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Stability Assessment of 85 Sandblasted and Laser-Etched Surface Zirconia Implant Using the Periotest Method over 4 Months of Bone Integration Time

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Abstract. The stability of a series of 85 one-piece zirconia implants performed by the same surgeon between 2011 and 2015 has been analyzed retrospectively. The stability was measured using the Periotest device during 4 months of osseointegration. The implants had two type of endosseous surfaces: fully sandblasted and laser etched at the crest of the threads. Stability values were assessed starting at the time of placement, two, four, eight, 12 and 16 weeks. The pattern and timing of osseointegration and implant stability resulted in observations similar to that observed with sandblasted and coated titanium implants. As a result of laser etching, the implants displayed higher roughness with a bone like surface topography and appear to have faster osseointegration and higher values of stability in comparison with sandblasted implants.

Introduction

Yttria-stabilized zirconia polycrystal (YTZP- zirconia in the following) was used as a structural material for a medical device the first time in the SIGMA dental implant system introduced to dental implantology by S. Sandhaus on 1980 [1]. The mechanical properties and behavior of zirconia outweigh that of ceramics formerly used in structural applications for dental implants. This is due to the toughening and reinforcing effect of tetragonal-to-monoclinic (t-m) transformation of the tetragonal grains which are maintained at room temperature after sintering by the stabilizing effects of Yttria [2]. The t-m transformation is a very effective dissipative mechanism of the energy field associated with an advancing crack, hindering its propagation and preventing fractures. The biological safety of zirconia has been extensively tested and proven [3].

So far, zirconia is used as toughening and reinforcing phase in composites with alumina used in joint replacements [4]. In addition, zirconia has many applications in dentistry [5,6], especially in the structure and frameworks of crown and bridges obtained by machining of blanks. The next main application of zirconia in dentistry is for dental implants, presently made as one-piece/monoblock or in two-piece (fixture + abutment) configuration. In 2014 Zirconia implants were accounting for about 2% of the global dental implants market, which was about 4.5 Billion US$ worth. It is expected to grow up to 6% -10% in the next five years because of several concurrent factors such as the growing demand of metal-free solutions due to concerns about adverse reactions to metals [7-9], increasing aesthetic requirements especially for front teeth [10], advantages in terms of hygienic properties of zirconia implants due to less plaque formation [11,12]. Oxide ceramics like zirconia, do not exhibit bone-bonding behavior and in order to obtain the osseointegration and ultimate stability of the implant, it is necessary to modify its surface and provide it some roughness [13]. This subtractive surface enhancement not only allows for mechanical interlock by bone ingrowth but also by direct bone-to-implant material contact in the case of zirconia provided that the surface roughness is adequately created [14]. A number of manufacturers, mainly based in Europe, are proposing implant systems with different design and surface enhancement treatments. To verify the effects of two different surface treatments on zirconia implants we analyzed retrospectively a series of 85 one-piece dental implants, measuring their stability over four months and determining objectively their level of osseointegration.

Materials and Methods

Data were collected on 85 consecutively placed one-piece zirconia implants (Z-Systems, Oensingen, CH). All implant procedures were performed by the same surgeon between 2011 and 2015. A total of 37 patients were treated with ages ranging from 36 to75 years of age. There were twenty seven male and 10 female patients. 25 implants were sandblasted, while the remaining 60 had a laser modified surface on the crest of the threads to obtain locally a higher roughness (See Figure 1), while the rest of the thread surface remains unchanged. The stability of the implants was measured using the Periotest method [15] starting immediately post implantation, then two, four, eight, 12 and 16 weeks after implant placement. Periotest Values (PTV) range from most stable to least stable between -8 and +50. Implants were placed as determined during treatment planning and all sizes and diameters available from the manufacturer were used namely small diameter (3.6mm), standard (4.0 mm) and large diameter (5.0 mm). Osteotomies in preparation for implant insertion were done according to manufacturer's guidelines under profuse irrigation. All implants were inserted at slow speed (20 RPM) with insertion torque ranging from 35 to 55 Ncm.

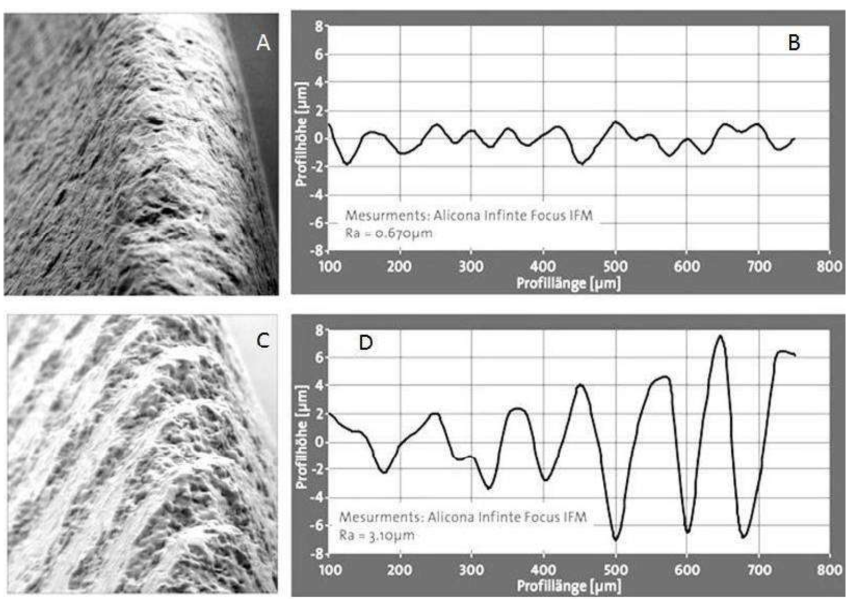

Figure 1. Typical surface and profile of sandblasted implant (A,B) and of sandblasted and laser modified implants (C,D). Magnification 500x. (Courtesy Z-Systems, Oensingen, CH).

Immediately after implant placement, the insertion torque value was recorded as well as the PTV. Since the implants were one-piece, there were cases where the implant abutment had to be reduced. An initial PTV was recorded then another immediately after abutment reduction and no statistically significant difference between the PT values was observed. Type, number, length and position of the implants are summarized in Table 1. The data collected were analyzed to investigate if there was any correlation between implant diameter, length, location, insertion torque and implant surface characteristics on the pattern of osseointegration and implant stability during the four months pre-restorative.

Table 1. Type, position and length of the implants used.

Implant Type	Diameter (mm)	Position		Implant length (mm)			
		mandible	maxilla	8	10	11	13
Small	3.6	4	8		7	5	
Medium	4.0	17	21	5	17	16	
Large	5.0	20	15	11	16	7	1

Results

Results are summarized in Table 2. All implants were evaluated at two weeks post placement where an increase in PerioTest Value (PTV) was observed. There was no statistical difference between the values recorded. Between week 3 and week 4 there was a decrease in PTV across all surface types and insertion torque value categories. However the PTV values for the laser etched surfaced implants was lower than that of sandblasted but remained at levels of stability suitable for the restorative phase of treatment. Two implants failed early, both large in diameter placed in the posterior maxilla and in ridges previously augmented with xenogenic bone. There were no mechanical failures of the zirconia implants during the follow-up period, nor within this cohort.

Table 2. Summary of the average PTVs measured during the study.

Implant Type	Implant Location	Average Insertion Torque (Ncm)	Average PTV					
			Day 1	Week 2	Week 4	Month 2	Month 4	Month 5
Sandblasted	Maxilla	44.7	- 4.7	- 2.1	- 2.7	- 3.3	- 4.1	- 4.3
	Mandible	49.3	- 5.3	- 4.3	- 3.9	- 4.8	- 5.4	- 5.7
Laser Etched	Maxilla	41.3	-3.2	-2.6	-4.7	-5.1	-5.9	-6.3
	Mandible	55.7	-4.7	-3.3	-4.9	-5.7	-5.9	-6.7

Discussion

The stability of an oral implant is essential for its success and optimal function. Implant stability is sought from the time of placement and is known to evolve over time as osseointegration takes place. Based on our data the implant length and diameter have no effect on the PTV values, even when the abutments had to be reduced for occlusal clearance. There was a direct correlation between insertion torque value and initial stability. However, this did not translate to higher PTV compared to lower insertion torque implants at the time the PTV averaged -4.3 value at the time of implant placement. Such findings mirror that of h titanium implants and measuring devices [16].

Conclusion

The results observed over 4 months post implant insertion reflect the already well documented pattern of osseointegration of zirconia implants. The data collected during this analysis show that the laser etched surfaces have higher levels of stability than sandblasted ones.

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