Evaluation of Physical Properties of Different Core Build-up Materials

September 2, 2009

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Purpose
The purpose of this study was to evaluate the compressive strength, fracture toughness and flexural strength of five different core materials.

Methods and Materials
The tested materials are summarized in Table 1:

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>Curing Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Build-It Light Cure</td>
<td>Pentron</td>
<td>Light cured</td>
</tr>
<tr>
<td>B Light-Core</td>
<td>BISCO</td>
<td>Light cured</td>
</tr>
<tr>
<td>C SuperCure-Q</td>
<td>Centrix</td>
<td>Light cured</td>
</tr>
<tr>
<td>D Absolute Dentin</td>
<td>Parkell, inc.</td>
<td>Dual-cured</td>
</tr>
<tr>
<td>E ParaCore Automix</td>
<td>Coltene whaledent</td>
<td>Dual-cured</td>
</tr>
</tbody>
</table>

Preparation of Specimens
Compressive strength
Ten specimens for each of the materials were prepared on a Teflon mold (4mm X 6 mm). The resins were placed inside the mould and a second glass slide was placed on top of the mould and gentle pressure was applied so that excess material was extruded. The mould was then light polymerized on each side following manufacturer’s instructions for each material. Ten additional specimens were made for each of the dual-cured materials. These specimens were prepared using the same procedure described but, instead of polymerizing the materials with light, they were placed in a water bath at 37°C for 15 minutes before removing them from the mold.

Flexural strength
Ten specimens of each material were made in a mold measuring 25 mm X 2 mm X 2 mm (± 0.1 mm). A glass slide was placed at the bottom of the mold. The resin was then placed inside the mould and a second glass slide was gently pressed on the top of the mould so that excess material was extruded. The specimens were then light polymerized at 6 different spots following manufacturer’s instructions. The center of the specimen was polymerized first and then the light was moved outwards alternating between left and right until all six sections were polymerized, making sure that the light reached the entire specimen surface. Ten additional specimens were made for each of the dual-cured materials. These specimens were prepared using the same procedure described but, instead of polymerizing the materials with light, they were placed in a water bath at 37°C for 15 minutes before removing them from the mold.

Fracture toughness
Specimens were made using the same procedure described for the flexural strength specimens but the mould used was 25 mm X 4 mm X 4 mm and had a 2 mm notch on the center of the specimen.

All specimens were inspected for flaws using back light and any specimens showing porosity were discarded and prepared again. After fabrication, all the specimens were stored in a water bath at 100% humidity and 37°C for 24 hours and tested.

Testing

Compressive strength
Each specimen was placed in between two platens and tested at a rate of 1mm/min. The maximum stress was calculated using the formula:

\[ S = \frac{F}{A} \]

where \( S \) is the compressive strength, expressed in MPa, \( F \) is the load needed to brake the specimen, expressed in newtons, and \( A \) is the area of the surface where the force is applied to the specimen, expressed in mm\(^2\).

Flexural strength
Each specimen dimensions were measured and then the specimen was placed in a three point bending jig. The specimen was loaded at a cross head speed of 0.75 mm/min until it fractured. The flexural strength was calculated following formula:

\[ \sigma = \frac{3Fl}{2hd} \]

where \( \sigma \) is the flexural strength, expressed in MPa; \( F \) is the maximum load, in newtons, exerted to the specimen; \( l \) is the distance, in millimeters between the supports; \( b \) is the width, in millimeters, of the specimen measured immediately prior to testing; and \( h \) is the height, in millimeters, of the specimen measured immediately prior to testing.

Fracture toughness
Specimens were loaded in a special loading apparatus and tested to failure. The fracture toughness was calculated using the formula:

\[ K_{lc} = 1.12\sigma\sqrt{a} \]

where \( K_{lc} \) is the fracture toughness, expressed in MPa m\(^{1/2}\); \( \sigma \) is the stress applied to the material, expressed in MPa and calculated as shown in the flexural strength equation; and \( a \) is the crack length, expressed in meters.
Data entry, tabulation and analysis
The calculated parameters were analyzed by using one-way analysis of variance (ANOVA) to evaluate the existence of differences between the tested materials. If differences were found, a Newman Keul’s test was used to identify the differences. Student t test was used to evaluate differences between light-cured and self-cured groups of the dual-cured materials.
Results
Compressive strength
The compressive strength values measured for the tested materials are in the same range that has been reported in the scientific literature for other materials of similar characteristics. Results obtained from the compressive strength test are shown in Figure 1.

![Figure 1 Mean Compressive Strength.](image)

For light-cured samples, one-way ANOVA did not reveal any significant differences among the tested groups ($P = 0.518$).

Student’s t-test did not reveal any significant differences on compressive strength between light-cured and self-cured samples for Absolute Dentin ($P=0.690$) and ParaCore ($P=0.272$).

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Flexural strength

Flexural strength results are shown in Figure 2.

![Figure 2 Mean Flexural Strength values.](image)

For light-cured samples, one-way ANOVA revealed significant differences among the tested groups (P < 0.001). Table 4 shows results for the Newman-Keul’s comparison.

<table>
<thead>
<tr>
<th>Comparisson</th>
<th>Diff of Means (MPa)</th>
<th>P</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build-It vs. SuperCure</td>
<td>64.31</td>
<td>&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>Build-It vs. LightCore</td>
<td>39.18</td>
<td>0.22</td>
<td>Yes</td>
</tr>
<tr>
<td>Build-It vs. ParaCore</td>
<td>14.27</td>
<td>0.558</td>
<td>No</td>
</tr>
<tr>
<td>Build-It vs. Absolute</td>
<td>11.26</td>
<td>0.403</td>
<td>No</td>
</tr>
<tr>
<td>Absolute vs. SuperCure</td>
<td>27.92</td>
<td>0.003</td>
<td>Yes</td>
</tr>
<tr>
<td>Absolute vs. LightCore</td>
<td>53.04</td>
<td>0.104</td>
<td>No</td>
</tr>
<tr>
<td>Absolute vs. ParaCore</td>
<td>3.01</td>
<td>0.832</td>
<td>No</td>
</tr>
<tr>
<td>ParaCore vs. SuperCure</td>
<td>50.04</td>
<td>0.004</td>
<td>Yes</td>
</tr>
<tr>
<td>ParaCore vs. LightCore</td>
<td>24.91</td>
<td>0.078</td>
<td>No</td>
</tr>
<tr>
<td>LightCore vs. SuperCure</td>
<td>25.13</td>
<td>0.075</td>
<td>No</td>
</tr>
</tbody>
</table>
Student’s t-test did not reveal significant differences on the flexural strength values of Absolute Dentin when tested on light-cured or self-cured mode (P=0.109). However, for ParaCore statistically significant differences were detected between the two curing modes (P=0.003).

Fracture Toughness

The fracture toughness values obtained in this study are in the same range that has been previously reported in the scientific literature for other core buildup materials.\(^2\) Results obtained from the fracture toughness test are shown in Figure 3.

![Figure 3 Mean Fracture Toughness values](image)

For light-cured samples, one-way ANOVA revealed significant differences among the tested groups (P < 0.001). After Newman-Keul’s comparison, statistically significant differences were not detected on two pairs of cements: Build-It and LightCore (P=0.883) and SuperCure and ParaCore (P=0.722). The rest the groups were detected to be statistically different from the others (P<0.001).


Student’s t-test revealed significant differences on the fracture toughness values of Absolute Dentin when tested on light-cured or self-cured mode (P=0.021). However, for ParaCore statistically significant differences were not detected between the two curing modes (P=0.521).

**Conclusion:**

Build-It Light core material meets and/or exceeds all physical properties for comparable core-build up materials currently available in the market.

**Submitted by:**

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**Date:**