An In-vitro Evaluation of Effects of Light and Light-Heat Curing Inlay Composite Restorations on Fracture Resistance of Pulpless Maxillary Premolars

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Statement of Problem: The restoration of the teeth should have enough ability to withstand masticator forces while preserving as much tooth structure as possible. Purpose: The purpose of this study was to compare the effects of light-heat cured composite with light cured composite restorations on fracture resistance of the restored teeth. Materials and Methods: Forty healthy maxillary premolar teeth were chosen, endodontic treatment performed in 30 of them. MOD cavities were prepared in all of them to weaken tooth structures. Then, they were divided into 3 groups each of which contains 10 specimens. The groups were as follows: Group 1: unprepared teeth (sound teeth acted as control) Group 2: restored teeth with direct light cured composite resin. Group 3: restored teeth with light-heat cured composite resin as inlay without any cementing surface treatment Group 4: restored teeth with light-heat cured composite resin inlays with cementing surface treatment. Finally all samples were subjected to compressive load by testing machine. The data were analyzed using ANOVA and Duncan tests. Results: There was a significant difference in fracture resistance between 4 groups (P<0.001) except groups 2 and 3. The mean fracture load for groups 1, 2, 3 and 4 were 98.96±16.05, 58.72±15.33, 54.04±15.56 and 78.36±9.83 kgf respectively. Conclusion: Using light-heat curing method and cementing surface treating of composite resin will increase fracture resistance of endodontically treated maxillary premolars.

Key words: Inlay composite; Heat curing; Fracture resistance

In addition to aesthetic, biocompatibility, strength and marginal adaptation, an ideal restorative material must also be able to reinforce remaining tooth structures and increase its fracture resistance. One of the best ways to gain this is to use composite inlay and onlays. The use of composite inlay has some advantages and disadvantages. They have better mechanical properties, lesser marginal leakage, higher...
degree of polymerization and small stresses caused by polymerization process. As their disadvantages, they have high technique sensitivity, high price, and more time consumption.\(^{(2,3,4)}\)

The indications of using this material are in moderate and big cavities with weakened tooth structures and root treated teeth.\(^{(5)}\) They aren’t useful in highly damaged tooth with little remaining tooth structures for bonding, and where a good isolation is impossible.

The tooth fracture will increase following root canal therapy.\(^{(6,7)}\) The main reason for decrease in fracture resistance in root treated teeth is likely due to trauma and loss of the top portion of pulp chamber.\(^{(8,9)}\) In posterior root treated teeth, there is a reduction in tooth resistance due to deep and wide cavities.\(^{(10)}\)

A requirement of an ideal restorative material is that it can reinforce tooth structures and increase tooth fracture resistance.\(^{(11,12)}\)

Some studies have indicated that the heat of polymerization can weaken the bond between cement and composite inlay, so that the treatment of cementing surface can improve the bonding process.\(^{(13,14)}\)

Some studies reported that sandblasting the cementing surface with 50µ aluminum oxide particles produced most stable and strong bond. Treating of cementing surface with 50µ aluminum oxide particles and phosphoric acid can produce the most regular and reliable pattern of cementing surface of composite.\(^{(15,16)}\)

Crumpler et al showed that roughening the cementing surface by diamond or carbide burs increases bond strength of cured composite. This technique can impair and damage marginal adaptation, thus it is not recommended.\(^{(17)}\)

However, there is no general agreement for the best surface treatment method among researchers.\(^{(18)}\)

The purpose of this study was to compare the effect of light-heat cured composites with light cured composite restorations on fracture resistance of maxillary premolar pulpless treated teeth.

**Materials and Methods**

In this in-vitro study, forty healthy maxillary premolars teeth were collected. The teeth were divided into four groups based on their intercuspal distances to gain the same mean size in all groups. Endodontic treatment was performed on 3 groups and the samples of all groups were mounted in plastic rings (2×2.5cm) using self-cured resin (Pekatray Bayer Bertal). The long axis of teeth was perpendicular to the horizontal plane. The root of teeth was embedded in resin even to 1 mm below CEJ.

MOD cavities with following characters were prepared to weaken the remaining tooth structures. The gingival walls were positioned in CEJ, buccolingual width was one half of the intercuspal distance and 6-8 degrees divergence in each wall with a 90 degrees cavosurface angle margins (Fig 1). The pulp chambers of all specimens were filled with a chemically cured glass ionomer (Opusfil W Daxis scottlander. England). The teeth were unprepared in group 1.

In group 2, the surfaces of cavities treated with 37% phosphoric acid for 20 seconds then they were washed for 15 seconds and gently dried by air jet.

Then Scotchbond Multipurpose (3M,USA) was applied according to the manufacturer’s description and cured for 20 seconds. After that, the cavities were filled with Coltene Brilliant composite incrementally. Every increment was cured for 40 seconds using visible light cure unit (Coltlux II, Coltene, Brilliant, output energy=450 mw/cm²). Finally, the occlusal surfaces of restorations were finished and polished, and the samples were stored in distilled water (Fig 2).

In group 3, the surfaces of cavities coated with one layer of coca butter as spacer, and then, the cavities were filled with composite incrementally and cured like group 2. Then the cured restorations were dislodged and placed in boiling water for about 5 minutes to gain a
higher degree of polymerization (Fig.3). (19,20,21) The spacer layer was washed out and the cavities etched with 37% phosphoric acid for 20 seconds. Then they were washed for 15 seconds and gently air-dried. Scotchbond Multipurpose applied as manufacturer prescription and cured for 20 seconds.

Finally, the restorations were fixed in related cavities using Enforce (Dentsply/Caulk) dual curing resin cement, finished, polished, and stored in distilled water.

Samples in group 4 had the steps like the ones in group 3, except that the cementing surface of restorations sand blasted using 50µ aluminum oxide particles (using Dento-Prep device at 60 psi air pressure) for about 10 seconds. Then, they were etched using phosphoric acid 37% for 15 seconds before fixation (cementation). All the specimens in all groups subjected to compressive load at a crosshead speed about $1\text{mm/min}$ using specially designed crosshead under Dartec testing machine. The point of effects was on cusps evenly on both buccal and lingual cusps slop. The collected data were statistically analyzed using ANOVA and Duncan Post HOC test.

**Results**

The mean fracture load for all groups was 98.96, 58.72, 54.04, and 78.36 kgf respectively (Table I).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>98.96±16.05</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>58.72±15.33</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>54.04±15.56</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>78.36±9.83</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>72.51±22.72</td>
</tr>
</tbody>
</table>

ANOVA analysis indicated significant differences in fracture resistance between 4 groups (P<0.001). But Duncan test showed that the tooth fracture resistance for groups 2 and 3 was identical while it was different for other groups (P<0.001) (Graph 1).

The manner of fracture also was studied. The results were as follows:

Group 1 had 2 fractures in buccal cusps and 8 in palatal cusps. There were 2 fractures in buccal interfaces and 7 in palatal interfaces and one was undetectable in group2. Group 3 had 2 fractures in buccal and 6 in palatal interfaces, 1 fracture in palatal cusp and one was undetectable. There were 3 fractures in buccal and 7 in palatal interfaces in group4. Groups 2,
3 and 4 fractured in a similar manner irrespective of the restorative method. Chi-square test showed no difference in fracture manner of the 2nd, 3rd and 4th groups.

**Discussion**
Many studies have supported the use of bonding composite resin in root treated teeth as permanent restoration. Because of some problems like microleakage and polymerization shrinkage, the use of composite resin in posterior treated teeth is not usually warranted.\(^22\-24\)

The use of inlay composite resin is one way to overcome these problems that adversely affects the fracture resistance of teeth.\(^25\) A major advantage of the composite inlay system is their ability to reduce the adverse consequences of polymerization shrinkage and stresses of directly placed posterior composites as only the resin lute remains to be polymerized at cementation.

Loops et al have shown that large MOD preparations in premolar teeth reduce cuspal stiffness to one-third of the sound teeth. Indirect composite inlay restorations are able to recover tooth stiffness not significantly different from that of the sound tooth. This offers the prospect of successful restoration of teeth with weakened cusps and extensive intracoronal cavities; which is less needed for cuspal coverage and protection.\(^26\)

The results of this study showed that fracture resistance of unprepared samples (group 1) had the highest value. So, restoring the cavities with composite can improve low (decreased) fracture resistance resulted from cavity preparation in groups 2, 3 and 4. The mean of fracture resistance in-group 2 was about 59% of unprepared teeth. In another word the restored teeth with direct composite restoration increased fracture resistance of group 2 up to 59% comparable with the intact teeth (group 1). This value in-group 3 and 4 were about 54% and 73% of mean of unprepared teeth.

The results of this study were in agreement to the results of other studies in the same field. In a study by Gelb and Simonsen this increase in fracture resistance was 100%.\(^27\)

Difference in values between groups 2 and 4 indicated the role of cement resin and heat curing in increasing fracture resistance, as indicated by some researches.\(^28\)

Joynt believed that direct composite method can increase fracture resistance, but not as effective as indirect composite restorations with treated cementing surfaces of composite inlays.\(^29\)

Comparison of fracture resistance in groups 2 and 4 showed the effect of shrinkage forces control on fracture resistance increase and also the role of surface treatment on it, as have indicated by some researchers.\(^30,31\)

Bonding relies upon mechanical retention and residual free carbon bonds for chemical bonding. Secondary curing reduces the amount of residual free carbon bonds available for bonding. Grit blasting of composite roughens it by removing some of the matrix resin and exposing surface filler particles.\(^32\)

Comparison between groups 3 and 4 showed the effect of cementing surface sandblasting in increasing teeth fracture resistance as has been supported in some studies.\(^33,34\)

The heat treatment of resin composite resulted...
in reduced adherence both in the bond strength and the bond energy. With sandblasting only the bond energy was reduced as a consequence of heat treatment. In fact secondary cure of resin composite takes place at the expense of the adherence to the resin cement.\(^{(35)}\)

Gaining a higher degree of polymerization in inlay composite by heat can impair bond strength and surface sandblasting can compensate for it, as has been seen in our study. Comparison between Groups 2 and 3 did not show any differences in fracture resistance.

Though polymerization shrinkage control and inlay composite restorations were effective in improving bond strength. But, surface treating of inlay composite restoration was more effective. Finally it can be concluded that the use of light and heat curing method and surface treating compared with light and heat curing method without surface treating will increase fracture resistance of endodontically treated maxillary premolars.

**Conclusion**

- Effects of indirect composite inlay without cementing surface treatment and direct light curing composite on tooth fracture resistance were the same.
- Surface treated composite inlays were more effective than non-surface treated inlays on tooth fracture resistance increase.
- Fracture resistance of teeth restored with direct and indirect composite with and without surface treatment was less than of unprepared teeth.
- Composite inlays with cementing surface treatment were suitable restorations in restoring maxillary premolars root treated teeth.

**References:**

24- Fabra-Campos H. Restoration of endodontically treated teeth using a combined composite resin technique. Quintessence Int 1992; 23(7): 461-64.