Fracture resistance of endodontically treated premolars restored with different restorations

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Purpose: To compare in vitro fracture resistance of endodontically treated premolars restored with bonded amalgam or resin composite.
Materials and Methods: Fifty intact and caries-free premolars that had been extracted for orthodontic treatment were selected. All teeth were subjected to endodontic procedures and MOD cavity preparation. They were then randomly divided into the five following groups of ten teeth each: without restoration (control group), intracoronal bonded resin composite restoration, intracoronal bonded amalgam restoration, cuspal coverage bonded resin composite restoration, and cuspal coverage bonded amalgam restoration. The teeth were embedded in poly(vinyl chloride) (PVC) blocks and subjected to compressive fracture tests. The fracture resistance was statistically analyzed using ANOVA and multiple comparison; Dunnett T3 test was performed at the 5% level.
Results: The cuspal coverage bonded amalgam group provided significantly highest fracture resistance (1138.94 N). The fracture resistance of intracoronal bonded amalgam restoration (279.68 N) was less than the group of intracoronal resin composite (383.37 N) and not significantly different from that of the cuspal coverage bonded resin composite restoration (346.19 N) and the control group (257.90 N).
Conclusion: Cuspal-coverage bonded amalgam restoration provided higher fracture resistance than cuspal-coverage bonded resin composite restoration while intracoronal bonded amalgam restoration provided lower fracture resistance than intracoronal bonded resin composite restoration.
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Key Words: endodontically treated premolar, fracture resistance, restoration.

Introduction

The success of endodontic treatment depends not only on the endodontic procedure but also on appropriate and timely coronal restoration of the tooth. One study has reported that failure to restore properly the endodontically treated tooth was a primary cause of endodontic failure.[1] Studies showed that an endodontically treated tooth was susceptible to fracture.[2,3] Reduction in tooth stiffness due to loss of tooth structures from caries and endodontic or restorative procedures may cause this fracture.[4-6]

Various restorative procedures have been used to reinforce endodontically treated teeth. Studies showed the advantages of coronal-coverage indirect restorations especially in posterior teeth.[7-9] The importance of cuspal coverage had been proposed to minimize marginal and cuspal fractures in endodontically treated teeth.[7] However, many different issues including patients' medical and financial status have limited the use of the ideal restoration. Dentists have sought alternatives that address these issues. Recent improvement of restorative techniques and materials had offered conservative way of restoring endodontically treated posterior teeth.[10-12]

The purpose of this study was to compare in vitro fracture resistance of endodontically treated teeth restored with amalgam or resin composite in conjunction with adhesive materials by using intracoronal or cuspal coverage technique.

Materials and Methods

Fifty intact and caries free premolars extracted for orthodontic reason were selected and kept in distilled water at room temperature. All teeth had undergone endodontic procedures with master apical file number 40 at 1 mm from anatomical apex and flared up to number 110 at cemento-enamel junction. The root canals were filled with gutta percha using lateral condensation technique, and gutta percha was removed to the level of 1 mm from cemento-enamel junction. Then the root canal orifices were sealed with zinc phosphate cement to the cemento-enamel junction level. All teeth were divided into five groups of ten teeth each and embedded in plaster stone. An impression was made for the occlusal part in each group with silicone impression material for plaster stone occlusal index making. The teeth that were embedded in plaster stone and the plaster stone occlusal index in each group were mounted in a plain-line articulator before the teeth were prepared for the MOD cavity. The thickness of buccal and lingual surfaces at cemento-enamel junction was left 3 and 2 mm, respectively. The teeth were subjected to the following materials and procedures.

Group 1: The control group. All teeth were left unrestored.

Group 2: The teeth were intracoronally restored with a resin composite (Z100, 5AG; 3M ESPE, St. Paul, MN, USA) and Scotchbond Multipurpose (Acid Gel, 5JC; Primer, 5HT, Bonding Agent, 5BJ; 3M ESPE) using incremental technique.

Group 3: The teeth were intracoronally restored with amalgam (Valiant Ph.D, 950915A; Dentsply, Milford, DE, USA), All Bond II (9500009869; Bisco, Schaumburg, IL, USA), and Resinomer (9500007930; Bisco).

Group 4: The buccal and lingual cusps were reduced 2 mm, with a 5-degree wall convergence toward occlusal plane, and restored with indirect resin composite restoration (Z100). The restorations were fixed with All Bond II and Resinomer.

Group 5: The buccal and lingual cusps of all teeth were horizontally reduced for 2 mm and were restored using cuspal coverage bonded amalgam (Valiant Ph.D) with All Bond II and Resinomer.

All restored teeth were removed from plain-line articulators before they were embedded in PVC blocks and subjected to compressive fracture tests using a universal testing machine (4502, Instron Corp., London, UK) with a crosshead speed of 0.5 mm/minute until fracture occurred. The load required to fracture and the fracture patterns were recorded. The fracture resistance was statistically analyzed using ANOVA and multiple comparisons. Dunnett T3 test was performed test at the 5 % level.

Results

The mean fracture load of each group is shown in Table 1. The results reveal that the group of cuspal coverage bonded amalgam restoration had the highest fracture resistance. The second highest group was the group of intracoronal bonded resin composite restoration, which was not statistically different from the group of cuspal coverage bonded resin composite restoration ($p>0.05$). The group without any restorations; the negative-control group, provided the least fracture resistance while the group of intracoronal bonded amalgam restoration and the group of cuspal coverage bonded resin composite restoration showed no difference from the negative-control group.

The fracture pattern is shown in Table 1 and Fig. 1. Patterns of fracture remained consistent within groups. All restorations without cuspal coverage experienced vertical fracture that split the teeth at the cemento-enamel junction, while those restorations with cuspal protection, the fractures occurred within the restorative materials.

Table 1. Fracture load, statistical category, and fracture mode.

Group	Mean (N)	S.D. (N)	Category	Fracture mode
1. Unrestored	257.90	55.30	a	Vertical tooth fracture
2. Intracoronal resin composite	383.37	48.54	b	Vertical tooth fracture
3. Intracoronally bonded amalgam	279.68	56.95	a	Vertical tooth fracture
4. Cuspal coverage resin composite	346.19	136.43	a b	Fracture in resin composite
5. Cuspal coverage bonded amalgam	1138.94	310.91	c	Fracture in amalgam

S.D.; Standard deviation. Category; Identical letters indicate that the values are not statistically different (p>0.05).

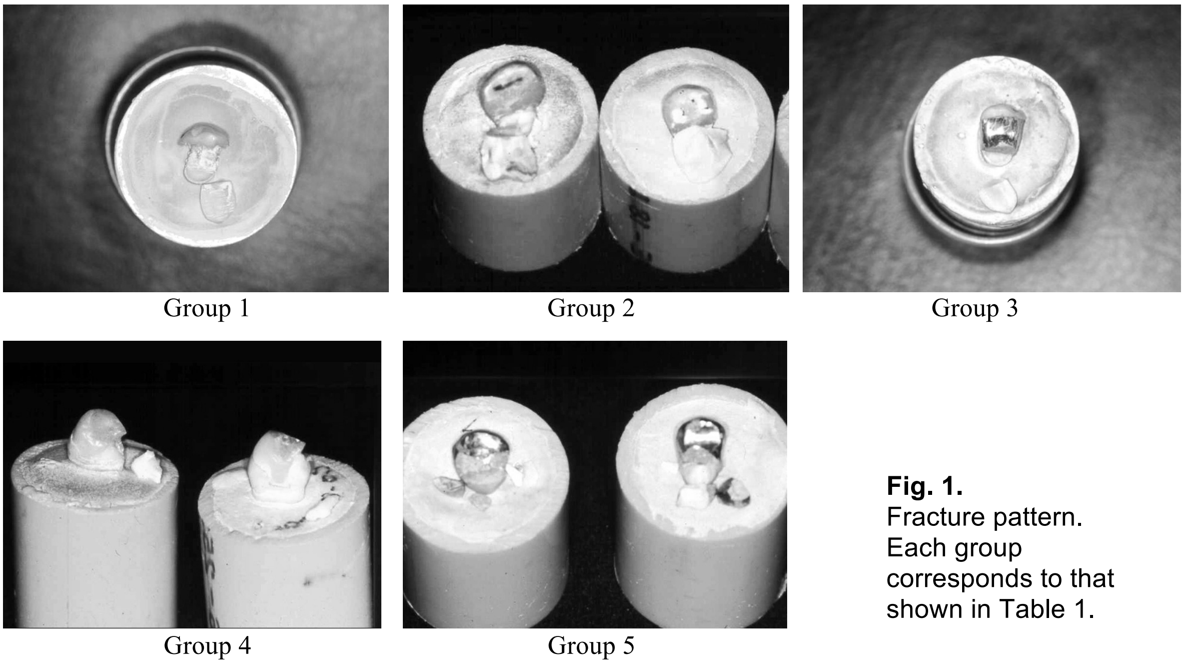

Fig. 1.
Fracture pattern. Each group corresponds to that shown in Table 1.

Discussion

The previous study had showed no significant difference in fracture resistance between unrestored MOD preparation and restored with bonded amalgam or resin composite.[3] The results of this study confirmed the finding that the benefit of adhesive materials was not significant for the group of intracoronal bonded amalgam restorations. Therefore, the force required for fracture in the group of resin composite was higher than in the group of amalgam. The reason may be the strength of the amalgam bonded to the tooth structure which was range from 1-10 MPa[13-17] has been lower than resin composite which was in excess of 17 MPa.[18-20] The results clearly indicated that the fracture resistance of endodontically treated posterior teeth could not be improved by using an intracoronal bonded amalgam restoration since the fracture resistance is not different from the unrestored teeth.

The restorations in this study used simple materials and techniques that are generally used in operative dentistry. We used direct technique in the groups of intracoronal amalgam or resin composite and cuspal coverage amalgam restoration but indirect technique in the group of cuspal coverage resin composite because it is easier to create the large resin composite restoration with this technique.

The results showed that cuspal coverage restoration provided the highest fracture resistance when amalgam was used but not with resin composite. The reason is due to the higher compressive strength of amalgam.[21,22]

The different fracture pattern that each group demonstrated was also interesting. For those with cuspal coverage restorations, the fractures occurred at the restorative materials while those restorations without cuspal protection experienced vertical fracture that split the teeth at the cemento-enamel junction. For the intracoronal restoration groups, the force loads were applied directly to the remaining dentine. Thus, the teeth split at the cemento-enamel junction, which is the thinnest part.

In this study, after root canal treatment, cuspal coverage restoration with high compressive strength material such as amalgam provided high fracture resistance that withstood the mean maximal normal bite force in the posterior teeth region, 500-900 N for men and 400-600 N for women.[23,24] Moreover, when the cuspal coverage restoration failed, the fracture was usually within the restorative material itself, which could be easily replaced or repaired. On the other hand, the restorations without cuspal coverage not only provided low fracture resistance but also their fracture pattern usually involved tooth structures, which would make the failure difficult to be repaired or eventually cause the tooth loss. Although many previous studies have demonstrated that casting cuspal coverage restoration is proper treatment for endodontically treated posterior teeth,[8,9] the results from this study indicate that direct cuspal coverage restoration with high strength materials such as amalgam are an alternative restoration to patients who have questionable prognosis or compromised treatment.

Since this study was conducted in vitro, there might be difference in the results in vivo. Several factors beyond our control made the situation different from real-life scenarios. The factors that might affect the results include the size and shape of sample teeth, tooth preparation and biting force from only one direction instead of the multiple directions of actual biting force.

Conclusion

1. Cuspal coverage restoration provided higher fracture resistance than intracoronal restoration when amalgam was the restorative material. When resin composite was the restorative material, cuspal coverage and intracoronal restoration had no statistically different fracture resistance.
2. Intracoronally bonded amalgam restoration provided lower fracture resistance than intracoronally bonded resin composite restoration.
3. The fractures of cuspal coverage restorations occurred at the restorative materials while those restorations without cuspal protection experienced tooth fracture.

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