COMPARATIVE EVALUATION OF MICRO—LEAKAGE OF FOUR RECENT RESIN-BASED CORE MATERIALS - AN IN VITRO STUDY

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Abstract: Aim: This in vitro study aimed to compare the microleakage of four different core materials (Paracore, Luxacore, Multicore and Fluorocore). Materials and Method: 40 samples of permanent mandibular first premolars were selected and divided into three groups, each group consisting of 10 samples. Standardized Class V cavities were prepared on buccal surfaces and were restored with assigned core materials. After thermocycling for 500 cycles (50°C-5°C), the specimens were then coated with two layers of nail varnish leaving an area of 1mm around the filling material uncovered. The samples were then immersed in 0.5% methylene blue dye for 24 hours. The teeth were sectioned longitudinally and greatest depth of dye penetration was recorded in coronal and cervical surface under stereomicroscope (15X). Result: The result revealed that, at occlusal and gingival surface, Paracore showed less microleakage as compared to other materials in the study. Conclusion: Paracore (at occlusal & gingival) core build-up material showed significantly more effective seal than Luxacore, Multicore and Fluorocore.

Keywords: dye penetration, fluorocore, luxacore, multicore, microleakage, paracore.

Introduction
The prognosis of final coronal restoration depends on the type of core reconstruction and the material used. A variety of composite resin materials with variable physical properties and different modes of polymerization (light activated, self activated or dual activated) are used for core build up. Core materials differ in terms of strength, stiffness, elasticity and other properties that may influence the structural integrity as well as the durability of the final restoration.

The tooth/restoration interface must resist dimensional changes to prevent developing leakage and possible further deterioration of the adhesive restoration. The permeability of dentinal tubules in adhesive-bonded restorations depends not only on the sealing ability of the adhesive, but also on bonding of the restorative material to the adhesive, as shrinkage of resin tags from the tubular walls during composite polymerization may result in incomplete dentinal sealing.

During polymerization shrinkage, stresses are generated within the restoration and at the...
margins, and if these stresses exceed the bond strength, gap formation and microleakage may occur at the tooth-restoration interface [4]. Microleakage is the passage of fluids, bacteria, molecules or ions and even air between a restorative material and prepared cavity wall of a tooth.

Different methods are available to evaluate the microleakage, out of which one of the established methods is dye penetration. Jensen and Chan (1985) [5] stated that the evaluation of microleakage in a restoration must include thermocycling the restoration. Inspite of great deal of developments in technology and techniques, none of the material could perfectly seal the gap between material and tooth structure. Achieving a perfect seal is still problematic with commercially available simplified etch and rinse adhesives.

The present in vitro study aimed to compare the microleakage of the following four recently introduced core build up materials - Paracore (Coltene/ Whalendent), Luxacore (DMG America), Multicore (Viva dent) and Fluorocore (DENTSPLY) with dye penetration.

Materials and methods

Thirty extracted non carious premolars were selected for this study. Previously restored teeth, teeth with visible cracks and those with non-carious cervical lesions were excluded. After cavity preparations, Group A was restored with Para core; Group B was restored with Luxa core, Group C was restored with Multi core and Group D was restored with Fluorocore according to the manufacturer’s instructions.

Following restorations, the teeth were stored in distilled water at room temperature for 24 hours before being subjected to 500 thermal cycles between 5-55°C water baths with a 30 second dwell time and a 15-second transfer time. The root apices were sealed with utility wax, and all the surfaces, except for the restorations and 1mm from the margins, were coated with two layers of nail varnish. The teeth were then immersed in a 0.5% methylene blue dye solution for 24 hours. They were then rinsed in running water, blot-dried and sectioned longitudinally through the center of the restorations in a buccolingual direction using diamond disk in slow speed handpiece. The sections were assessed for dye penetration using a stereomicroscope (Wild Heerbrugg) with software (Leica application suit) at 15x magnification. Dye penetration at the core/ tooth interface was scored for both the occlusal and gingival margins on a non-parametric scale from 0 to 3. A statistical analysis was performed using the Kolmogorov-Smirnov test and Kruskall Wallis Test.

Figure 1: Core materials used in the study.

Figure 2: Class V tooth preparation.
Table 1: Composition of core materials.

<table>
<thead>
<tr>
<th>Core Material</th>
<th>Composition</th>
<th>Filler content/Particle size</th>
</tr>
</thead>
</table>
| PARACORE      | A- Para Post Para core contains: Methacrylate, Fluoride Barium Glass - Amorphous Silica  
B- Para Bond None rinse conditioner contains: Water, Acrylamide monophonic acid, Methacrylate Para Bond Adhesive A  
- Methacrylates, Methyl Acrylate, Benzoyl peroxide  
Para Bond Adhesive B-  
- Ethanol, Water, Initiators | 68 wt%  
0.1 μm |
| FLUOROCORE    | Urethane Dimethacrylate  
di and Tri functional Methacrylates, Barium Boron Fluorobismutino silicate  
Glass, Camphorquinone Photo initiator, Photo accelerators, Silicon Dioxide, Benzoyl Peroxide |                              |
| LUXACORE      | Barium glass, Pyrogenic Silica acid, Nano fillers and Zirconium oxide in a Bis GMA based dendral resin matrix, Total filler volume 71 weight% and 50 vol% | 71 wt%  
0.01 μm |
| MULTICORE     | Bis GMA, Urethane dimethacrylate and Triethylene glycol dimethacrylate (79 wt%)  
- barium glass, Ytterbiumtride, Ba-Al-Fluorosilicate glass and highly dispersed silicon dioxide (70 wt%)  
- catalysts, stabilizers and pigments | 70 wt%  
0.04 μm |

Table 2: Scoring Criteria

<table>
<thead>
<tr>
<th>SCORE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No dye penetration</td>
</tr>
<tr>
<td>1</td>
<td>Dye penetration of less than half of the cavity depth</td>
</tr>
<tr>
<td>2</td>
<td>Dye penetration more than half of the cavity depth</td>
</tr>
<tr>
<td>3</td>
<td>Dye penetration spreading along the axial wall.</td>
</tr>
</tbody>
</table>

Figure 3: Stereomicroscopic image

Figure 4: Samples for thermal cycle

Figure 5: Sample of methylene blue
Result
At the occlusal level, Paracore demonstrated the least microleakage as compared to Luxacore, Multicore and Fluorocore. Microleakage observed in ascending order in the groups are Paracore (Group A), followed by Luxacore (Group B), Multicore (Group C) and Fluorocore (Group D). The difference in microleakage score among these groups was statistically significant at occlusal level.

At gingival level Paracore demonstrated least microleakage as compared to other. Microleakage observed in gingival level in ascending order is Paracore (group A) followed by Multicore (Group C), Fluorocore (Group D) and Luxacore (Group B) in Table III. The Kruskall Wallis Test was applied to determine the difference between microleakage in four groups.

Discussion
The dye leakage with 0.5% Methylene blue dye method was used in this study because it is simple, quantitative, effective, inexpensive and did not require the use of complex laboratory equipment. The degree of dye penetration indicates the inert space between the tooth margin (enamel and dentin or cementum) and the restorative material interface that could allow the ingress of bacterial endotoxins and their inflammatory products. In dye penetration testing, which is one of the main methods of assessing microleakage, the sample is subjected to a dye marker such as methylene blue, which was previously used by the Ernst [6].

Recently, Heitze and others reported that there is no significant difference in tracer penetration between fuchsin, silver nitrate and methylene blue [7]. Methylene blue is one of the most common tracers and can be used in different concentrations, from 0.5% up to 5% [8]. It was pointed out that, because of the small surface area of the particles (approximately 0.52 nm²), methylene blue may lead to an over estimation of leakage at the tooth-restoration interface, particularly with self-etch adhesive in relation to their increased hydrophilicity [6].

In the present study stereomicroscopic observations were done, for the microleakage at the interfaces, which is an established method and gives a clear in depth image with the help of recent image processors and softwares.

Extreme differences of linear co-efficient of thermal expansion between tooth and restorations causes percolation and subsequent microleakage. As core materials possess different thermal conductivity and co-efficient of thermal expansion from tooth structure, these properties are important in controlling and minimizing microleakage [9].

Because the cavities were only 1.5 mm in depth, the bulk technique was used to restore them with the respective composite resin [10]. It aims at thermally stressing the junction at the tooth-restoration interface by subjecting the restored tooth to extreme temperature changes compatible with temperature changes encountered intra-orally [11].

Para core composites exhibited least microleakage at both the enamel and the dentin margins as compared to other core materials. These results can be attributed to higher filler loading with smaller particle size of Multicore, Fluorocore and Luxacore in comparison with comparatively larger-sized filler particles and lesser filler loading in the Paracore composition. High filler loading results in a high degree of stiffness, which can lead to high shrinkage stress [12]. Also, smaller-sized particles in Fluorocore cause scattering of light and decrease its absorption, thereby reducing the overall polymerization and increasing the microleakage in the material [13]. Also, Fluorocore contain a high amount of Urethane Dimethacrylate in comparison with other core materials. The low-molecular weight UDMA and resultant higher number of double bonds per unit weight create a high degree of cross-linking, creating a rigid resin with a relatively high shrinkage.

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Table 3: Comparison of microleakage

<table>
<thead>
<tr>
<th>SN</th>
<th>Group</th>
<th>No. of samples</th>
<th>Occlusal Mean</th>
<th>Occlusal SD</th>
<th>Gingival Mean</th>
<th>Gingival SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Group B (LUXACORE)</td>
<td>10</td>
<td>10.964</td>
<td>4.411</td>
<td>13.730</td>
<td>2.465</td>
</tr>
<tr>
<td>3</td>
<td>Group C (MULTICORE)</td>
<td>10</td>
<td>12.670</td>
<td>3.795</td>
<td>11.670</td>
<td>5.722</td>
</tr>
<tr>
<td>4</td>
<td>Group D (FLUOROCORE)</td>
<td>10</td>
<td>13.940</td>
<td>4.3492</td>
<td>12.860</td>
<td>9.150</td>
</tr>
</tbody>
</table>

Figure 6: Graphic representation.
At gingival level, Luxacore demonstrated maximum microleakage which may be explained on the basis of application of total-etch bonding as recommended by its manufactures, as there is comparatively weak bond in absence of enamel at gingival margin.

The class V cavity design was chosen because it had a high C-factor value. It was relatively easy to restore and therefore exhibited minimized inter-operator variability. It had both enamel and dentinal margins and did not offer any inherent macro-mechanical retention[14]. As they involve both enamel and the dentin margins, the nature of adaptation of core material could be compared at both the margins. The enamel margins were bevelled in order to increase the surface area for core material to bond to enamel. The samples were subjected to the thermocycling in order to replicate the intraoral environment, because there was a difference in the coefficient of thermal expansion of the restoration and the tooth interface. The resulting mismatch in its value was said to cause fatigue of the bond between the restoration and the tooth, leading to a gap formation, which could lead to microleakage[12]. In the current study all specimens were subject to 500 cycles between 5°C and 55°C which is considered an appropriate artificial aging test according to ISO TR standard 11405:1994[15]. The dye penetration method used in the current study is a gross assessment of the quality of the interface.

At present there is lack of literature regarding evaluation of microleakage using the dye penetration method when studying four different core materials (Paracore, Multicore, Fluorocore, Luxacore). This research will add to the body of knowledge already present on core materials. This research also questions the benefit of materials with low volumetric polymerization shrinkage, which should not be considered as the only parameter for decreasing stress, and other factors such as modulus of elasticity much also be kept in mind.

In summary, the result of our study indicated that –

At occlusion- Paracore < Luxacore < Multicore < Fluorocore.
At gingival- Paracore < Multicore < Fluorocore < Luxacore

**Conclusion**

According to the methodology proposed and within the limitations of an in vitro study, the following conclusions can be drawn: Paracore (at occlusal & gingival) produced significantly more effective seal than the Luxacore, Multicore and Fluorocore and neither of these core materials was able to fully prevent microleakage.

**References**


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