VALIDATION OF AN INDIRECT METHOD FOR TOOTH SURFACE EVALUATION

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Abstract.*Dental wear is a clinical problem that can produce irreversible dental loss. The task of monitoring dental wear is essential to prevent possible progressions and to plan an intervention in this process, but the damage is only perceived to the clinicians when loss and surface changes are severe. Some studies used profilometry to access dental wear with copies of teeth with casts but none of them verified if those copies were reliable. Profilometry is a method that makes possible to extract data from superficial topography in nanometric scale. In this method, a very sensitive stylus slides over a surface and its vertical dislocations are converted on a graphic representing its profile. Data is recorded as a distribution of peaks and valleys This study analyzed both profilometry and tested the reliability of different materials for construction of the samples, epoxy resin and low viscosity dental resin. The use of casts in profilometry is not recommended because casts can be easily destroyed by the stylus. Eight extracted teeth were used, from which three copies in epoxy and three in low viscosity resin were prepared for each specimen. The values of superficial parameters of the original teeth and all copies were extracted and the differences were compared using the average values. The copies in resin, as well as in epoxy, did not present statistically relevant differences from the original tooth at 95% significance, demonstrating that it is possible to use models in epoxy and in flow resin to study teeth superficial texture. As a result, an indirect in vivo study is possible and superficial changes that are not sensed by other methods in a short period of the time can be detected.*

Keywords*: tooth surface, profilometry, wear, teeth, models, superficial parameters*

1. INTRODUCTION

1.1. Dental wear

Tooth wear is an irreversible condition and it may progress in severity with age. Early diagnosis, prevention and intervention are keystones of tooth wear management to avoid future complex restorative treatment (Al-Omiri, 2010). Dental wear is the most common signal of bruxism that is the habit of clenching or grinding tooth (Koyano, 2008; Okeson, 2008). Most of the population (85-90%) will, at some point of life, present this habit to a certain degree (Bader & Lavigne, 2000). Many methods have been developed and used to quantify tooth wear. The most popular method is using clinical tooth wear indices based on a subjective scale used by the clinician. Also, the presence of many wear indices caused problems in the standardization, quantification and reliability of tooth wear quantification (Al-Omiri, 2010).

Other associated problem is the fact that dental wear can occurs in micro scale, being difficult to recognize clinically, even though this micro scale wear is able to cause damage on oralfacial structures such as the temporomandibular joint and pain.

1.2. Profilometry

Profilometry is a very common and sophisticated method, and makes possible to extract data from superficial topography in nanometric scale. In this method, a very delicate stylus slides over a surface and its vertical dislocations are converted in a two-dimensional graphic represention of its profile. The assembly of several profile images results in a tridimensional image. Data are recorded as a peaks and valleys distribution (Figure 1). Profilometry is a potential method to evaluate teeth wear due the high accuracy of the measurements, the use of statistical analysis for the superficial parameters and to the fact that it provides analysis on a shorter period generating reliable data. Some authors have already used profilometry to study dental wear (De Long, Pintado & Douglas, 1994; Bastos, 2004, 2008; Ren et al 2009) but they did not evaluated the capacity of the models to reproduce the grinded teeth surface.

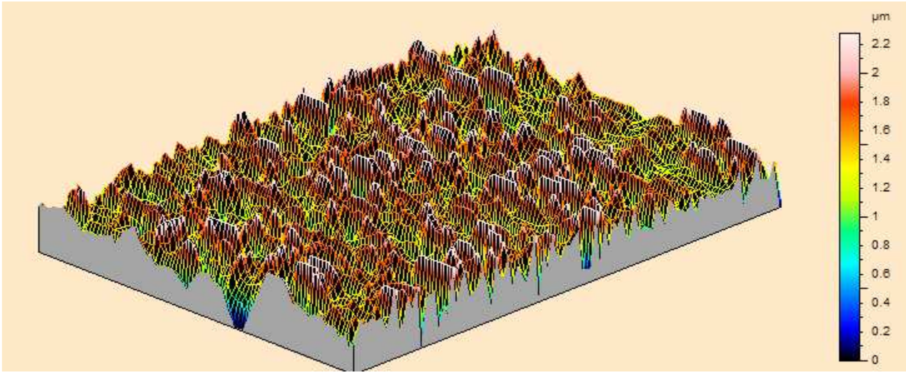

Figure 1. Rugosity profile of a tooth (Bastos, 2004)

Using superficial parameters description, actual pressures developed on dental contact are estimated to indicate the severity of teeth wear mechanisms. Such estimate is based on the classical Greenwood and Williamson model (Greenwood and Williamson, 1966), which considers that all asperities have spherical peaks with same radius R and deform elastically under normal contact according to Hertz equations (Bastos, 2008). The peaks heights (z) are statistically distributed under a probability density function $\phi(z)$. The total load supported by all asperities *W* and the real contact area *A* are given by:

$$W = \frac{4}{3} NER^{\frac{1}{2}} \int_d^{\infty} (z-d)^{\frac{3}{2}} \phi(z) dz \tag{1}$$

$$A = \pi NR \int_d^{\infty} (z-d) \phi(z) dz \tag{2}$$

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 is the standard deviation.

This study analyzed values of profilometry parameters to test the reliability of different materials for construction of the samples, epoxy resin and low viscosity dental resin. The use of casts in profilometry is not recommended because it can be easily destroyed by the stylus. Those materials, epoxy resin and low viscosity dental resin, present advantages that could be useful to obtain reliable copies of real tooth. Eight extracted teeth were used, from which three copies in epoxy and three in low viscosity resin were prepared. The values of superficial parameters of the original teeth and all copies were extracted and the differences were compared using average values.

2. METHODOLOGY

The reliability of the use of dental replicas was previously suggested by Bastos (Bastos, 2004, 2008) for a direct *in vivo* application of profilometry for the analysis of dental surfaces changes. The number of samples in her study was reduced and is extended for this paper together with the use of copy materials that are not usual in dentistry (epoxy resin and low viscosity dental resin). Data here presented came from another sample (Meireles, 2009) and the methodology is based in previous works (Bastos, 2004 and 2008). In this part of the study eight extracted teeth were used, after patient's informed consent and donation under the procedures approved by the Bioethics Committee (process UFMG-ETIC 300/03). The teeth were extracted due to orthodontics or periodontal indication and were preserved in normal saline at 4 °C until prepared for tests. Two canines, two incisors and four premolars were used. The teeth roots were cut off by a high speed air turbine handpiece with spray water cooling (Destisply, USA). The purpose of the cooling was to avoid any overheating that may cause denaturation of tooth. To improve the measuring procedure, the crown was sectioned longitudinally into two halves along the occlusal or mid labial surface using a high speed air turbine handpiece cooled by water spray and the surface containing the area of interest were selected. The tooth fragment was then stabilized in self cured acrylic resin (Jet Classic- Jet®) as shown in Fig. 2.

Later each fragment was molded with addition-curing silicone and then the resulting models were filled with two materials that are not usually used in Dentistry for similar applications: epoxy resin and low viscosity dental resin. The choice of these materials was due to the fact that they have the required fluidity to copy details of the geometry and provide specimen with sufficient hardness to support the profilometry procedure (Figure 2). Models in cast in this case are not recommended because the stylus from profilometer scratches the casts surfaces that are fragile to this test. For each tooth three copies were made in each tested material (Flow and epoxy resin).

Figure 2. Fragment after preparation. Is possible to notice the teeth wear facet.

Profilometry tests (Hommel Tester T4000 from Hommelwerke Gmbh) were performed over selected surfaces of the eight teeth fragments and their replicas. After the test, *Sa, Sq, Sdq, Ssc, Ssk, Sku* and *Sds* parameters were extracted by the profilometer software and the values of the sample were compared. Those parameters were chosen to represent the surface characteristics:

1) Sa (μm/μm): average roughness;
2) Sq (μm/μm): quadratic average roughness,
3) Sdq (μm/μm): quadratic average slope,
4) Ssc (1/μm): quadratic average curvature,
5) Ssk: asymmetry coefficient for the distribution height curve relative to the average,
6) Sku: curtosis coefficient.
7) Sds (p/mm^2): peak density

The first and second coefficients provide an insight on the height's dispersion in relation to the medium plane of the surface, while the next two help in characterizing their shapes. Asymmetry and kurtosis coefficients measure the departure of the obtained surface from a standard normal distribution and the parameter *Sds* provide the number of peaks on the selected area. Those parameters are described on the profilometer handbook (Mummery, 1992).

The roughness standard used was the one proposed by Bastos (2008) based on DIN EM ISO 3274 : 1996 - Europe Standard for Surface Texture: profile method for contact (stylus) instruments. In her study, Bastos (Bastos, 2008) shows that the cut-off value for teeth of 0.05 is ideal.

Comparison between the original tooth and its replicas were made using 2-tailed Student t test for paired samples, with an alpha of 0.05 described by Fisher (Sampaio, 2007). The comparison was done using average values of the parameters, both for tooth/epoxy replica and tooth/resin replica.

Those parameters were used on the analytical model to predict the actual pressure in function of nominal pressure.

3. RESULTS AND DISCUSSION

The values of t were calculated for each parameter according Sampaio (2007), using an Excel spreadsheet. After the calculation of t of Student, a table expressing the difference level of significance was consulted. In this level, and with 7 degrees of liberty, the value founded in the table was 2.365, in these conditions, the value of t calculated for each parameter must be on the interval of -2.365 and +2.365 (two-tailed) for no difference. Table 1 shows that the copies in low viscosity dental resin as well the copies in Epoxi do not present statistically relevant difference from the original tooth at 95% of significance. That means that it is possible to use models in Epoxi and models in Flow resin to study superficial texture. In this case, the study *in vivo* is possible and superficial changes, which are not sensed to other methods in a short period of time, could be done.

Table 1. Mean and *t* values for *Sa, Sq, Sdq, Ssc, Ssk* and *Sku* for surfaces in tooth, epoxy and low viscosity resin replies

	Original Tooth	**Epoxi**		**Low viscosity resin**	
Parameters	**Value**	**Mean of 3 samples**	**t**	**Mean of 3 samples**	**t**
Sa (μm/μm)	0.27 ^{a}	0.26 ^{a}	1.33	0.28 ^{a}	-0.36
Sq (μm/μm)	0.35 ^{a}	0.33 ^{a}	0.94	0.30 ^{a}	1.6
Sdq (μm/μm)	0.10 ^{a}	0.17 ^{a}	-1.1	0.10 ^{a}	-0.22
Ssc (1/μm)	0.10 ^{a}	0.16 ^{a}	-1.62	0.14 ^{a}	-1.46
Ssk	-0.17 ^{a}	-0.09 ^{a}	-1.45	0.06 ^{a}	-2.02
Sku	3.34 ^{a}	3.31 ^{a}	0.21	3.29 ^{a}	0.46

Same letters in same line indicates that there is no significant difference among parameters means on the tooth, epoxy and flow resin replies surfaces. ($t_{7DF,\ 2\text{-tailed, alfa } 5\%}$ = 2.365).

A total of 48 profilometry tests were made (24 for each material) and 8 for the original teeth. For the calculus of real pressures, only the data from original teeth were used. Table 2 presents the values for actual pressure for the eigtht teeth based on Greenwood e Williamson analytical model using Sa, Sq, Ssc and Sds to predict the actual pressure in function of Nominal Pressures. Actual pressure (Total Force/ Number of Peaks - mm^2) is more sensitive than nominal pressure (Total Force/ Nominal Area), then actual pressure values are compatible with values of dental enamel hardness. For the analytical model, were found a nominal pressure of 50 MPa and a actual pressure in agreement with values for the dental enamel hardness described on literature (Bastos, 2004, Heintz, 2006, Field, 2010). 62.5% of the sample presented the value of 2 GPa of Actual Pressure and this could be indicate more severe wear conditions (the values of dental enamel getting smaller for deepiest layers).

Table 2. Experimental results for actual pressure*. Average results of 8 specimens (original teeth).

TEETH	**TYPE**	**ACTUAL PRESSURE (GPa)**
1	incisor	1.90
2	canine	1.95
3	premolar	5.10
4	premolar	2.00
5	premolar	6.00
6	canine	2.00
7	premolar	2.10
8	incisor	2.85

*for nominal pressure value of 50 MPa

4. CONCLUSIONS

In this paper the validity of using replicas to study dental wear was tested and confirmed. Materials not usually employed in Dentistry for similar applications were tested and the results indicate that they can be used effectively for this purpose. The analytical model indicated pressure values in accordance with referenced in literature and suggests that the actual pressure of dental enamel decreases with the depth of enamel layer, which could be associated with more severe conditions of dental wear.

5. ACKNOWLEDGEMENTS

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