

## Effect of Different Cusp Coverage Patterns on Fracture Resistance of Maxillary Premolar Teeth in MOD Composite Restorations

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### Abstract

**Background and Aim:** Tooth fracture is a common complication following MOD restorations. This study sought to assess the effect of different cusp coverage patterns on fracture resistance of maxillary premolar teeth in MOD composite restorations.

**Materials and Methods:** In this invitro experimental study, 40 human maxillary sound premolar teeth were chosen and stored in Chloramine solution. Using bleaching shield, an over impression was made from each tooth and then wide MOD cavities were prepared. The teeth were randomly divided into 4 groups of 10 each: Group A, without cusp coverage; Group B, with 1.5 mm palatal cusp coverage; Group C, with 1.5 mm buccal cusp coverage; and group D, with 1.5 mm both buccal and palatal cusp coverage. The cavities were restored using Z100 composite resin and the prepared over impressions (in order to restore the normal anatomy of teeth). The teeth were then stored in water at 37°C for 24h and their fracture resistance was assessed using Universal Testing Machine. The load at fracture was recorded in N. Data were analyzed using one-way ANOVA and Tukey's test with 95% CI.

**Results:** The mean fracture strength was 873.11±243.5 N in group A, 750.53±270.7 N in group B, 824.22±330.2 N in group C and 1499.25±305 N in group D. The results showed that the fracture resistance of MOD restorations with the coverage of both cusps was significantly more than that of other groups ( $p < 0.05$ ).

**Conclusion:** MOD restorations with cusp coverage in maxillary premolar teeth increased the fracture strength of teeth against compressive forces. However, covering only one cusp had no significant effect on fracture strength.

**Key Words:** Onlay, Fractures, Composite

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### Introduction

Prevalence of fracture in maxillary premolars is higher than molars and mandibular premolars due to the lack of marginal ridge and their specific morphology. Occlusal forces applied to premolar teeth tend to separate the buccal and lingual cusps [1]. Moreover, large MOD restorations make these teeth more susceptible to fracture [2]. In premolar teeth, absence of one marginal ridge weakens the cusps by 40%. This rate will be 60% if both marginal ridges are lost [3]. Type of occlusion and oral

habits can also affect the odds of tooth fracture and characteristics of loads [4]. In maxillary premolar teeth, during cavity preparation, the buccolingual width of palatal cusp is more decreased; therefore, this cusp is more susceptible to fracture [5]. In the past, most cavities used to be restored with amalgam; but at present, tooth-colored restorative materials are more popular because of higher esthetics, chemical bond to tooth structure and less thermal conduction [6]. Premolars are close to the anterior region and are located in the esthetic zone. They

are visible when smiling or speaking. Thus, patients prefer these teeth to be restored with composite resins [7].

Intact teeth rarely fracture as the result of masticatory forces; however, loss of tooth structure as the result of caries and cavity preparation can decrease the fracture resistance of teeth [8]. This is especially true for endodontically treated teeth with MOD cavities [9]. Some researchers recommend the use of indirect restorations to increase the fracture strength of these teeth [10, 11]. However, indirect restorations have some drawbacks compared to direct restorations. For example, treatment should be done in multiple sessions. Presence of laboratory phases increases the cost and duration of treatment. Moreover, these restorations cause significant wear of the opposing teeth. Also, polishing of these restorations is more difficult [12]. Some other clinicians recommend direct restorations along with cusp coverage for the reinforcement of the residual tooth structure [13]. It has been reported that cusp coverage increases fracture strength against compressive forces [14, 15].

This study aimed to compare the effect of different cusp coverage patterns in MOD composite restorations on fracture resistance of maxillary premolar teeth.

### Materials and Methods

This in-vitro experimental study was performed on 40 intact (caries-free) maxillary premolar teeth that had been extracted for orthodontic purposes.

The teeth were immersed in 0.5% chloramine T solution. Mesiodistal and buccolingual widths of teeth were measured by a caliper and teeth with 7 mm mesiodistal and 9 mm buccolingual width with 0.5 mm error rate were selected for the study. Teeth surfaces were debrided by scaling hand instruments and polished with rubber cup and pumice paste. The teeth were evaluated at X10 magnification and those with cracks were excluded from the study.

The roots were soaked in wax up to 1 mm below the CEJ in such way that a layer of wax with 0.3 mm thickness covered the roots just like the PDL. The teeth were then mounted into acrylic blocks with 25 mm diameter up to 1 mm below the CEJ. The teeth, covered in wax, were removed from the block and the wax layer was washed off. The ho-

lewas filled with Impregum Soft polyether impression material (3M ESPE, USA) and the teeth were remounted to simulate the action of PDL.

Before cavity preparation, an over-impression was made of all teeth using bleaching shield (Easy Vac gasket, Korea) and vacuum machine. Over-impressions were divided into two halves of mesial and distal and used as reference for reconstruction of margins. Using this method, the teeth were returned to their baseline condition in terms of size and morphology.

An MOD cavity with the below-mentioned characteristics was prepared using cylindrical bur (Diaswiss, Swiss) with 0.8 mm diameter and high-speed handpiece. A new bur was used after 5 cavity preparations.

Cavity characteristics were as follows:

Buccolingual width of cavity:  $\frac{1}{2}$  of the intercusp distance

Pulpal floor depth from the Cavo surface: 3 mm

Gingival floor width: 1 mm

Gingival floor depth: 1 mm above the CEJ

(Figure 1).

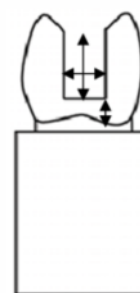
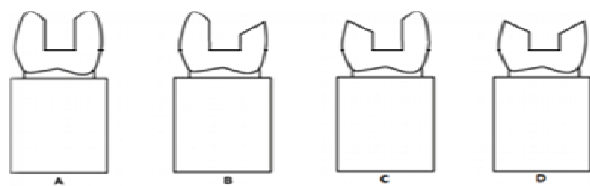


Figure 1. Cavity characteristics

Above-mentioned measurements were done by a periodontal probe. The teeth were randomly divided into 4 groups of 10. In the first group, cavities were remained unchanged (control group) (Figure 2A). In group 2, 1.5 mm palatal cusp reduction was done (Figure 2B). In group 3, 1.5 mm buccal cusp reduction was done (Figure 2C) and in group 4, 1.5 mm buccal and palatal cusp reduction were performed (Figure 2D). It should be noted that since no difference existed between the functional and non-functional cusps in our in-vitro study, both cusps were reduced in the same amount in order to match the load application process.

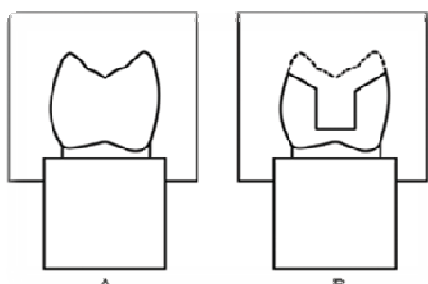
After preparation of teeth, matrix band was placed



**Figure 2.** Cavity preparation methods

around the teeth and specimens were etched with 37% phosphoric acid for 30s in the enamel and 15s in the dentin areas followed by rinsing with water for 15s and air-drying using air spray.

Single-bond (3M ESPE, USA) bonding agent was applied to the cavity floor and light cured for 20s using a light-curing unit (Art-Bonart Co, Taiwan). Z100 (3M ESPE, USA) composite resin was applied to the cavity in 2mm thick increments and cured for 40s. The final increment was cured along with the bleaching shield over-impression (Easy vac gasket, Korea) in order for the restoration contour to be exactly the same as that of intact tooth (Figure 3).



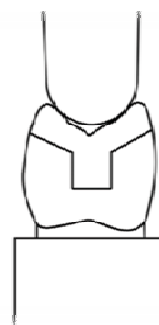
**Figure 3.** Occlusal surface reconstruction under in-vitro conditions using a bleaching shield

The teeth were stored in water for 24h and then polished using a flame bur (Diaitaly, Italy). The teeth were then stored at 37°C water in an incubator until fracture strength testing by Universal Testing Machine.

*Measurement of tooth fracture resistance:*

Tooth blocks were fixed in the Universal Testing Machine jig in such way that the angle between the upper rod and long axis of the tooth was zero. Thus, the load was applied vertically (similar to occlusal loads) to the cusp surfaces and not to the central groove of the tooth. The load was applied by a metal ball with 7mm diameter attached to the

end of the metal rod at a crosshead speed of 0.5 mm/min and primary load of 20N (Figure 4)[15]. The load was increased until fracture occurred and load at the time of fracture was recorded in N. Data were analyzed using ANOVA and Tukey's test with 95% CI.



**Figure 4.** Load application

### Results

After data analysis, the mean ( $\pm$ SD) fracture load was  $873.11 \pm 243.5$  in group 1 (no cusp coverage),  $750.53 \pm 270.7$  in group 2 (palatal cusp coverage),  $824.22 \pm 330.2$  in group 3 (buccal cusp coverage) and  $1499.25 \pm 305$  in group 4 (Table 1). One-way ANOVA revealed significant differences between groups ( $p < 0.05$ ).

Tukey's test was used to evaluate the difference between groups and showed that only the difference between group 4 and the remaining groups was statistically significant and the remaining differences were not statistically significant ( $p > 0.05$ ).

### Discussion

Tooth fracture after MOD restoration is a common problem in dentistry [18]. As mentioned earlier, the prevalence of fracture is higher in maxillary premolars due to steep cusps and tooth anatomy [19].

It is expected that the restored teeth tolerate occlusal loads but sometimes, due to various reasons, tooth resistance is decreased to the level that the tooth is no longer able to tolerate masticatory loads or even smaller forces [20]. Fracture resistance of teeth is influenced by several factors; of which, some are controllable and some are not. This issue is very important because these fractures impose complex and high-cost treatments to patients and

**Table 1.** Fracture strength values of the understudy groups

Groups	Pattern	Number	Fracture resistance		
			Mean	Minimum	Maximum
1	No cusp coverage	10	873/11±243/5	455/83	1216/69
2	Palatal cusp coverage	10	750/53±270/7	562/32	1466/26
3	Buccal cusp coverage	10	824/22±330/2	410/5	1431/49
4	Buccal and palatal cusp coverage	-	1499/25±305	959/71	1975/22

sometimes lead to tooth loss [1]. These factors include high compressive forces, unfavorable occlusal contacts in centric, lateral and or protrusive movements, restorative problems, malocclusions, dehydration due to RCT, steep cusps, deep grooves, caries, deficient root form, dental morphology problems, change in tooth structure due to aging and etc [21].

Some suggest that onlays that cover the cusps and reduce cuspal flexure are the optimal restorations for teeth with MOD cavities. Studies using photoelastic analysis have shown that occlusal coverage by onlays decreases the stress in the residual tooth structure. Hood [13] demonstrated the reinforcing effect of overlays compared to inlays and prepared cavities using strain gauge method. The relative stiffness values of teeth restored with overlays were significantly higher than those of intact teeth indicating rigidity higher than that of sound teeth. But, stiffness of teeth restored with inlays and those with cavities and no restoration was less than that of sound tooth [22].

Some other researchers stated that cusp coverage may decrease the fracture resistance of teeth. In the mentioned studies, similar cavities were prepared in teeth and specimens were evaluated in terms of cusp coverage [18, 23]. Our study results did not confirm this finding and showed that cusp coverage increases the fracture resistance of teeth. This difference can be explained by the fact that in the mentioned studies a large volume (2/3) of the occlusogingival cusp was removed for coverage and due to significant tooth reduction (and not because of cusp coverage) fracture resistance decreased.

A group of researchers in their studies reported that fracture resistance was not significantly different between teeth with functional cusp coverage and teeth with coverage of both cusps [11, 23, 24]. Our study did not confirm this finding and showed that teeth with coverage of both cusps had significantly higher fracture resistance than those with functional cusp coverage only. This difference may be at-

tributed to the non-functional cusp bevel and extension of restoration to cover this cusp in the mentioned studies; whereas, in our study non-functional cusp bevel was not done.

The overall results of our study showed that composite resins may be used for restoration of large MOD cavities in premolar teeth. Cusp coverage in premolars reinforces the remaining tooth structure and significantly increases the fracture strength of these teeth.

### Conclusion

Coverage of both buccal and lingual cusps in large MOD composite restorations of maxillary premolars significantly increases the fracture resistance of teeth compared to the coverage of one cusp or no cusp coverage.

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### References

- 1- Sanei M, Torabzadeh H. Influence of composite thickness on fracture resistance of direct restorations in root canal treated teeth. [Thesis]. Tehran: Dental school. Shahid Beheshti University of Medical Sciences; 2006-7.
- 2- Summit B, Robbins J, Hilton J, Schwarz S. A contemporary approach. IN: Summit B, Robbins J, Schwarz S. Fundermental of operative dentistry. 3<sup>th</sup> ed. [S.L]: Quintessence Publishing Co; 2006, 514-537.
- 3- Safaei A, Aminian R. The influence of cavity design preparation on fracture resistance of posterior direct resin composite restorations. [Thesis]. Tehran: Dental School. Shahid Beheshti University of Medical Sciences; 2009,10.
- 4- Khera Satia C, Carpenter Chistopher W, Vetter James D, Staley Robert N. Anatomy of Casps of

- Posterior Teeth and their Fracture Potential. *J Prosthet Dent.* 1990 Aug; 64(2):139-147.
- 5- Phuntikaphadr V. Effect of direct adhesive restoration on cuspal stiffness of endodontically treated premolars. [Thesis]. [S.L]: Mahidal University; 2004, 13-26.
- 6- Hilton TJ, Broom JC. Direct posterior static restoration. In: Summitt. *Fundamentals of Operative Dentistry.* 3<sup>rd</sup> ed. USA: Quintessence; 2006, 236-7.
- 7- Burke FJT. Tooth fracture in vivo and in vitro. *J Dent.* 1992 June; 20(3):131-139.
- 8- Assif D, Nissan J, Gafni Y, Gordon M. Assessment of the resistance to fracture of endodontically treated molars restored with amalgam. *J Prosthet Dent.* 2003 May; 55(2):184-5.
- 9- Ortega VL, Pegoraro LF, Conti PCR, Dovalle AL, Bonfante G. Evaluation of fracture resistance of endodontically treated maxillary premolars restored with seromer with heat-pressed ceramic inlays and fixed with dual resin cements. *J Oral Rehabil.* 2004 Apr; 31(4):393-7.
- 10- Soares Carlos Joes, Marcondes martins luis roberto, fonseca rodrige borges, Correr-sobrinho lourenco, fernandes-neto alferedo julio. The influence of cavity preparation design on fracture resistance of posterior leucite-reinforced ceramic restoration. *J Prosthet Dent.* 2006 June; 95(6): 421-429.
- 11- Bitter K, Meyer-LH, Fotiadis N, Blunch U, Neumann K, Kielbassa AM, et al. Influence of endodontic treatment, post insertion, and ceramic restoration on the fracture resistance of maxillary premolars. *Inter Endod J.* 2010 June; 43(6):469-477.
- 12- Alavi AA, Zahedi S. Evaluation of fracture resistance of teeth restored with three types of tooth colored onlay. *J Mashhad Dent School.* 2006; 30(3-4):289-300.
- 13- Burke F, Wilson N, Watts D. the effect of cuspal coverage on the fracture resistance of teeth restored with indirect composite resin restorations. *Quintessence Int.* 1993 Dec; 24(12):875-880.
- 14- Mohammadi N, Abed Kahnamoii M, Karimi Yegane P, Jafari Navamipour E. Effect of Fiber Post and Cusp Coverage on Fracture Resistance of Endodontically Treated Maxillary Premolars Directly Restored with Composite Resin. *J Endod.* 2009 Oct; 35(10):1428-1432.
- 15- Mondelli R, Francisro L, Ishikiriyama S, Kiyoshi F, Otavio De O, Mondelli J. Fracture resistance of weekend teeth restored with condensable resin with and without cusp coverage. *J Applied Oral Sci.* 2009 June; 17(3):163-165.
- 16- Shor A, Nicholls JJ, Phillips KM, Libman WJ. Fatiguemload of teeth restored with bonded direct composite and indirect ceramic inleynin MOD cl II cavity preparation. *Int J Prosthodont.* 2006 Jan-Feb; 16(1):64-9.
- 17- Eakle WS, Maxweel EH, Braly BU. Fracture of posterior teeth in adults. *J Am Dent Asso.* 1986; 112(1):215-18.
- 18- Lina Chun-Li, Changb Yen-Hsiang, Liuc Perng-Ru. Multi-factorial analysis of a cusp-replasing adhesive premolar restoration: A finite element study. *J Dent.* 2008 Mar; 36(3):194-203.
- 19- Santiago LC, Pegoraro LF, Bonfante G. Influence of different metal restoration with resin on fracture resistance of endodontically treated maxillary premolars. *J Prosthet Dent.* 1997 Apr; 77(4): 365-69.
- 20-Hanning C, Westphal Ch, Becker K. Fracture resistance of endodontically treated maxillary premolars restored with CAD/CAM ceramic inlays. *J Prosthet Dent.* 2005 Oct; 94(4):342-49.
- 21-Kuijsa RH, Fennisb WMM, Kreulenb CM, Roestersa FJM, Verdonschotc N, Creugersb NHJ. A comparison of fatigue resistance of three materials for cusp-replacing adhesive restoration. *J Dent.* 2006 Jan; 34(1):19-25.
- 22-Hood J. Biomechanism of the intact, prepared and restored tooth. *Int Dent J.* 1991 Feb; 41(1):20-32.
- 23-Soares Carlos Joes, Soares Paulo Vinicius, Santos-filbo Paulo Cesar De Freitas, Castero Carolina Guimaraes, Magalbaes Denildo, Versluis Antbeunis. The Influence of Cavity Design and Glass Fiber Post on Biomechanical Behavior of Endodontically Treated Premolars. *J Endod.* 2008 Aug; 34(8):1015-1019.
- 24- Ghavamnasiri M, Hosseini A, Aghili yeganeh F. Assessment of fracture resistance of endodontically treated molars, Beheshti Uni Dent J. 2006; 24(3):369-77.