodontically treated teeth.

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