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Research Paper

Effects of different blasting materials on charge generation and decay on titanium surface after sandblasting

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ABSTRACT

It has been reported that sandblasting titanium with alumina (Al_2O_3) powder could generate a negative electric charge on titanium surface. This has been proven to promote osteoblast activities and possibly osseointegration. The purpose of this pilot study was to investigate the effects of different blasting materials, in terms of the grit sizes and electronegativity, on the generation of a negative charge on the titanium surface. The aim was also to make use of these results to deduct the underlying mechanism of charge generation by sandblasting.

Together 60 c.p. 2 titanium plates were machine-cut and polished for sandblasting, and divided into 6 groups with 10 plates in each. Every plate in the study groups was sandblasted with one of the following 6 powder materials: 110 μm Al_2O_3 grits, 50 μm Al_2O_3 grits, 150–300 μm glass beads, 45–75 μm glass beads, 250 μm Al powder and 44 μm Al powder. The static voltage on the surface of every titanium plate was measured immediately after sandblasting. The static voltages of the titanium plates were recorded and processed using statistical analysis. The results suggested that only sandblasting with 45–75 μm glass beads generated a positive charge on titanium, while using all other blasting materials lead to a negative charge. Furthermore, blasting grits of the same powder material but of different sizes might lead to different amount and polarity of the charges. This triboelectric effect is likely to be the main mechanism for charge generation through sandblasting.

1. Introduction

Sandblasting is a commonly used surface treatment method for titanium dental implants to improve on their bone-to-implant bonding. Previous studies have mostly focused on the mechanical impacts of sandblasting on the titanium surface, such as the created roughness (Papadopoulos et al., 1999), residual stress, subsurface microstructure (Pazos et al., 2010) and eventual contamination (Al Jabbari et al., 2012). Among these effects, modifying the surface roughness of

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titanium and its alloys has been considered the main positive effect of sandblasting. Hence, the sandblasting process is designed according to its roughening effects in creating macro and/or micro-level roughness on the titanium surface (Guo et al., 2012). Our recent study indicated that sandblasting with Al_2O_3 powder could generate negative charges on the titanium surfaces (Guo et al., 2012). The negative surface charges on the titanium implant is believed to promote the osseointegration between the subgingival implant fixture and its adjacent bone tissues (Guo et al., 2012; Hamdan et al., 2006; Marcolonongo et al., 1998). Thus, this *de novo* finding might provide a new explanation to the supposed positive effects of sandblasting on osseointegration to titanium surface. This discovery has the potential to lead to optimized sandblasting techniques and, consequently, it might enable Ti implants to form faster, stronger and more durable clinical osseointegration. According to the results reported (Guo et al., 2012), the negative charge generated through sandblasting with Al_2O_3 powder may remain stable on the titanium surface for several minutes until it gradually diminishes.

Before knowing how the charge retention is possible and what clinical applications would be feasible, it is of great interest to find out the origin of the charges. Two possible mechanisms for this charge are considered. First, the generated charges come from the titanium material itself, *e.g.*, sandblasting removes the various titanium oxide layers from the titanium (or Ti alloy) surface, exposing electrons from the atoms of the Ti (or Ti alloy), which are detected as a negative surface charge. The removed TiO_2 (Ti oxides) layer instantly reforms, which then covers up the negative charges of the exposed electrons, and could gradually reduce the negative charge detected on the titanium (alloy) surface. The charges generated on the titanium surface with this above described mechanism should always be negative, regardless of the weight and electro-negativities of blasting materials. Second, the electric charge is generated from the contact of the titanium material and the blasting powder particles. Such contact gives rise to the triboelectric effect, which is the phenomenon involving charge exchange whenever two arbitrary surfaces come into close contact. After the contact disconnects a net charge will remain on each of the surfaces (Lowell and Rose-Innes, 1980). According to the properties of the triboelectric effect certain types of blasting grits would generate a negative charge on the titanium surface, whereas some would generate a positive charge. Therefore, by observing the polarity of the charge generated by blasting grits with different positions in the so-called triboelectric series (Fig. 1, explained further in Section 4), the possible mechanism of charge generation on Ti surface by sandblasting can be deducted.

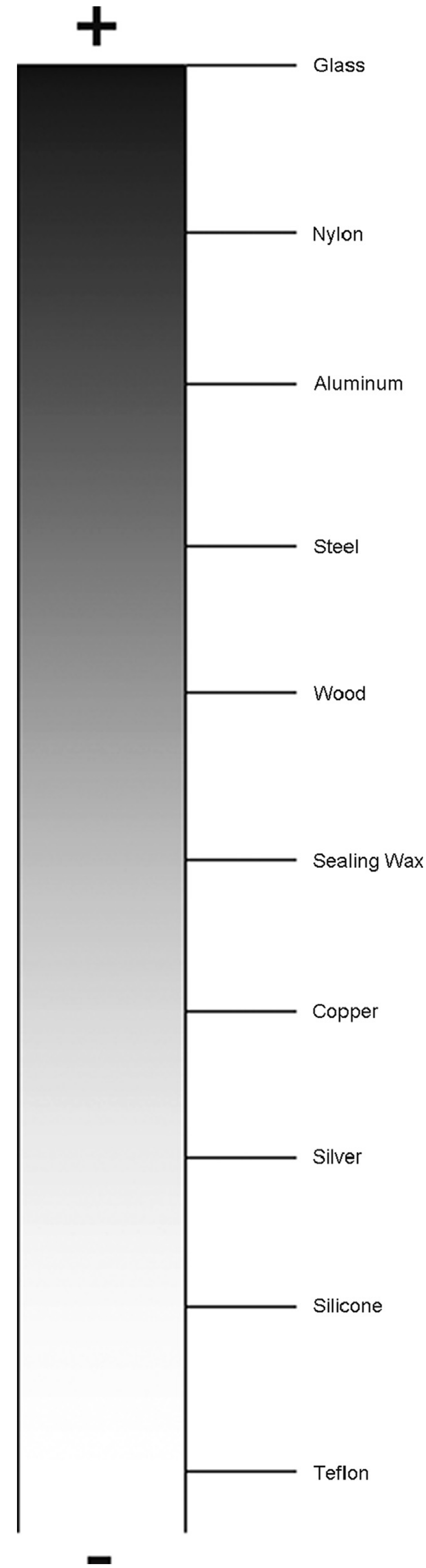

Fig. 1 – Example of the triboelectric series: a relative scale.

2. Materials and methods

2.1. *Titanium plates*

Together 60 c.p. 2 titanium plates, which were 1 mm in thickness and 15 mm in both length and width were used. All plates were pretreated by polishing with abrasive papers in the sequence of the grades 220, 320, 550 and 1000. Next they were ultrasonically cleansed by acetone for 15 min and dried in an incubator at 37 °C overnight. The 60 Ti plates were randomly divided into 6 experimental study groups with 10 plates in each.