Comparative Evaluation of Tensile Strength and Rupture Elongation of Two Brazilian Silicones for Facial Prostheses

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The tensile strength and rupture elongation of two Brazilian silicones, one American silicone and a resilient resin were studied. Original and aged samples were used. We concluded the following: aging increases or tends to increase elongation of silicones but lowers that of resilient resin; the Brazilian silicones (Fascil L and Fascil R) presented lower elongation than the American one but higher than that of resilient resin; tensile strength of Brazilian silicones is low; aging of silicones does not affect their tensile strength, but does affect that of resilient resin.

Key Words: facial prostheses, silicone.

Introduction

A facial prosthesis must be resistant, have a long life and remain suave and flexible to accompany facial movements. Recently, much research is being carried out with materials used in facial prostheses, not only due to the large development of industries of these materials, but also due to the advances in oncologic treatment, which led to an increase in life expectancy of oncologic patients.

For a good result, these materials have to meet a series of requirements, such as: biocompatibility, flexibility, low density, translucence, durability, ease of use, texture similar to skin and general satisfactory mechanical properties.

Bell et al. (1985) considered the ideal tensile strength to be 70-140 kgf/cm² and rupture elongation to be 400-800%. Similar ideal values were reported earlier by Lewis and Castleberry (1980) and Sweeny et al. (1972), who reported tensile strength values of 125 kgf/cm². In 1978, May and Guerra reported desirable values for tensile strength greater than 70 kgf/cm² and greater than 900% for rupture elongation.

The high cost and difficulty of importing products led the chemist and dental surgeon Romualdo Rossa, Teaching Assistant of the Discipline of Mouth-Maxilla-Facial Prostheses, to develop silicones for use in facial prostheses. Two Brazilian polymerized silicones were thus developed (RTV, room temperature vulcanization): one of thermal polymerization, Fascil L, and the other of chemical polymerization, Fascil R.
The tensile strength and the rupture elongation of these two silicones were compared to MDX4-4210, an American silicone, and a resilient resin, Rapidaflex, which has already been studied by Rezende (1974) and Rezende and Maringoni Filho (1979).

Material and Methods

The composition base of developed silicones is dimethyl siloxane, reinforced with silicium oxide. In thermal polymerization the catalyzer is stannous dibutyl dilaurate and in chemical polymerization, stannous octate. The silicone MDX4-4210 has a base of vinyl polysiloxane with a load of silicium oxide and a catalyzer of platinum salts, produced by Dow Corning Corporation. The resilient resin Rapidaflex is chemically activated using butyl phthalate as a plastifier, produced by Artigos Odontológicos Clássico Ltda., SP/Br.

The sample properties were based on the norm of ABNT-MB-57-CO, model F3 (Associação Brasileira de Normas Técnicas, 1968) for the confection of samples, and aging was carried out at 70°C for 70 hours, based on the norm ASTM D 573-812 (American Society for Testing and Materials, 1983).

Based on research by Rezende (1974), the oven was opened 6 hours after polymerization for Facsil R and 24 hours for the remaining materials.

Samples were obtained by sections using special equipment from plates of polymerized material, in 10 x 10 x 0.25 cm plaster molds, where mixed powder and liquid, still liquid, were poured. The Brazilian silicones were manipulated with 3% in catalyzer volume; MDX4-4210 in a proportion of 10:1 of paste and catalyzer. The polymerization of this material was accelerated at 75°C for 30 min according to manufacturer recommendation (Dow Corning, 1973). The proportion of Rapidaflex was 3 cm³ of powder to 1 cm² of liquid (1 cm³ monomer and 2 cm² of plastifier). After polymerization at room temperature, the material was submitted to slow heating up to 100°C, remaining at this temperature for 30 min. The plaster isolation for Rapidaflex was Cel-Lac and for the silicones water was used for moistening.

Each of the 4 plates obtained from each of the materials provided 5 samples, with half of the samples submitted to aging at 70°C for 70 hours.

The tests were carried out at a velocity of 50 cm/min. Elongation was obtained by calculation of the separation of two points on the sample and tensile strength by the quotient of the rupture load and the corresponding area.

Results and Discussion

Table 1 shows the results of analysis of variance of rupture elongation and tensile strength. Note that the main factors, material and aging, were significant for rupture elongation and tensile strength and for the corresponding interactions material vs aging.

Table 2 shows the relative means of these interactions as well as critical values (Tukey test). The significance of the main factors, shown in Table 1, can be verified by the means of corresponding interactions in Table 2.
Table 1 - Analysis of variance of rupture elongation and tensile strength. M, Material; A, aging; M x A, interaction of material x aging. *Significant at the level of 5%, **significant at the level of 0.1%.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variation</th>
<th>G.L.</th>
<th>Mean squares</th>
<th>R.Q.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture elongation</td>
<td>M</td>
<td>3</td>
<td>622,048.20</td>
<td>2,885.45**</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>1</td>
<td>9,504.80</td>
<td>4.14*</td>
</tr>
<tr>
<td></td>
<td>M x A</td>
<td>3</td>
<td>37,978.13</td>
<td>16.55**</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>72</td>
<td>2,294.44</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>79</td>
<td>(28,794.73)</td>
<td>-</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>M</td>
<td>3</td>
<td>20,698.6898</td>
<td>838.12**</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>1</td>
<td>1,548.8000</td>
<td>62.71**</td>
</tr>
<tr>
<td></td>
<td>M x A</td>
<td>3</td>
<td>1,499.0333</td>
<td>60.70**</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>72</td>
<td>24.6966</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>79</td>
<td>(855.0649)</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2 - Means of rupture elongation (%) and of tensile strength (kgf/cm²), corresponding to the interaction material x aging and critical values for contrasts.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Aging</th>
<th>Facsil L</th>
<th>Facsil R</th>
<th>MDX4-4210</th>
<th>Rapidaflex</th>
<th>Tukey test (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture elongation</td>
<td>without</td>
<td>340</td>
<td>308</td>
<td>526</td>
<td>169</td>
<td>66.9</td>
</tr>
<tr>
<td></td>
<td>with</td>
<td>443</td>
<td>325</td>
<td>591</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Tensile strength</td>
<td>without</td>
<td>12.3</td>
<td>11.6</td>
<td>55.5</td>
<td>57.7</td>
<td>6.94</td>
</tr>
<tr>
<td></td>
<td>with</td>
<td>13.0</td>
<td>9.6</td>
<td>57.4</td>
<td>92.4</td>
<td></td>
</tr>
</tbody>
</table>

Rupture elongation: According to Lewis and Castleberry (1980), ideal elongation is between 400 and 800%. Observing the values of Table 2, one can verify that the material MDX4-4210 satisfies this interval. In the case of the developed silicones only aged Facsil L presented a value in this interval (443%). Without aging the values were less than the ideal as were the values for Facsil R with or without aging. However, these values are not much lower than the ideal minimum of 400%. The material Rapidaflex had very low values for rupture elongation. Aging significantly reduced its elongation, while for silicones, aging, when not significant, showed tendency towards significance.
The values obtained in this study for MDX4-4210 were greater than those presented by Dow Corning (1973) and other authors such as May and Guerra (1978), Lewis and Castleberry (1980), Yu et al. (1980), Turner et al. (1984) and Bell et al. (1985). This is probably due to variations in polymerization, addition of plastifiers in variable percentages or differences in test methods. The values obtained for Rapidaflex were less than those found by Rezende (1974); however, there is agreement that aging decreases rupture elongation.

Tensile strength: Table 2 shows that the silicones Facsil L and R present very low values of tensile strength, which would mainly indicate these materials for use in situations where great mechanical strength is not necessary. Silicone MDX4-4210, which approaches the resilient resin Rapidaflex when not aged, presents much higher values. Artificial aging did not significantly influence the silicones; however, in the case of Rapidaflex, the increase was considerable (from 57.7 kgf/cm² to 92.4 kgf/cm²).

Tensile strength is very important because this indicates the resistance of a prosthesis to breakage. A material is considered satisfactory when it presents a strength between 70 and 140 kgf/cm², according to Sweeney et al. (1972), May and Guerra (1978) and Lewis and Castleberry (1980). Only aged Rapidaflex presented a satisfactory value in this study. The silicones, especially Facsil L and Facsil R, were below this. Values from MDX4-4210 were slightly greater than those reported by Dow Corning (1973) and much less than those reported by Lewis and Castleberry (1980), Abdelnabi et al. (1984) and Bell et al. (1985). Moore and colleagues (1977) reported tensile strength of 70 kgf/cm² for this material. The lack of influence of aging on the silicones is not in agreement with the results of Rezende (1974) and Yu et al. (1980); however, the increase in strength of Rapidaflex with aging is in agreement with that reported by Rezende (1974).

Conclusions

1. Aging increased or tended to increase the rupture elongation of silicones; however, the opposite occurred with resilient resin.

2. Developed silicones presented lower values of rupture elongation than MDX4-4210; however, much higher than resilient resin.

3. Tensile strength of silicones Facsil L and Facsil R was low, thus being indicated only for regions where low mechanical strength is needed.

4. Aging did not influence the tensile strength of the silicones, but did increase that of resilient resin.

References


Tensile strength and rupture elongation


Rezende JRV, Maringoni Filho N: Novo material para prótese facial. Quintessência 6: 73-78, 1979


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