

# The influence of recent adhesive onlay fabrication techniques on the fracture resistance of endodontically treated premolars (An in vitro study)

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## ABSTRACT

**Background:** Endodontically treated teeth have low resistance to fracture against occlusal forces. The strengthening effect of bonded esthetic onlay restoration on weakened tooth has been reported. This study aimed to assess the fracture resistance of endodontically treated premolars restored with composite with and without cuspal coverage by using direct and indirect techniques. Indirect technique done by CAD/CAM system (computer aided design – computer aided manufacturer) and laboratory processing.

**Material and methods:** Forty human extracted maxillary premolars of approximately comparable sizes were divided into four groups: Group (A): Ten endodontically treated teeth directly filled with Filtek Z250xt without cuspal coverage. Group (B): Ten endodontically treated teeth prepared with onlay cavities and restored directly with Filtek Z250 XT. Group(C): Ten endodontically treated teeth prepared with onlay cavities and restored indirectly with Filtek Z250 XT. Group (D): Ten endodontically treated teeth prepared with onlay cavities and restored indirectly with Paradigm MZ100 CAD/CAM blocks. Fracture strength of the samples was measured by using universal testing machine (an axial compression test). Data were analyzed statistically by one way ANOVA test and least significant difference test.

Results showed that Group A has the lowest fracture resistance value than all experimental Groups and the difference are highly significant. While Group B has a high significant fracture resistant value than the indirectly restored groups. Group C and Group D showed an approximate fracture resistant result (1.13KN and 1.07KN respectively) and the difference is statistically not significant.

**Conclusion** All CAD/CAM composite onlay, indirect Filtek z250 XT and direct cuspal coverage survived maximum biting force for posterior single tooth, so these types of onlays provide good reinforcement in an extensive MOD cavities in premolars The mode of fracture for Group D was 90% restorable which is higher than group C (80%) restorable and group B (30%) restorable type of fracture.

**Key words:** Fracture resistance, Filtek z250 XT, CAD/CAM composite, cuspal coverage. (J Bagh Coll Dentistry 2014; 26(2): 12-17).

## INTRODUCTION

Endodontically treated teeth may have a considerably reduced capacity to resist functional forces, and this may be attributed to the loss of tooth structure beside Loss of inherent dentinal fluid which may affect in tooth properties making it weaker <sup>1</sup> The classical treatment is to build up the tooth with a post and core but, these teeth are generally weaker and would increase the risk of fracture due to more dentine removed <sup>(1,2)</sup>.

Cuspal coverage in endodontically treated tooth have a good prognosis with preference toward the partial coverage (onlay) rather than full coverage (crown), the direct adhesive composite resin used to restore teeth is the potential for a more conservative cavity preparation with less reliance on mechanical retention <sup>(3)</sup> but with shortcoming of polymerization shrinkage that leads to marginal defect and gaps problems like microleakage and Wear, the indirect composite resin restoration reduce the shortcoming of direct restoration that it control occlusal and proximal contact points, minimal polymerization shrinkage due to cement agents, good polishing and finishing possibilities <sup>(4)</sup>.

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The introduction of digital dentistry and, with that, of computer aided design/computer assisted manufacturing, enable additional application.

## MATERIALS AND METHODS

### Teeth selection criteria

Forty sound human maxillary first premolars with two separated roots extracted for orthodontic reasons were used. teeth were cleaned, stored in thymol solution at 0.1% teeth dimensions were between (9.0-10.0mm)for buccolingual and (7.0-7.9mm) for mesiodistal and (8.5-9.5mm) for occlusoapical. Every tooth was examined under a 10x for cracks or fractures and embedded into acrylic 2.0 mm below the cemento enamel junction.

### Samples grouping

The experimental teeth were divided into 4 groups, ten teeth each as follow

**Group (A):** Ten endodontically treated teeth filled with Filtek Z250 XT without cuspal coverage.

**Group (B):** Ten endodontically treated teeth prepared with onlay cavity and restored directly with Filtek Z250 XT.

**Group (C):** Ten endodontically treated teeth prepared with onlay cavity and restored indirectly with Filtek Z250 XT.

**Group (D):** Ten endodontically treated teeth prepared with onlay cavity and restored with Paradigm MZ 100 blocks

Impression for the teeth before preparation for group B and C was to fabricate the model that were subjected to crown coping with a copyplast and Biostar machine to get silicon matrix (template) which is identical to the cusps of each individual tooth

All the teeth in all groups were endodontically treated with Protaper system up to size F2, after obturation completed, glass ionomer cement was used as barrier to the ingress of fluid<sup>(5-7)</sup>.

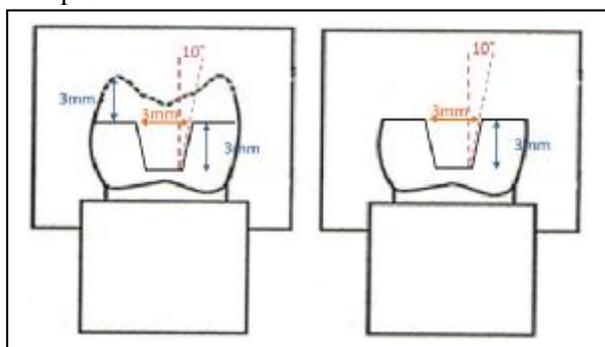
#### Cusp reduction (cutting)

Each tooth in groups B, C and D was subjected to cusp cutting (reduction) to 3.0 from the buccal cusp<sup>(8)</sup> with slow speed diamond machine under cooling water

#### Cavity preparation

For Group A the glass liner was removed from the access opening to about (6mm) measured from the cusp tip to the depth of the cavity creating flat floor<sup>(9)</sup>.

Each tooth in group B, C and D was subjected to a preparation of onlay cavity, with a water cooled high speed hand piece, with round ended tapered diamond bur (NO.8845KR.314.018) that were replaced every five preparations<sup>(10)</sup>. MOD cavities were prepared in (3mm) depth, (3mm) width with diverged wall in (10°) occlusally, all walls were without undercut and were flared, the cavosurface line angles were (90°) and all the internal line angles were rounded<sup>(11)</sup>. As shown Figure (1) Cavity preparations were standardized using a modified dental surveyor and all the cavity dimensions were measured using digital caliper.



**Figure 1: Dimensions of the preparation**

Impressions of the prepared teeth in group C and group D was done in an individual plastic tray<sup>(12)</sup> and poured with distone to fabricate the master cast in which the filling will be fabricated.

#### Filling the samples

**Group (A):** Applying a single bond universal adhesive (scotch bond) (3M) and the filling material (Filtek Z250 XT) was placed till the whole access opening was completely filled (three layers).

**Group (B):** Filled directly with composite material (Filtek Z250 XT) by first Single Bond Universal Adhesive (Scotch bond) and the restoration was fabricated in a layering mode of with the final layer was made with the aid of the template (copyplast) to reconstruct the original occlusal anatomy of the tooth<sup>(9)</sup>.

**Group (C):** Layer of separating medium was applied to the cast before margination. Then the filling material (Filtek Z250 XT) was added horizontally on the tooth with aid of template then the final restoration was cemented to the samples with the self adhesive resin cement (Rely X Unicem 2) after being smoothed and polished.

**Group (D):** A CAD/CAM device (CEREC3; Cerec inLab MC XL Sirona Dental Systems GmbH, Germany) scanning and milling machine (Figure 2) and software (version 3.10) was used to fabricate the onlays.



**Figure 2: InLab MC-XL milling machine.**

After fabrication of the model, each specimen was scanned with InEos Scanner; IPS Contrast Spray Lab side (Cerecoptispray) was sprayed on the model and scanned as in figure 3.

The whole margins of the cavity was marked accurately on the model of the three dimensional picture (margination of the cavity) as in (Figure4).

Then restoration was filled the scanned tooth cavity and the virtual restoration was displayed in the monitor and viewed from all surfaces (Figure 5).

The Paradigm MZ100 block was inserted in the button for fabrication of the onlay from composite blocks in the milling device, after the milling procedure was completed and the onlay was fabricated, the restoration spur was removed, All

milling device, milling started by clicking Mill onlays were checked for fitting on the samples and cemented with (Rely X unicem2) as in Group C.

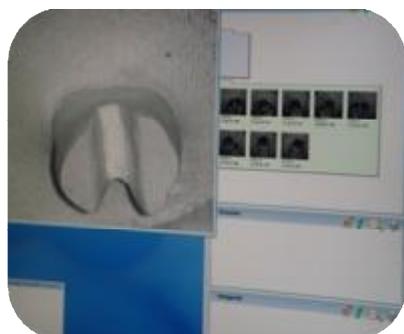


Figure 3: Scanning the model

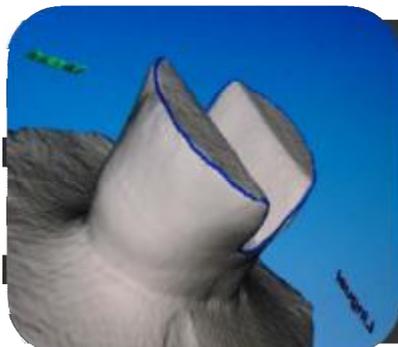


Figure 4: Margination of the cavity



Figure 5: Filling and shaping the restoration

**RESULTS**

**Fracture resistance values of all experimental groups**

The descriptive statistics which represent the mean, standard deviation ( $\pm$ SD) with the maximum (Max) and minimum (Min) values of the fracture resistance in (KN) are shown in (Table 1).

**Table 1: Descriptive statistics of the fracture resistance of each group in KN**

Groups	Mean	$\pm$ SD	Max	Min
Group A	0.67	0.13	0.9	0.5
Group B	1.65	0.27	2.01	1.236
Group C	1.13	0.15	1.35	0.91
Group D	1.07	0.18	1.29	0.78

Endodontically treated teeth with only access opening filled presented the lowest mean value (0.67), while endodontically treated teeth with indirect cuspal coverage showed the highest resistance to fracture (1.65). One way ANOVA test detected statistically high significant differences among experimental groups (Table2).

**Table 2: One way ANOVA test of fracture resistance among all groups**

Comparison	Sum of squares	Df	Mean square	F-test	P-value
Between Groups	4.79	3	1.6	44.61	0.000
Within Groups	1.29	36	0.04		
Total	6.07	39			

Comparison between each two groups least significant difference (LSD) test was performed, it is clear from (Figure 6) that teeth restored with direct restoration (Filtek Z250 XT) (group B) had more fracture resistance than all experimental

groups and the results are highly significant. Endodontically treated teeth without cuspal coverage(group A) showed the least fracture resistance value than group (C and D) and the results are highly significant, Teeth restored indirectly with Filtek Z250 XT presented more resistance to fracture than teeth restored with paradigm MZ100block CAD/CAM but the values are not significant.

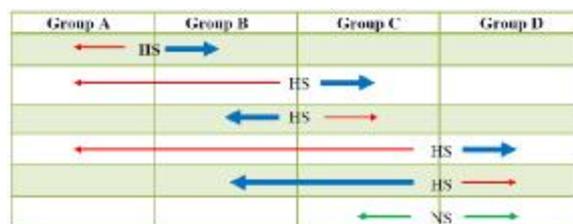


Figure (6) LSD between each two group  
 → Represent the highest fracture strength  
 → Represent the lowest fracture strength  
 → Represent the non significant difference

**Figure 6: LSD test between each two groups**

**Mode of fracture**

Group (A) (60%) of the fracture involving half of the tooth above the C.E.J (type III) while in Group (B) (70%) of the fracture was below the C.E.J. (type IV) which is non restorable and (30%) restorable, (10%) isolated fracture of the restoration (type I) and (20%) of the fracture involving half of the tooth above the C.E.J (type III), Group (C) (80%) restorable fracture, (60%) isolated fracture of the restoration and (20%) of the fractures of the samples above C.E.J (type III) and (20%) of the fractures below the C.E.J (type IV) which are non restorable and lastly in Group (D) (90%) is restorable fracture, ((80%) isolated

fracture of the restoration (type I) and (10%) fracture involving half of the tooth above C.E.J. (type III) and (10%) non restorable fracture

involving half of the tooth below C.E.J.(type IV) as in **Table 3**.

**Table 3: Mode of fracture in each group**

Groups	Isolated fracture of restoration (type I)	Fracture involving a small tooth portion (type II)	Fracture involving half of tooth above the C E J (type III)	Fracture below the C E J (type IV)
Group A	0	4	6	0
Group B	1	0	2	7
Group C	6	0	2	2
Group D	8	0	1	1

## DISCUSSION

### Fracture resistance among all experimental groups

There was a highly significant difference among all experimental groups (Table2). Group A (Endodontically treated teeth without cuspal coverage restoration) has the lowest fracture resistance mean value which is (0.67 KN); this come in agree with many researches<sup>(9, 8, 13-15)</sup>

The statistical analysis using ANOVA test (table 2) showed highly significant difference with other three groups, due to that the teeth with endodontic treatment are severely weakened due to the loss of reinforcing structures during access opening and instrumentation. The fracture is directly related to the amount of dentine lost and the continuity of the enamel which is broken and decrease in the moisture of the tooth after endodontic treatment.

Group B has the highest fracture resistance mean value than Group C and Group D and the difference is highly significant. This agrees with many findings<sup>(11,15,17)</sup>. That the difference in fracture resistant between group B and group C may be related to the difference in the adhesive materials and the difference in C factor between the two groups. In group B (scotch bond adhesive material) have shear bond strength which is about (30MPa) with dentine and (24MPa) with enamel with the formation of a continuum between tooth surfaces and adhesive material<sup>(17- 20)</sup>. While the shear bond strength of the cement (RelyX Unicem 2) with dentine is about (19MPa) and with enamel is about (26MPa), it is less than that of the scotch bond. Whereas Group B fractures strength is higher than that of group D may be due to the physical properties of the two materials that the Filtek Z250 XT which have fracture toughness (2.2k<sub>1c</sub>) that means it has higher load absorber as compared with Paradigm MZ100 composite block which have fracture toughness of about (1.4k<sub>1c</sub>). The result disagrees with Giordano<sup>(21)</sup> who stated that Paradigm MZ100 is a resin based composite

with micrometer and submicrometer zirconia-silica fillers, Its block form has mechanical properties superior to those of the conventional Z100 Restorative direct resin-based composite, as well as to other direct resin-based composites.

The fracture strength of group C is higher than group D but the values are statistically not significant, this agree with other findings<sup>(22-24)</sup>, this is because of the use of the same luting cement (Rely X Unicem2) in bonding both restorations which reinforce the composite in both groups to the same degree<sup>(25)</sup> but disagree with Giordano and Jansen<sup>(21,26)</sup> who stated that the CEREC system uses materials that have several benefits with respect to wear kindness, longevity and reinforcement of the tooth.

It was found clinically that maximum biting force was approximately (725N) for posterior single tooth, the fracture loads in this study exceeded maximal biting forces, but it can represent some overloading situations for example bruxism or traumatic occlusion<sup>(27)</sup>, in this investigation the direct composite restoration with cuspal coverage and indirect composite onlay and CAD/CAM onlays with (20%) of endodontically treated teeth without cuspal coverage survived this force so that these three types of restorations considered to be reinforcing an extensive cavities in endodontically treated premolars<sup>(9)</sup>.

The minimum force that cause fracture to sound premolar tooth in vitro (0.903KN-1.31KN)<sup>(28, 29)</sup> had been reached in this study for about (10%) of the samples of group A, (100%) of the samples of Group B, (100%) of the samples of Group C and (90%) of Group D

### Modes of fracture

The analysis of failure patterns demonstrated that if failure occurred in the restorations is better in the clinical situation, because the restoration could be replaced, while tooth failure may impair the prognosis<sup>(30,31)</sup>.

In group A (40%) of fracture is of type II and (60%) of type III this is due to the applied load

will stress the tooth structure directly and the anatomy of the tooth tend to separate the buccal and palatal cusps under occlusal load <sup>(9)</sup>.

While in Group B (70%) of type IV and the other 30% type I and type III which are restorable type of fracture, this could be explained that the bonding mechanism of self etch adhesive is based on the simultaneous etching and priming of enamel and dentin without rinsing, forming a continuum in the substrate and incorporating smear plugs into the resin <sup>(18)</sup>.

Indirect Filtek Z250 XT composite onlay (group C) have (60%) type I and (20%) type III so (80%) of fracture is restorable and only (20%) is type IV that is non restorable. This is due to that the cement upon curing will lead to shrinkage <sup>(20)</sup> that are detrimental for the bonded interfaces or even the cohesive strength of the cement. So when the fracture began in the restoration will ended in the cement region due to the dispersal of the fracture energy in it and might reduce the potential for crack propagation <sup>(32)</sup>; this situation minimize the tooth fracture in group C (20%) compared with group B (70%).

In Group D (80%) type I and (10%) type III so (90%) of the fracture are restorable fracture and only (10%) non restorable type IV. That means this group is the most favorable among other groups in preserving tooth structure. This is because fracture happened in the Paradigm MZ100 composite block rather than the tooth and with less value of load as compared with Filtek Z250 XT this could be related to the difference in the physical properties of the two materials that the Paradigm MZ100 composite block have fracture toughness of about (1.4 k<sub>1c</sub>) that means it is less load absorber as compared with Filtek Z250 XT which have fracture toughness (2.2k<sub>1c</sub>)

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