Specifying 3D roughness parameters for functional interfaces of dental

components

Ana Claudia Stadler Burak Mehl¹⁾, Giuseppe Pintaude¹⁾, Marjorie Benegra^{1)*} ¹⁾Biomedical Engineering Program, Universidade Tecnológica Federal do Paraná (UTFPR), Brazil Corresponding Author: marjbene@gmail.com

This investigation evaluated the possible contact stresses developed under dental implant/prosthetic pillar pair, considering the binding effect of biomaterials' surface characteristics on their functional performance. 3D surface parameters were used as input for the elastic contact model (Greenwood-Williamson). In this way, it was possible to specify a balance between Sq and Ssc roughness parameters to achieve small contact stress.

Keywords: 3D surface roughness, micromechanical contact, dental components

1. Introduction

During the mechanical contact between the dental implant and prosthetic pillar, the stress distribution is crucial. A lousy adaptation between these components under loading conditions can give rise to micro-slips, besides an opening for microorganisms that cause diseases [1, 2]. In this context, this investigation specifies a balance in the 3D roughness parameters to reduce the contact stress, helping the functions of adaptation and sealing of them.

2. Methods

Four samples were characterized using 3D optical interferometry:

- i. A plate of Ti-6Al-4V alloy (2 x 30 x 40 mm³), obtained using wire electro-discharge machining (WEDM)
- ii. The same sample of (i), but followed by an electropolishing
- iii. A platform surface of a dental implant Ti-CP4,4.1-mm diameter, machined by CNC
- iv. A seating platform of prosthetic pillar Ti-6Al-4V ELI, 4.5-mm diameter, machined by CNC

The average values resulted from three measurements, corresponding to 0.19 x 0.39 mm², with 247 x 512 pixels of resolution. The parameters Sq (root-mean-square height), Ssc (curvature of summits), and Sds (density of summits) were applied to a well-known contact model [3]. Skewness and Kurtosis parameters were used to check the Gaussian distribution. The separation between surfaces (h) was based on the summit height standard deviation (σ_s). Equation (1) gives a fraction of the real contact area (Ac). We chose an apparent area (A₀) of 5 mm² (Figure 1), and the individual contacts were simulated using an applied load of 100 N, typical of static bite.



Figure 1: Possible areas considered in the contact between the dental implant and prosthetic pillar.

2.1. Basic equation

In equation (1), the summit radius (R) and the summit density (D_{SUM}) were calculated based on the roughness parameters Ssc and Sds, respectively.

$$\frac{A_{c}}{A_{0}} = \pi R \sigma_{s} D_{sum} F_{1} \left(\frac{d}{\sigma_{s}} \right) \quad (1)$$

3. Results

After testing different separation values for different combinations of contacts (surfaces i, ii, iii, and iv), the values for contact stresses are presented in Figure 2.



Figure 2: Contact stresses resulting from different Sq/Ssc ratios, using $h = \sigma_{s}$.

For a better contact stress distribution, this investigation addresses a higher Sq/Ssc ratio.

4. References

- El-Anwar, M. I. et al., "New dental implant selection criterion based on implant design.," Eur. J. Dent., 11, 2, 2017,186–191.
- [2] Deceles, C. et al., "In vitro analysis of the microbiological sealing of tapered implants after mechanical cycling," Clin. Oral Investig, 2437– 2445, 2016.
- [3] McCool, J. I., "Comparison of models for the contact of rough surfaces," Wear, 107, 1, 37–60, 1986.