ORIGINAL ARTICLES

THE IMPACT OF THE THREAD DESIGN COMPARED TO THE IMPACT OF THE SURFACE TOPOGRAPHY ON THE PRIMARY STABILITY OF IMPLANTS INSERTED INTO FRESH PIG RIBS

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ABSTRACT

The aim of this investigation was to compare the effect of the thread pitch, thread profile and the surface morphology on the primary stability of implants of a different diameter. Eighty test specimens of dental implants were inserted into 16 untreated pig ribs, as the maximum insertion torque (MIT), periotest values (PTV) and implant stability quotient (ISQ) were measured. Considering the results, we concluded that the higher thread profile, even with a wider thread pitch, affects the primary stability more than the rougher surface of the implants.

Keywords: *primary stability, dental implants, design*

INTRODUCTION

Primary stability is significant for the osseointegration process and for the success of the implant treatment, especially when it comes to immediate loading of dental implants. The effect of thread geometry and the surface modification of the implants on their primary stability is well observed.

The aim of this study was to compare the influence of both elements of the implant design on the primary stability.

The implant thread design should increase the total surface area and create a better stress distribution and should lead to higher primary stability (1,2).

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Orsini et al. (3) placed implants with a thread pitch of 0.5mm and implants with a thread pitch of 1.7 mm into a sheep bone. Their results showed that greater bone-to-implant contact, gained by reducing the thread pitch, may result in greater primary stability in cancellous bone.

The narrower thread pitch is associated with a more favorable stress distribution and better primary stability. However, it should be taken into account that the optimal thread pitch is different for the different thread designs, and according to some authors (4), the optimal thread pitch for the triangular thread is 1.2 mm and for the trapezoidal one it is 1.6mm. A V-shaped thread profile with a thread pitch of 0.8 mm in cylindrical implants is considered by other authors to be optimal for achieving good primary stability (5).

The thread height can be calculated as the difference between the largest and the smallest thread diameter (6).

It is believed that the higher thread profile increases the functional surface of the bone-to-implant interface, which can improve primary stability in low density bone (7, 2).

In an experimental study on the effect of the implant thread height on the primary stability in low density bone, titanium implants of different length, diameter and thread profile with a height of 0.35 mm, 0.85 mm, 0.60 mm and 1.10 mm were placed. The implants with a thread profile height of 0.60 mm and 1.10 mm had an internal diameter of 4.8 mm and an external diameter of 6.0 mm and 7.0 mm, respectively, and those with a depth of 0.35 mm and 0.85 mm had an internal diameter of 3.3 mm and an external diameter of 4.0 mm and 5.0 mm, respectively. The results indicate that deep-thread implants have a statistically higher mean insertion torque, but not lower compressive strength. The deep thread is mechanically stable. The deeper thread can increase primary stability in a bone of lower quality without reducing the mechanical strength (8).

The surface topography is an element of the implant microdesign (7). Today there are many variations of surface modification (9-13). It should also be taken into account that the surface treatment is not always associated with the alteration in the implant microtopography (10,14-16).

Surface modification is definitely a factor for successful osseointegration, especially in lower quality bone (12,17,18). Modification of the implant surface increases the active surface area and helps to provide a stable connection with the surrounding tissue (19). The rougher implant surface favors both: anchoring in the bone and the biomechanical stability of the implant (17).

According to Mazzo et al. (20) acid-etched surface implants have better primary stability than the implants with machine-treated surface. Duncan et al. (21) conducted an experimental study involving implants with three different surface modification. The results obtained, using resonance-frequency analysis, do not differ significantly in the individual groups. Other authors also did not observe significant differences in ISQ values in different surface modification groups, but found lower IT values for the implants with machined surface (22). Dagher et al. (23) found significant differences in the resonance frequency analysis but observed similar torque values during the placement of implants with 4 different surfaces. Other authors (24) also observed that the rougher surface is associated with higher ISQ. According to Skalak et al. (25), there is no particular difference between the primary stability of implants, whose surface is large-grained and those with smaller grains.

MATERIALS AND METHODS

Eighty test specimens of dental implants were placed into 16 fresh pig ribs. The implants were distributed as follows: 20 implants with variable thread profile and thread pitch of 0.8 mm, with smooth surface; 20 implants with the same parameters, but with rougher surface; 20 implants with thread pitch of 1 mm (for diameter of 3.3 mm) and 1.25 mm (for diameter of 4.1 mm) and higher thread profile, with rough surface, and 20 with the same characteristics but with smooth surface. In each group 10 of the implants were with a diameter of 3.3 mm and the other 10 were with a larger diameter – 4.1 mm. The length of all implants is 10 mm. The wider thread pitched implants were tissue level, the rest were bone level, as both designs were cylindrical implants with parallel walls.

The surface of the smoother test specimens was colored by anodization of the titan. The other surface was modified by us by sandblasting it with 110 mm grit Al_2O_3 followed by acid-etching, whereby it became rougher and matter.

The thread profile of the implants with thread pitch of 0.8 mm becomes wider and lower in coronal direction and this of the implants with the thread pitch of 1.25 mm is the same all along the intraosseous part of the implant and as it was mentioned before, it is higher than the first one.

During the insertion of the implants in the pig ribs were measured: the maximum insertion torque (MIT) using iChiropro (Bien Air Dental SA, Bienne, Switzerland), the damping capacity using Periotest Classic (Medizintechnik Gulden, Germany). The resonance frequency analysis was performed using Osstell Mentor (Göteborg, Sweden). During the assessment, the ribs were kept stable using vise.

The site preparation protocol was the following:

1. The position of the osteotomy was marked with a 1.4 mm round bur, then the mark was expanded with a 2.3 mm round bur.

2. Pilot osteotomy was performed using 2.2 mm pilot drill to 10 mm depth at a maximum speed of 800 rpm.
3. The osteotomy was enlarged to the desired diameter with a 2.8 mm drill for the 3.3 diameter implants, then with a 3.5 mm drill for the implants with a diameter of 4.1 mm
4. The orifice of the osteotomy was enlarged with a profile drill with a corresponding diameter. The implant site preparation was performed with continuous cooling with sterile saline solution.

The implants were inserted utilizing contra-angle handpiece CA 20:1 L Micro-series (Bien Air). The insertion torque was controlled and measured during the implant placement using the torque function of the implant unit iChiropro (Bien Air Dental SA, Bienne, Switzerland). Implants were inserted into the osteotomy with speed of 15 rpm. At the end of the insertion, the software calculated the maximum insertion torque.

The damping capacity was assessed using Periotest Classic, utilizing the transfer part of the implants as a suprastucture. The measurements were performed, as the handpiece of the device was held perpendicular to the transfer axis, 0.7-2.0 mm away from its surface and 4 mm above the marginal bone area.

Resonance frequency analysis (RFA) was performed using Osstell Mentor. Smartpeg element was installed on the implant platform. Different types of Smartpeg were used, because of the different implant platforms. The probe of the Osstell Mentor device was held perpendicular to the axis of the Smartpeg at the level of its magnet. Two measurements in two perpendicular directions were done for each implant and as final was considered the mean value of both measurements.

The analysis of all results was performed using IBM SPSS Statistics 19 software.

RESULTS

The mean maximum insertion torque (MIT), periotest values (PTV) and implant stability quotient (ISQ) values of the 3.3 diameter implants of both designs and both types of surface topography are shown on Fig 1.

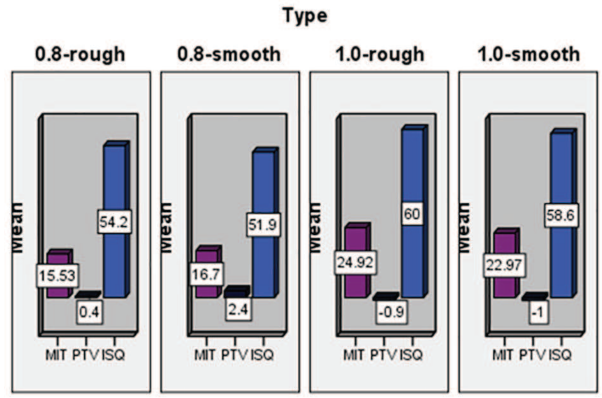

Fig. 1. The distribution of the mean values of the 3.3 mm diameter implants by thread design and surface topography

The results obtained during the placement of the implants of the larger diameter (4.1 mm) are shown on Fig 2.

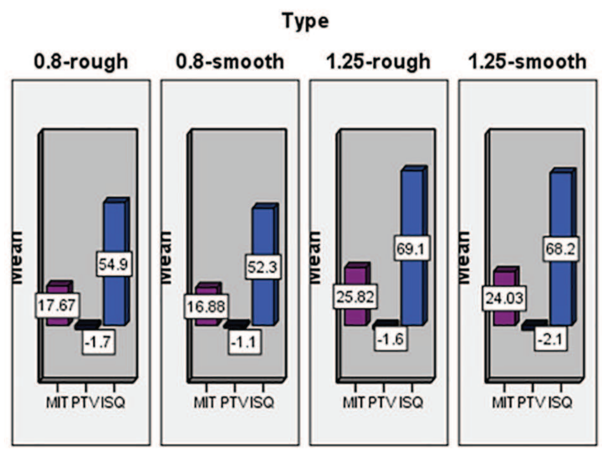

Fig. 2. The distribution of the mean values of the 4.1 mm diameter implants by thread design and surface topography

It becomes clear that the rougher surface and the higher thread profile lead to better primary stability of the implants with dimensions of 3.3 mm/10 mm and 4.1 mm/10 mm. To find out which one of the two factors influences more strongly the implant primary stability we compared the mean MIT, PTV and ISQ of the variable thread profile implants with smooth surface to those of the same implants, but with rougher surface and to the MIT, PTV and ISQ of the smooth surface implants with the higher thread profile. We established that the higher thread profile enhanced the primary stability measured using MIT, damping capacity and resonance frequency analysis more than the rougher surface topography.

DISCUSSION

We observed better primary stability of implants with higher thread profile. The same relation is described by other authors (2,7,8). In our study, the implants with the narrower thread pitch show lower primary stability, which does not match the results of most authors (1-5). It must be taken into account that the thread profile of the 0.8 mm thread pitch implants included in our study is lower than that of the 1.0 mm and 1.25 mm thread pitch implants. Considering the literature data, we suppose that the greater primary stability of the wider thread pitch implants is due to their higher thread profile, not to their wider thread pitch.

In most of the cases we established higher primary stability of the rougher surface implants, as the difference in the measured values does not seem to be very pronounced (between the two groups: rough and smooth surface). Duncan et al. (21) and others (25) also discussed similar relation. Some authors did not observe significant differences in ISQ values in different surface modification groups, but found lower IT values for the implants with machine-treated surface (22), others (23) found significant differences in the resonance frequency analysis but observed similar torque values during the insertion of implants with different surfaces. We think that surface topography affects almost equally both of the parameters.

CONCLUSION

Considering our results and the literature data we concluded that the higher thread profile contributes more to improve the primary stability than the surface modification. To establish how the thread pitch affects the primary stability of the implants, a study, which includes placing of implants with the same thread profile and different thread pitch, should be conducted.

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