ESTIMATE OF REAL PRESSURES OF DENTAL OCCLUSAL CONTACT FROM THE STUDY OF SURFACE TEXTURE PARAMETERS

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INTRODUCTION

Oral health and longevity of teeth and dental restorations are something desirable for dentists and patients but it is common to find collapse or changes on oral structures caused by events that overcome the physiological tolerance. Tooth wear is the most significant signal of dentition collapse and the major part is a consequence of bruxism that is the habit of clenching or grinding teeth [6].

In general, tooth wear studies present high quality, standardization and more calibrated methods [5]. Nevertheless, for studying tooth wear in bruxism it is important to distinguish these particular condition from others such as diet disturbs, metabolism problems and systematic dysfunctions.

Profilometry is a micrometric scale technique that permits to detect an eventual wear in days by scanning on replicas of patient’s teeth. The description for the replica process is available on several papers [1,2,4,8].

Throughout the description of surface texture it is expected to estimate real pressures developed from occlusal contact. It indicates the severity of the mechanism involved in tooth wear. Such estimative is based on the classical model from Greenwood e Williamson [3] that consider that all asperities have the same radius and deform elastically under normal contact according to Hertz equations (1896). Peaks and valleys heights of asperities z are statistically distributed according to a probability density function \( \phi(z) \). The total load supported by all asperities \( W \) and the real contact area \( A \) are given as:

\[
W = \frac{4}{3} N E R^2 \int_{d}^{\infty} (z - d)^{\frac{3}{2}} \phi(z) dz \tag{1}
\]

\[
A = \pi N R \int_{d}^{\infty} (z - d) \phi(z) dz \tag{2}
\]

where \( N \) is the number of peaks, \( E \) is the elasticity modulus and \( d \) is the separation between the reference planes from the two surfaces. For a normal distribution:

\[
\phi(z) = \frac{1}{\sigma \sqrt{2\pi}} exp \left[ -\frac{(z - m)^2}{2\sigma^2} \right] \tag{3}
\]

where \( m \) is the mean of the heights and \( \sigma \) is the standard deviation.

In this paper, we describe an analysis of the contact pressure by means of a classical mathematical model for rough surfaces. An in vitro study will evaluate such free from wear surfaces as grinded surfaces. An in vivo study will evaluate the evolution of bruxers patients using dental models. For this purpose it is necessary to validate statistically the tooth replica process for 3D profilometry essays. The aim of this work is to study dental wear in biomechanical aspects fusing clinical, experimental and analytical techniques of surface and dental contact evaluation.

METHODS

a. In vitro study using analytical model

21 tests were performed by 3D contact profilometry of samples of extracted teeth, 10 were evaluated at free from wear surfaces and the others 11 at worn surfaces. The selected surface texture parameters were: \( S_a \) – mean roughness; \( S_q \) – quadratic mean roughness; \( S_d \) – peaks area density; and \( S_{sc} \) – quadratic mean curvature. These parameters were used on the analytical model to calculate real contact pressures in function of nominal pressure.

b. Replica validation

Extracted teeth (by orthodontics or periodontal indication) with intact crowns were donated for molding (with the agreement of the Ethics Committee of UFMG - ETIC 300/03). The technique used was developed by Pintado et al [7] using addition silicon for molding and epoxy resin for founding.

In this paper it was verified the use of non usual material for dental founding as low viscosity dental resin. The analysis of surface parameters was executed such for the teeth as for their respective replicas with Student test. On a first moment, impressions of vestibular surface from five premolars teeth (one copy for each tooth) were made. Afterward, impressions of occlusal surfaces from another 8 extracted teeth were made. Three copies in epoxy resin and three copies in low viscosity resin (flow) were made for each tooth.

c. In vivo: clinical and experimental analysis

On the first stage of this study the aim was adjust the methodology to verify changes in surface texture from bruxers. Two volunteers had their arcades molded from a period of 18 months with 3 months intervals. On the second stage of this study, the clinical aspects were connected with experimental data to achieve a real comprehension of the
involved mechanisms. For this purpose it were selected 03 volunteers, men, age from 20 to 23 years, without history of systemic diseases, reflow or deleterious habits or using medication, with all teeth and presenting bruxism without the use of miorelaxing plaque.

Those volunteers were examined by a dentist and their models were made for profilometry essays. They were evaluated for a period of 18 months with intervals of 6 months among evaluations.

RESULTS AND DISCUSSION

in vitro study. A real pressure of 6,6GPa for a nominal pressures of 50MPa were found for free from wear teeth and 5,4GPa for grinded teeth (difference of 18, 18%).

Replica verification. Flow and epoxi resin did not differ statistically from original teeth on 95 % significance level for the Student test such as for the grinded as for free from wear areas.

In vivo study. Table 1 presents values for real contact pressures for a nominal occlusal pressure of 50MPa on the first and the final evaluation of each volunteer. Following, the clinical discussion for patients C,D,E:

C – for the first period was observed a raise of cracks on the teeth that agree with the variation of surface texture. On the second period, although the patient related more pain it was not observed changes in surface texture, which indicates that this patient mainly clenched teeth, affecting the temporomandibular articulations.

D – Clinical evaluations registered a raise of roughness on teeth borders that was not verified by profilometry because scan takes place within the wear facet, more flat. On the act of grinding teeth, the facets presents naturally rough borders. On a second moment the patient will unconscious eliminate those rough borders, that, once fragile, will shrink.

E – for this patient the experimental verification agree exactly with the clinical evaluation. The wear is so severe that it is visible which leads this patient to restorative treatments.

CONCLUSIONS

Even though the studied teeth were from different individuals, and each one could be in different stages of wear, this paper brought indicatives of severity degree and evolution of the mechanisms involved. This is a motivation to keep investigating on multidisciplinary approaches, increasing clinical and numerical-experimental methods to investigate the dental wear process.

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REFERENCES


Table 1: Real pressures for occlusal contact of volunteers

<table>
<thead>
<tr>
<th>Real pressures(GPa)</th>
<th>Initial</th>
<th>Final</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient A</td>
<td>2,9GPa</td>
<td>3,2GPa</td>
<td>10,34%</td>
</tr>
<tr>
<td>Patient B</td>
<td>5,9GPa</td>
<td>1,7GPa</td>
<td>71,19%</td>
</tr>
<tr>
<td>Patient C</td>
<td>3,8GPa</td>
<td>3,4GPa</td>
<td>-10,53%</td>
</tr>
<tr>
<td>Patient D</td>
<td>3,2GPa</td>
<td>3,1GPa</td>
<td>-3,13%</td>
</tr>
<tr>
<td>Patient E</td>
<td>2,4GPa</td>
<td>8,2GPa</td>
<td>241,7%</td>
</tr>
</tbody>
</table>