Original Article

Evaluation of Changes in the Surface Topography of Implant after Implantation

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ABSTRACT

Objective: This study aimed to evaluate the changes in the surface topography of implant system after implantation procedure. **Materials and Methods:** Branemark implant system was selected and placed and removed in the patient and viewed under SEM for the changes in surface topography. Sandblasting, plasma spraying, and acid etching are the most common approaches used by manufacturers to alter surface topography and increase the surface area of implants. Changes on the implant surface are known to affect the percentage of osseointegration and success of the procedure. The various surface modifications, which aid in osseointegration, could be affected by the insertion torque (35–45 N) exerted during implantation. In this study, we have used SEM – Stereo Scan 440 to evaluate the surface topography. **Results:** The SEM images of the implant system after implantation showedat there is no noticeable difference between the apical and middle portions of the implant. Surface irregularities (roughness) reduced in the coronal portionof the implant. **Conclusion:** Implant surface topography is not the only criterion for implant success; the other considerations such as type of bone, quality of bone, and host response also have an important role in implant success. The complete characterization of complex surface topographies of commercial implants requires more than one method to describe the whole surface topography, from macro to nano range.

Keywords: *Acid etching, osseointegration, plasma spraying, sandblasting, scanning electron microscopy, surface topography*

Introduction

Based on the discovery of Professor Per-Ingvar Brånemark that titanium could be successfully incorporated into bone when osteoblasts grow on and into the rough surface of the implanted titanium, this osseointegrated implant-supported prosthesis has become one of the most acceptable and successful treatment modalities.

Osseointegration was initially defined on the light microscopic level as “A direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant.” A short time later, osseointegration was given more clinical definition as a process in which clinically asymptomatic rigid fixation of alloplastic materials is achieved and maintained in bone during functional loading. Factors that affect osseointegration are implant biocompatibility, fixture design, surface characteristics, surgical techniques, state of host, and biomechanical status and time. The main goal of implanting any material is to obtain an appropriate host tissue response for the particular application.

Endosseous dental implants are introduced as artificial structures into a site that is surgically created within mature tissues, and a sequence of cellular and molecular events is initiated as response to trauma that includes inflammation, repair, and remodeling. It is now widely

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acknowledged that the surface anatomy of an implant at the bone/implant interface has a direct bearing on the "bond strength" between the living bone and the artificial implant surface and will also have a direct effect upon the rate and degree of osseointegration.

Sandblasting, plasma spraying, and acid etching are the most common approaches used by manufacturers to alter surface topography and increase the surface area of implants. A change on the implant surface is known to affect the percentage of osseointegration and success of the procedure. The various surface modifications, which aid in osseointegration, could be affected by the insertion torque (35–45 N) exerted during implantation. Various implant systems with various modifications are available in the market, and manufacturers claim that their product is superior due to surface treatment meted to the implant, which enhances osteogenesis.

Materials and Methods

Nobel Biocare – 3. 5 mm × 13 m. Nobel Biocare (MSR), Dental Implant Centre Chitlapakkam, Chennai, Tamil Nadu, India.

Patients with missing maxillary anterior teeth were selected for this study. A medical history revealed no contraindication to implant therapy.

Methodology

Patient selection

Patients with missing maxillary anterior teeth were selected for this study. Those patients who had a history of diabetes or of any other debilitating systemic disease, or who required ridge augmentation with barrier membranes, or allogenic bone grafting, were excluded from the study. Patients were given detailed explanations of the study protocol and were asked to sign implant surgical consent forms. In each case, irreversible hydrocolloid impressions of maxillary and mandibular arch were made and poured in dental stone. Bone mapping was done to evaluate the bone availability for implant placement.

Fabrication of surgical template

To establish a logical continuity between the planned restoration and the surgical phases, it is essential to use a transfer device. The restoring dentist fabricates the surgical template after the presurgical restorative appointments, once the final prosthesis' optional abutment number and location, occlusal scheme, and implant angulation have been determined. The template should be stable and rigid when in correct position. The ideal angulation for implant insertion should be determined on the diagnostic wax-up, and the template should relate this position during surgery.

Figure 1: Diagnostic wax-up

Diagnostic wax-up [Figure 1] was completed in the cast to preview the tooth size, position, contour, and occlusion in the edentulous regions where implants will be inserted. A full-arch irreversible hydrocolloid impression was made of the diagnostic wax-up and poured in dental stone. On the duplicate cast of the wax-up teeth, a thermoplastic sheet was pressed and trimmed to fit over the teeth and gingival contours of the buccal aspect of the ridge. A surgical template [Figure 2] with 2-mm holes [Figure 3] through the incisal edge position of the anterior tooth was made. It precisely identifies the ideal implant placement.[1]

Surgical procedure

Brănemark (Nobel Biocare)

Brånemark implant [Figure 4] was placed with the help of a surgical template that guides the angulation of the twist drill. An initial access up to a depth of 13 mm with D2 mm twist drill was made. Midcrestal incisions connected with two vertical releasing incisions were performed mesially and distally, and a full-thickness mucoperiosteal flap was elevated [Figure 5], exposing the underlying bone. Progressive widening of the site with a drill of diameter 3.5 mm and length 13 mm was done. Brånemark implants which have TiUnite™ surface and of 3.5 mm diameter were placed with the help of a manual torque wrench of 45 N (implant torque mark on the manual torque wrench) [Figure 6] and retrieved from the site immediately after placement. The measurement of removal torque values was used to evaluate the interface shear strength of titanium implants.[2] The retrieved implants were cleaned with hydrogen peroxide and ultrasonic cleanser to remove organic tissues and unattached bone.

The smallest diameters of the study implants were selected so as to enlarge the osteotomy site with a subsequent drill. TiUnite surface 4.3 mm × 13 mm implant fixture was placed at the surgical site.

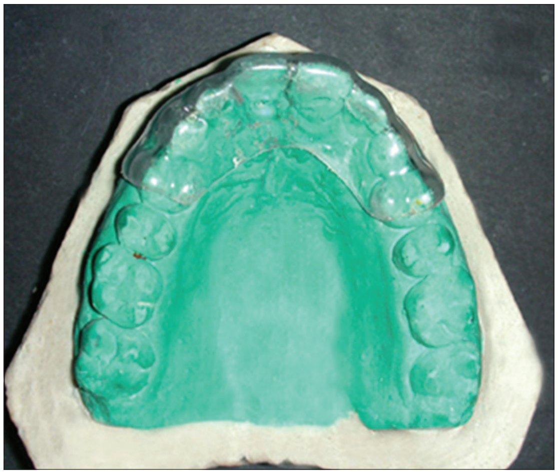

Figure 2: Surgical template

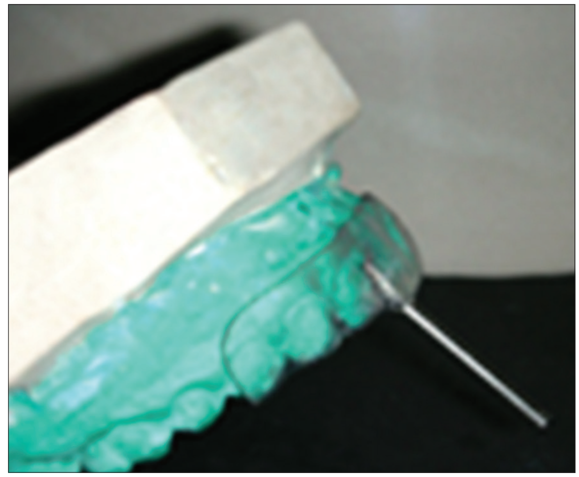

Figure 3: Two-millimeter holes

Figure 4: Branemark implant

The surface topography of the implant surfaces was examined using SEM (Stereo Scan 440) at high magnification (2000 nm) to evaluate changes in the surface topography after implantation procedure. Due to the manner in which the image is created, SEM images have a characteristic three-dimensional (3D) appearance and are useful for judging the surface structure of the test implants. Five micrographs of the implant were examined. The investigation demonstrated a high irregularity of the TiO_2 blasted surface compared to the machined surface.[3]

Results

Sandblasting, plasma spraying, and acid etching are the most common approaches used by manufacturers to alter surface topography and increase the surface area of implants. Changes on the implant surface are known to affect the percentage of osseointegration and success of the procedure. The various surface modifications, which aid in osseointegration, could be affected by the insertion torque (35–45 N) exerted during implantation.

Various implant systems with various modifications are available in the market, and manufacturers claim that their product is superior due to surface treatment meted to the implant, which enhances osteogenesis. However, are these surfaces still maintain their intended patency even after forcing them into the bone at 45 N torque?

Figure 5: Flap elevated

The purpose of this study is to evaluate the changes in the surface topography of the different implant systems after implantation procedure.

In this study, we used SEM – Stereo Scan 440 to evaluate the surface topography. Since profilometer can be used only on flat surfaces to evaluate average roughness (R_a) and S_a values, SEM was used to evaluate the implant surface topography. The advantages of SEM include a large depth of focus, high lateral resolution down to the nanometer range, the feasibility to study structures with a high aspect ratio, and direct production of images of the surfaces. Micrographs produced by SEM easily demonstrate a 3D impression of the surface.

TiUnite surface (Nobel Biocare)

Figure 7 shows the SEM image of TIUN-ITE surface of Brånemark (Nobel Biocare) before implantation. This structure is most similar to that of human cancellous bone.

Figure 8 shows the SEM image of TiUnite surface (apical portion of implant) after implantation. Grains on the surface are more closely packed. There was no noticeable difference compared to the surface topography of the implant before implantation.

Figure 9 shows the SEM image of TiUnite surface (between the apical and middle portions of the implant) after implantation which shows that grains are slightly dispersed compared to the apical portion.

Figure 10 shows the SEM image of TiUnite surface (middle portion of the implant) after implantation. The grains are slightly dispersed compared to those of the apical portion.

Figure 11 shows the SEM image of TiUnite surface (between the middle and coronal portions of the implant) after implantation. The grains appear more widespread when compared to the areas apical to it.

Figure 12 shows the SEM image of TiUnite surface (coronal portion of the implant) after implantation. Grains are more widespread compared to those of apical portion due to contact of the coronal part of the implant to the cortical bone.

Discussion

Titanium and its alloys have been widely used for dental and orthopedic implants under occlusal load-bearing conditions because of their good compatibility, superior mechanical strength, and high corrosion resistance. However, being bio-inert materials, they do not form a chemical bond with bony tissue. Therefore, they must be fixed to bone by mechanical interlocking in clinical use.[4]

One means to improve implant success is through methods to increase the amount of bony contact along the body of implant. Enhanced surface roughness allows a greater area of load transfer of bone against the implant surface.[5] The strongest biomechanical

Figure 6: Implant placement

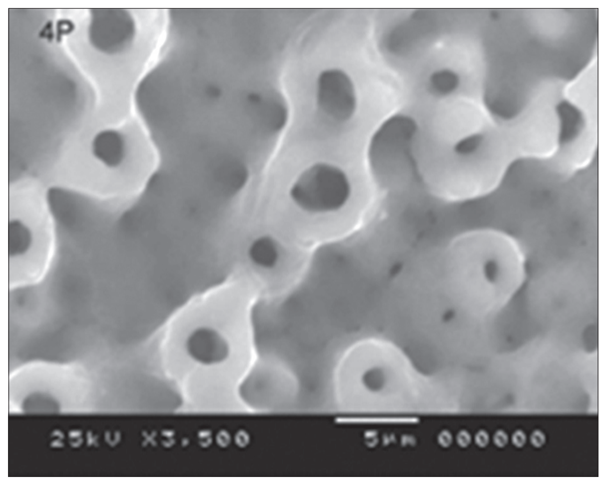

Figure 7: The scanning electron microscope image of TIUN-ITE surface of Brånemark (Nobel Biocare) before implantation

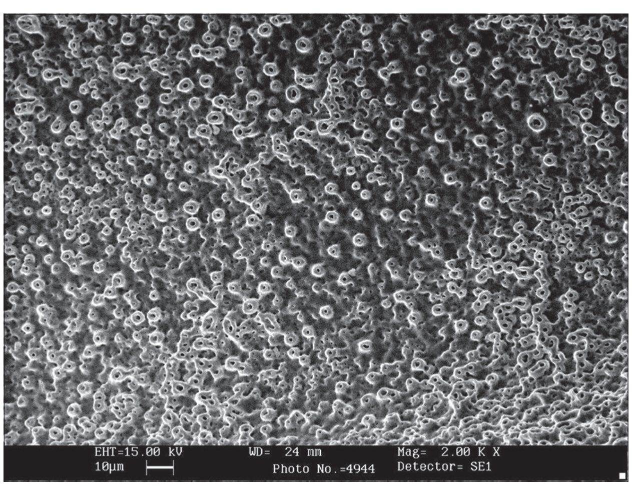

Figure 8: The scanning electron microscope image of TiUnite surface (apical portion of the implant) after implantation

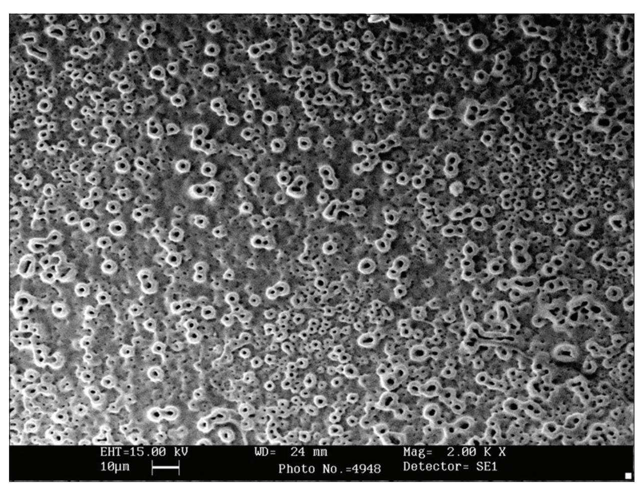

Figure 9: The scanning electron microscope image of TiUnite surface (between the apical and middle portions of the implant) after implantation

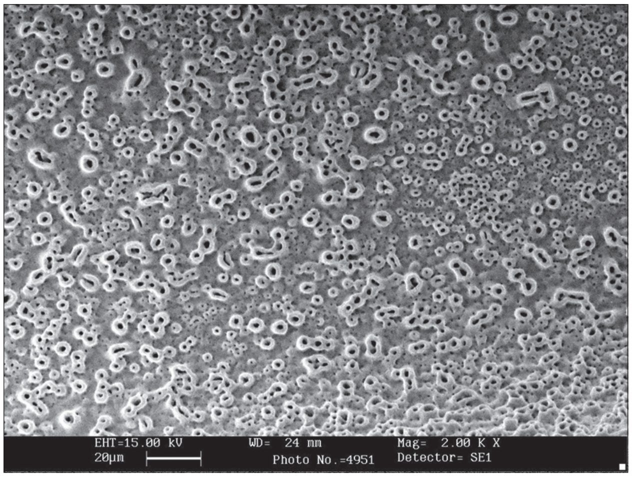

Figure 10: The scanning electron microscope image of TiUnite surface (middle portion of the implant) after implantation

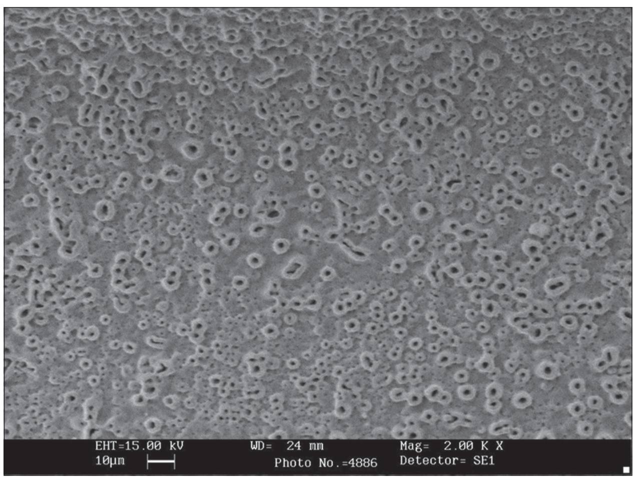

Figure 11: The scanning electron microscope image of TiUnite surface (between middle and coronal portions of the implant) after implantation

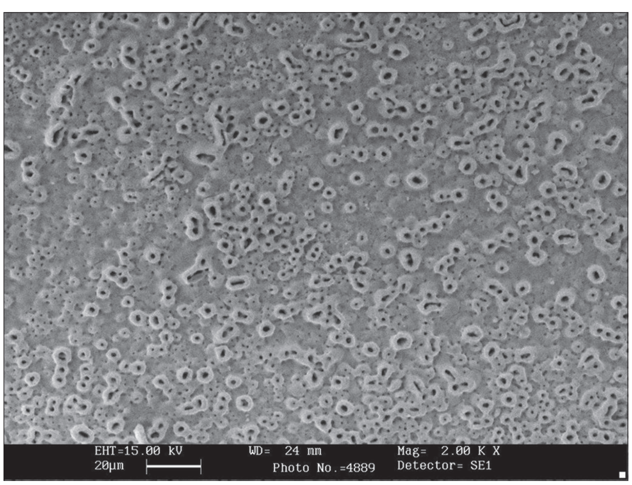

Figure 12: The scanning electron microscope image of TiUnite surface (coronal portion of the implant) after implantation

bonds are seen when the surface roughness of implant is about 1.5 um. Based on the average roughness (S_a), surfaces with an S_a <1 um are considered smooth, and those with S_a >1 um are considered as rough.[6] Surface roughness value for Ti plasma spray is 1.82 μm and that for hydroxylapatite plasma sprays is 1.59–2.94 μm.[7]

Surface characteristics are shown to have a significant effect on implant integration to bone. It is a well-established fact that surface on metal implants is beneficial for the osseointegration process on the bone–implant interface.[8] The current state of information regarding implant surface topography has provided clinicians with confusing options. Machined implants are not smooth, and rough implant surfaces are not at all equivalent. Surfaces are identified by the method of manufacturers and not by the resultant surface.[9]

The mechanical interlocking of micro nano irregularities with tissue plays an important role in bioactivity results, but it is not the only factor.[10] It is, therefore, reasonable to assume that the healing or chronic inflammatory process should begin with reactions taking place between the foreign surface and blood.[11] When there is lack of implant–bone contact, osteogenesis is required to increase the bone–implant contact.[12]

A change on the implant surface is known to affect the percentage of osseointegration and success of the procedure. The various surface modifications, which aid in osseointegration, could be affected by the insertion torque (35–45 N) exerted during implantation. The purpose of this study is to evaluate the changes in the surface topography of the implant system after implantation procedure.

Branemark implant system was used for this study. The surface topography of the implant surfaces was examined using SEM – Stereo Scan 440 at high magnification (2000 nm) to evaluate changes in the surface topography after implantation procedure. SEM of surface topography of the implant system before implantation was taken from respective companies. Surface topography of the implants before implantation shows surface irregularities that are more evenly spaced.

The SEM images of the implant system after implantation showed that there is no noticeable difference between the apical and middle portions of the implant. Surface irregularities (roughness) reduced in the coronal portion of the implant.

Under SEM, the grains on the surface are more closely packed at the apical end of the implant, whereas toward the coronal portion, the grains are more widespread, indicating that the rough surface present preimplantation on the implant smoothen out during implantation due to the torquing force. The greatest diversion from the original surface topography is seen in the coronal portion of the implant because the maximum affect of the torquing force used during implant placement is taken up by it. This is because the coronal portion of the dental implant contact with dense cortical bone during insertion torque, and this might affect the surface topography of the implant.

Conclusion

In spite of these change in the surface topography, we are still achieving good osseointegration. Clinicians must know about the cellular and molecular events that lead to osseointegration. Clinical judgment of bone quality and quantity, implantation site, as well as biomechanics of the implant and type of the final restoration, is important considerations evaluating the properties and features of an implant system.

Implant surface topography is not the only criterion for implant success; the other considerations such as type of bone, quality of bone, and host response also have an important role in implant success. The complete characterization of complex surface topographies of commercial implants requires more than one method to describe the whole surface topography; from macro to nano range.[13]

Limitations of the study

- In this study, the implant was placed and retrieved, so the removal torque might also affect the surface topography
- After retrieval of the implant even if ultrasonic cleansing was done to remove the debris, there may be bone fragment or debris that might alter the original surface topography
- This study should be correlated with clinical results.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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