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, 40human maxillary sound premolar teeth were chosen and stored in Chloramine solution. Usingbleaching shield, an over impression was made from each tooth and then wide MOD cavities were prepared. The teeth were randomly divided into 4groups of 10each: 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 anatomyof 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 resistanceof MOD restorations with the coverage of both cusps was significantly more than that of other groups (P<0.05).

Conclusion: MOD restorationswith 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 fracturestrength.

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 significantwearof 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 9mm 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 1mm below the CEJ. The teeth, covered in wax, were removed from the block and the wax layer was washed off. The

holewas 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: ½ of the intercuspal distance

Pulpal floor depth from the Cavosurface: 3mm

Gingival floor width: 1 mm

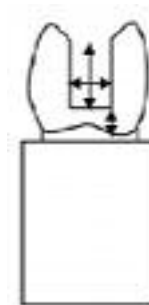Gingival floor depth: 1mm above the CEJ

(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.
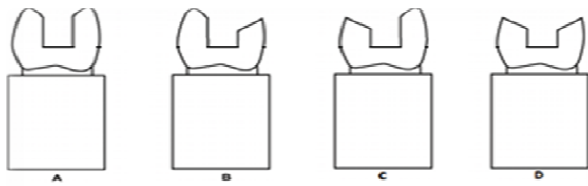
Figure 2: Cavity preparation methods

After preparation of teeth, matrix band was placed 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).
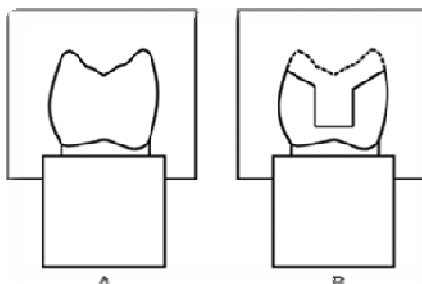

Figure 3: Occlusal surface reconstruction under in-vitro conditions using a bleaching shied

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 (±SD) fracture load was873.11±243.5 in group 1 (no cusp coverage), 750.53±270.7 in group 2 (palatal cusp coverage), 824.22±330.2 in group 3 (buccal cusp coverage) and 1499.25±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 therestored 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 pa   tients 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 attributed 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 resinsmay 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.

Acknowledgement

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