Effect of the Polishing Technique at Low or High Speed on the Micro-Hardness of Dental Amalgam

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Dental cavities were prepared and restored with amalgam, using three different silver alloys. The surface of the restorations was finished 24 hours after condensation, with a rotatory instrument using a low- or high-speed handpiece. The specimens were then submitted to metallographic polishing and one of the margins of the amalgam restoration was submitted to Vickers' micro-hardness test. Another micro-hardness test was accomplished 168 hours after condensation and the two sets of micro-hardness values were compared. No significant statistical differences were detected between the micro-hardness values obtained with low or high speed in the polishing technique.

Key Words: amalgam micro-hardness, amalgam finishing.

Introduction

Amalgam has been successfully used as a restorative material for over a century, but most professionals have often neglected one important phase of its technical procedure: the polishing.

Worried with this fact, many authors have studied the amalgam, and Silva et al. (1980) and Anaise and Shem-Tov (1982) confirmed the low percentage of polished amalgam restorations encountered.

Other authors showed the importance of polishing amalgam, calling attention to the better performance of the polished restorations (Charbeneau, 1964; Richmond, 1972; Skogedal and Heloe, 1979; Creaven et al., 1980; Letzel and Vrijhoef, 1982), as well as to the quality of the polishing (Jeffrey and Pitts, 1989).

Several techniques have been proposed, and although some differences exist, a common point is usually present: the use of a rotatory instrument as the initial step.

Ribeiro et al. (1984) demonstrated that low-speed rotatory instruments used in the initial step of the polishing procedure cause a decrease in the micro-hardness at the margins of the restorations. Centola et al. (1988) verified that the use of high-speed
rotatory instruments, on the contrary, showed no decrease in the amalgam micro-hardness.

The objective of the present research was to study the effect of multiblade burs (used to polish amalgam at both low and high speed), on the surface micro-hardness at the margins of amalgam restorations.

Material and Methods

Human extracted healthy molars were used. The teeth had their cusps ground off and their roots sectioned 2 to 3 mm below the anatomical cervical line, using a cylindrical diamond point, so that two parallel smooth surfaces were obtained. At the center of the occlusal faces, standard 3.0 x 3.0 x 2.5 mm cavities were prepared. After preparation and finishing of the cavities, the teeth were embedded in Araldite resin, according to the technique described by Centola et al. (1988). Three silver alloys were used: New True/fine cut (S.S. White), Dispersalloy/admixture (Johnson & Johnson) and Sybraloy/spheroidal ternary (Sybron/Kerr), whose quantitative and qualitative analyses are shown in Table 1.

Table 1 - Qualitative and quantitative analysis of alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Ag%</th>
<th>Sn%</th>
<th>Cu%</th>
<th>Zn%</th>
</tr>
</thead>
<tbody>
<tr>
<td>New True</td>
<td>76.4</td>
<td>19.2</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Dispersalloy</td>
<td>75.6</td>
<td>12.8</td>
<td>13.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Sybraloy</td>
<td>43.6</td>
<td>22.8</td>
<td>34.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The mercury/alloy ratio, and the techniques for grinding, condensation, sculpture, metallographic polishing and micro-hardness measure were the same as previously utilized by Centola et al. (1988).

The clinical polishing was carried out 24 hours after the condensation since this is the ideal time, according to several authors (Nadal, 1962; Charbeneau, 1964; Marshall et al., 1976; Carron et al., 1981). In the initial phase of polishing, the excesses were removed by using multiblade burs, because they are the instrument preferred by practitioners to accomplish this operative step. Multiblade burs were used to polish at low or high speed. The present work differs from previous similar ones (Ribeiro et al., 1984; Centola et al., 1988) in this basic detail, since the objective was to verify the effect of the rotation speed on the amalgam micro-hardness at the restoration margin. After removal of the excess amalgam, clinical polishing was performed at low speed, using Sweeney's brushes, pumice and zinc oxide pastes, followed by metallographic polishing.
The wearing caused by the metallographic polishing, according to Samuels (1984), does not modify the physical or mechanical properties of the surface studied, as long as it does not surpass 5 μ in depth.

Results and Discussion

The original data consisted of 360 numerical values corresponding to the diagonal of the microindentations resultant from the application of Vickers' points. These data resulted from the factorial product of 3 trade marks of silver alloys, 2 treatments, 2 ages of the restorations, 6 replications, 5 measures: 3 x 2 x 2 x 6 x 5 = 360.

The number of original data was then reduced to 72 by taking the mean of the 5 measures corresponding to each replication. These 72 means were the experimental data used in the statistical analysis (Table 2).

Table 2 - Mean values of the diagonal of the indentations resultant from Vickers' micro-hardness tests.

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Low speed</th>
<th>High speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NT</td>
<td>DY</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>63.3</td>
<td>68.2</td>
</tr>
<tr>
<td></td>
<td>64.2</td>
<td>58.1</td>
</tr>
<tr>
<td></td>
<td>62.9</td>
<td>57.0</td>
</tr>
<tr>
<td></td>
<td>68.0</td>
<td>58.1</td>
</tr>
<tr>
<td></td>
<td>66.1</td>
<td>58.8</td>
</tr>
<tr>
<td></td>
<td>66.4</td>
<td>58.5</td>
</tr>
<tr>
<td>168</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>57.2</td>
<td>65.2</td>
</tr>
<tr>
<td></td>
<td>61.4</td>
<td>56.2</td>
</tr>
<tr>
<td></td>
<td>63.1</td>
<td>56.2</td>
</tr>
<tr>
<td></td>
<td>62.7</td>
<td>54.3</td>
</tr>
<tr>
<td></td>
<td>62.1</td>
<td>61.4</td>
</tr>
<tr>
<td></td>
<td>59.8</td>
<td>54.5</td>
</tr>
</tbody>
</table>

NT, New True; DY, Dispersalloy; SY, Sybraloy.

Preliminary tests demonstrated that the experimental data were normally distributed, homoscedastic, and that the means and variances involved were mutually independent, which made it possible to use parametric statistical tests (analysis of variance). The statistical model of analysis of variance employed was the split-plot model, because the data related to the age of the restorations were not independent, but paired ones. The results are shown in Table 3.
Table 3 - Analysis of variance (split-plot).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>df</th>
<th>Medium squares</th>
<th>F</th>
<th>p (H₀) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between speeds (S)</td>
<td>36.1875</td>
<td>1</td>
<td>36.1875</td>
<td>1.99</td>
<td>16.54 ns</td>
</tr>
<tr>
<td>Between alloys (A)</td>
<td>1497.4380</td>
<td>2</td>
<td>748.7188</td>
<td>41.20</td>
<td>&lt; 0.01 **</td>
</tr>
<tr>
<td>S x A interaction</td>
<td>19.2656</td>
<td>2</td>
<td>9.6328</td>
<td>0.53</td>
<td>40.08 ns</td>
</tr>
<tr>
<td>Residual I</td>
<td>545.1249</td>
<td>30</td>
<td>18.1708</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subtotal I</td>
<td>2098.0160</td>
<td>35</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Between ages (G)</td>
<td>120.1875</td>
<td>1</td>
<td>120.1875</td>
<td>37.17</td>
<td>&lt; 0.01 **</td>
</tr>
<tr>
<td>G x S interaction</td>
<td>0.3125</td>
<td>1</td>
<td>0.3125</td>
<td>0.09</td>
<td>23.64 ns</td>
</tr>
<tr>
<td>G x A interaction</td>
<td>14.0156</td>
<td>2</td>
<td>7.0078</td>
<td>2.16</td>
<td>13.12 ns</td>
</tr>
<tr>
<td>G x S x A interaction</td>
<td>36.1719</td>
<td>2</td>
<td>18.0859</td>
<td>5.59</td>
<td>0.87 ns</td>
</tr>
<tr>
<td>Residual II</td>
<td>96.9845</td>
<td>30</td>
<td>3.2328</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subtotal II</td>
<td>267.6720</td>
<td>36</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total variation</td>
<td>2365.6880</td>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns, Not significant.

**, Significant at the level of 1% of probability.

Age: The analysis of variance showed that the micro-hardness of the amalgam at the two ages of the restorations (24 and 168 hours) are statistically different at the level of 1% of probability. The confrontation between the means shows that after 168 hours (mean, 57.75) the amalgam is harder than after 24 hours (mean, 60.33) post-condensation, which characterizes the hardness of amalgam as a time-dependent property, confirming prior results encountered by other authors cited by Centola et al. (1988).

Alloy: The analysis of variance indicated a statistical significance at the 1% level of probability. The Tukey’s test showed that the three means were all statistically different. The comparison between the means established that Sybraloy (SY) presented the highest hardness (mean, 53.38), followed by Dispersalloy (DY) (mean, 59.21) and New True (NT) (mean, 64.54).

The amalgams resultant from alloys rich in copper (DY and SY) evidenced a greater hardness than the amalgam lacking that metal (NT), confirming previous results obtained by Santos and Silveira (1976), Duke et al. (1982), Venz (1982), Ribeiro et al. (1984) and Centola et al. (1988). The fact that Sybraloy produced the hardest amalgam might be justified by its higher percentage of copper (Table 1), the different manner of adding this element to the alloy (ternary), the different shape and size of the particles (microsphere), the lesser quantity of mercury used in trituration, or yet by the total sum of all these factors.
However, the importance of two of these factors - higher percentage of copper and the manner by which this element is added to the alloy - could be questioned, inasmuch as previous works by Ribeiro et al. (1984) and Centola et al. (1988) demonstrated that amalgams obtained from Negro Gato alloy presented values of micro-hardness significantly lower than the ones obtained from the three alloys studied in the present research.

Although not specified by the manufacturers, Negro Gato alloy and Sybraloy are similar in composition (near 30% copper) and manner of adding the copper (ternary particles). These facts lead one to believe that the role of high percent copper and the manner of adding this element play a minor role in the better results achieved by Sybraloy in relation to the hardness of amalgam. This finding partially contradicts the hypotheses proposed by Acharya et al. (1973) and Marshall et al. (1976), and at the same time valorizes the hypothesis that the shape and size of the particles, as well as the smaller quantity of mercury used in the trituration, better justify the higher values of hardness detected with Sybraloy.

**Speed:** No significant difference was statistically detected between the micro-hardness values obtained when low (mean, 58.33) or ultra-high speed (mean, 59.75) were used to polish the amalgam restorations.

Ribeiro et al. (1984) demonstrated that the three instruments utilized more frequently to remove excesses from the margins of the amalgam restorations - the round bur, the flame shaped finishing bur and the silicon carbide stone, moved by low-speed motor (about 2,000 rpm) - decreased the surface micro-hardness at the margins of amalgam restorations, in comparison to the micro-hardness of the margins on which these instruments were not used. The round burs and the finishing burs were responsible for the lower values, a fact ascribed to possible effects produced by heating and vibration generated by the rotation of these instruments.

Centola et al. (1988) showed that the rotatory instruments Roto Pro 404 bur, round-shaped finishing bur for polishing and silicon carbide stone, when utilized at ultra-high speed, produced no significant modifications on the micro-hardness at the margins of the amalgam restorations. This fact was a stimulating invitation to further investigate the effects of heating and vibration.

It was with this objective in mind that the same type of multiblade bur was used in this work, either at low speed (less heating and more vibration) or at ultra-high speed (more heating and less vibration). The results obtained, however, showed that the action of the rotatory instruments at the two speeds produced no statistically significant differences on the values of micro-hardness at the margins of the amalgam restorations. This finding seems to discard the hypothesis of a major interference of heating and vibration on the hardness of amalgam.

**Conclusions**

1. The values of micro-hardness of the amalgams obtained from the alloys studied increase with time, and are therefore time-dependent.
2. Amidst the amalgams studied, the highest values of micro-hardness were reached by Sybraloy.

3. The values of micro-hardness at the margins of the amalgam restorations were statistically not different, when the same type of rotatory instrument was used at low or high speed.

4. Indirectly, it can be said that heating and vibration do not interfere with the values of amalgam micro-hardness.

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Amalgam micro-hardness


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