A Pilot Manufacture of Biting Abrasion Testing Machine for the Full Denture and its Test Result

by

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1. Introduction

Although there is available an abundance of the published literature dealing with the abrasion of artificial teeth, the majority of it is directed to the materials of which these teeth are made [1-5]. So far, there is no research effort to examine the degrees of various abrasions on the occlusal surfaces planted on a complete denture. The present study is the first attempt to its kind to examine the abrasive degrees of artificial teeth as planted on a complete denture, i.e., in the situation approximating to the clinical conditions. Of course it is possible to conduct a survey on a variety of complete denture users on a periodic basis so as to keep track of various degrees of the dental abrasion on their teeth. It is to be admitted, however, there will be seen high individual differences in the resultant data influenced by such variables as the occlusal pressure of individuals concerned, masticatory habits, mode of living, occupations, etc. It follows then that we have to have a great body of statistical data before a significant study is possible. In order to avoid this cumbersome study method, the authors here designed a mechanical device by means of which the degrees of the abrasions on the artificial teeth could be measured with a maximum accuracy.

2. The Construction of Biting Abrasion Testing Machine

2.1 An examination of the articulator.

The study was conducted on the established policy that the artificial teeth planted on a complete denture would be induced to the abrasions by means of an articulator. Of various functional articulators currently available, a selection was made of the Okino articulator (developed by our senior colleague on the faculty of Nihon University School of Dentistry, Dr. Setsuzo Okino). This articulator is made of the aluminum and, in spots where particular strength is required such as in the sagittal condyle path, etc., a brass alloy is used.

A spring mechanism is incorporated in the sagittal condyle joint, so that the incisal guiding plane can be maintained in a centric position all the time.

A preliminary test confirmed the fact that this spring mechanism would suffi-
ciently bear under a repetitive movement for a long duration of time. The spring mechanism was so rendered as to move smoothly throughout the study and the motor revolutions were established not to exceed 25 piston movements per minute. The justifications for these provisions were that an excessive deformation of dental surface through the heat generated by motor revolutions could be checked at a minimum and that observation and recordings of the abrasive degrees were easy enough with this number of revolutions.

2.2 The design of machine components.

For the movement of an incisal guide plane, a special cam was designed (Fig. 1.). As seen from the diagrammatic presentation, rods a and c are activated by the revolution of the cam which is installed at ½ of the long axis of the cam itself. The rod e gives a reciprocal motion horizontally by the movement of the cam. As a durable material, a copper alloy was used to manufacture these rods.
As shown on Fig. 1, the rod is in contact with the cam at a point F, where the rod gives a back and forth motion which is conveyed to the incisal guide plane of the articulator through other rods, d and j. The motion transmitted by a, i and b actives the incisal guide plane to right and left, whereas that coming from c, d and j moves it back and forth.

The gear installed (Fig. 2) is based on a ratio on a ratio of 13:1 and since the motor is a variable one of 30W equipped with an impedance apparatus, the number of motor revolutions can be readily changed from 600 to 3000 r.p.m. by simply adjusting an electric resistance. As a result, the reciprocal motions can be adjustable from 46 to 230 times a minute.

2.3 The automatic stopping of the articulator.

The following device was introduced with a view to stopping the articulator automatically when the artificial teeth have abraded themselves to a given degree.

The dial plate of the incisal guide was replaced by a bakelite plate, 1mm thick, over which a copper plate is placed. The copper plate is connected by means of a wire with a micro relay switch and the guide rod is connected with a positive electrode of 6V dry battery. When the guide plate and rod are in contact, an electric current of 0.2 amperes will instantly activate the micro relay switch and stop the motor movement, thus resulting in an automatic stopping of the articulator. The micro relay switch has been used to avoid possible sparks at a contact point of the guide rod for damage and an oil condensor is also added to reinforce this delicate point of the mechanism. Fig. 3 depicts the stopping of the articulator (ON), while Fig. 4 shows a state in which the articulator is either working or can start moving at any time (OFF). A wiring diagram is given in Fig. 5.

Fig. 3 The state of the stopping of the articulator.
2.4 Automatic counting apparatus.

A time switch and counter have been combined to serve as an automatic counting apparatus throughout the articulator in motion. The revolving rod is equipped with a cam, 10mm in long radius, 6mm in short radius, 4mm thick, to which another rod 3mm in diameter and 50mm in length is attached together with a counter. The counter is activated by a time switch and the motor revolutions are so adjusted as to be 25 reciprocal motions per minute, which are automatically entered on a counting device as long as the motor is in operation.

2.5 Occlusal pressure.

The occlusal pressure in normal clinical conditions is usually accepted to be around 6Kg where the teeth are constantly moistened by the presence of saliva. In our present study, however, it was thought wise to restrict our occlusal pressure at 500g for reason of the heat generation on the occlusal surface. It is reasonable to expect that in actual masticatory habit of the individuals 500g pressure is exerted on one side of the jaws or the same amount of pressure is given on a few cusps.
For our purposes, we decided on the mean value of the repetitive occlusal movements exercised by the articulator, where the number of times till the guide rod was lifted to a height of 0.5mm established for the centric occlusion of the artificial teeth was recorded. Fig. 6 shows a apparatus of biting abrasion testing machine with the full denture.

3. Findings and Discussion

By the use of the testing machine described above, it was possible to record the prescribed movements with a maximum degree of accuracy. With 25 reciprocal movements per minute by activating the articulator for 6 hours daily, it took an average of one week to abrade a test piece by 0.5mm.

<table>
<thead>
<tr>
<th>Upper jaw</th>
<th>Shofu Ace porcelain teeth</th>
<th>G-C Homolooks porcelain teeth</th>
<th>Fujika porcelain teeth</th>
<th>Shofu resin teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower jaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shofu Ace porcelain teeth</td>
<td>135,269</td>
<td>98,896</td>
<td>142,998</td>
<td>172,187</td>
</tr>
<tr>
<td>G-C Homolooks porcelain teeth</td>
<td>93,826</td>
<td>132,497</td>
<td>102,505</td>
<td>146,366</td>
</tr>
<tr>
<td>Fujika porcelain teeth</td>
<td>135,362</td>
<td>126,918</td>
<td>91,004</td>
<td>70,592</td>
</tr>
<tr>
<td>Shofu resin teeth</td>
<td>181,466</td>
<td>150,795</td>
<td>70,939</td>
<td>65,120</td>
</tr>
</tbody>
</table>

Fig. 6 Photograph of the apparatus.
Table 1 gives the mean values of 4 repetitive measurements, where the 16 sections were subjected to one test (thus for a total of 64 abrasion tests).

The test specimens which had been abraded by 0.5mm in our initial work (Table 1) were further abraded by another 0.5mm (Table 2). Table 3 gives the comprehensive result of these findings. On the strength of these, we are enabled to make the following assumptions with a reasonable safety.

Table 2  Results abraded by another 0.5mm after initial work
(The number of times)

<table>
<thead>
<tr>
<th>Upper jaw</th>
<th>Shofu Ace porcelain teeth</th>
<th>G-C Homolooks porcelain teeth</th>
<th>Fujika porcelain teeth</th>
<th>Shofu resin teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower jaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shofu Ace porcelain teeth</td>
<td>149,289</td>
<td>107,388</td>
<td>158,953</td>
<td>184,087</td>
</tr>
<tr>
<td>G-C Homolooks porcelain teeth</td>
<td>105,642</td>
<td>143,960</td>
<td>137,991</td>
<td>163,374</td>
</tr>
<tr>
<td>Fujika teeth</td>
<td>146,506</td>
<td>143,837</td>
<td>103,768</td>
<td>88,652</td>
</tr>
<tr>
<td>Shofu resin teeth</td>
<td>193,680</td>
<td>170,861</td>
<td>85,430</td>
<td>79,704</td>
</tr>
</tbody>
</table>

Table 3  Comprehensive results of Tables 1 and 2
(The number of times)

<table>
<thead>
<tr>
<th>Lower jaw</th>
<th>Porcelain teeth</th>
<th>Resin teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porcelain teeth</td>
<td>130,845</td>
<td>144,807</td>
</tr>
<tr>
<td>Resin teeth</td>
<td>156,166</td>
<td>81,900</td>
</tr>
</tbody>
</table>

1. A complete denture which uses porcelain in the upper and resin teeth in the lower jaw has the highest degree of abrasion resistancy.
2. When this order is reversed, it still has the second highest degree of abrasion resistancy.
3. A complete denture using porcelain teeth in the both jaws is found to be third in order of abrasion resistancy.
4. The use of resin teeth in the both jaws is most susceptible to the abrasion.
5. The sharper the artificial cusps are, the easier are they abraded.

References