Evaluations of SLA Surface Completeness

Lee Dae Hee, Hyeon Myeong Ho, Choi Gyeong Hee and Kim Su Hong

With the increasing surface roughness of dental implants, the proliferation, differentiation and substrate formation of osteoblasts are increasing, and consequently, the bone−implant contact surface (BIC) and the removal torque force are also increasing. As a result, bone tissue healing and osteogenesis are facilitated.

According to the physicochemical properties of the implant surface, the growth of calcium hydroxyapatite is determined, biochemical and cellular physical changes in the osteoblasts are induced, and consequently, the bone fusion is affected.

Implants with various SLA surfaces have recently been put on the market.

In this study, the roughness distribution on the whole implant that had an acid−etching SLA surface was examined with the lapse of time, and the changes in the oxide film that could be formed in an ideal sample were analyzed in cooperation with the Cowellmedi Research Center.

1. Test Method

1.1. Surface Treatment

An RBM−surface−treated implant (INNO RBM, Cowellmedi) was put into a solution that was heated at 70° C, and mixed with 50% (w/w) sulfuric acid and 50% (w/w) hydrochloric acid, and then, acid etching was conducted every 10 minutes for 180 minutes.

Using stereo scanning electron microscopy (stereo−SEM), the surface roughness was observed and photographed at a magnification of 10,000x. Using the typical cut−off method of observing the surface roughness by area, stereo wavelength−dependent measurement was performed to calculate the mean roughness Sa per unit surface. In addition, changes in the implant diameter were measured with the lapse of the acid etching time.

1.2. Changes in the Oxide Film During the Implant Placement

Implants that were acid−etched for 70 minutes and had a diameter of 4 mm and a length of 10 mm were implanted at the counter−sink−drilled and non−counter−sink−drilled sites of a first−grade swine bib bone. After the implants were removed, the contaminated surface was cleaned using a 30% phosphate solution and distilled water. Changes in the oxide film in the upper, middle and lower sections of the specimens were observed using EDAX.

2. Results

2.1. Surface Treatment

Fig. 1 shows the changes in the mean surface roughness (Ra) with the passage of the surface treatment time. The Ra was highest in the 70−minute treatment group, followed by the 170−minute and 120−minute treatment groups.

Fig. 2 shows the changes in the implant diameter with the passage of the surface treatment time. The diameter gradually decreased to up to 90 minutes in proportion to the acid etching time, and then abruptly decreased.

Since the acid−etched surfaces of all the groups showed a bright gray color, the distribution of the oxide film was difficult to observe. Nevertheless, the SEM findings for the 10−minute treatment group, which are presented in Fig. 3, showed an irregular distribution of the oxide film in the entire implant area, whereas the SEM findings for the 70−minute group showed a regular distribution of the same.

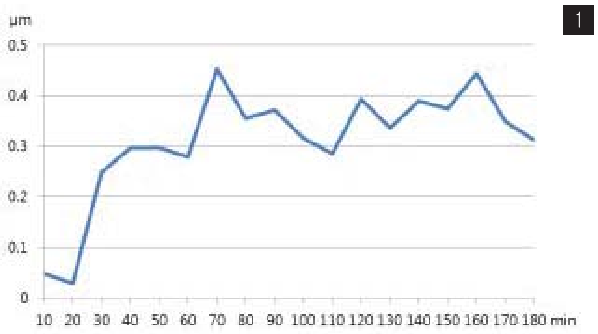
Fig. 4 shows the microstructure of the oxide film with the passage of the surface treatment time. In the 40−minute treatment group, a large dent of 5−10μm was formed. In the 10−minute treatment group, the surface roughness was 0.049 μm, and only microprojections were formed.

Fig. 5 shows the microstructure of the oxide film with the passage of the surface treatment time. In the 10− to 50−minute treatment groups, mainly 1 μm or larger micropores were observed, and in the 60−minute treatment group, less than 1μm micropores.

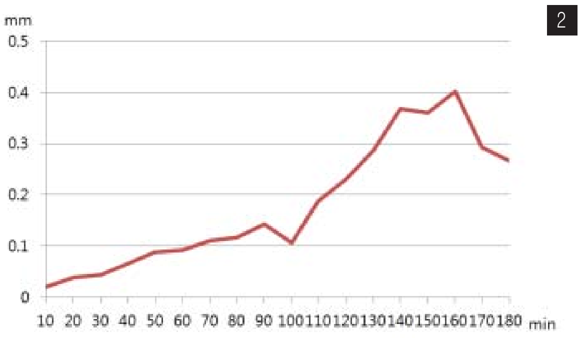
2.2. Changes in the Shape of the Oxide Film During the Placements

On the first−grade swine rib bone, an INNO implant that was acid−etched for 70 minutes and had a diameter of 4 mm

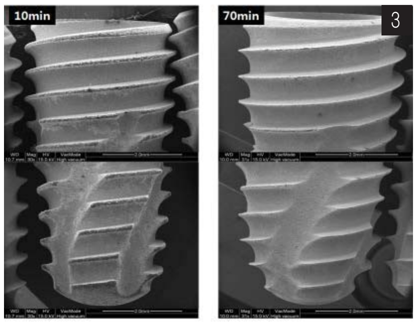
1



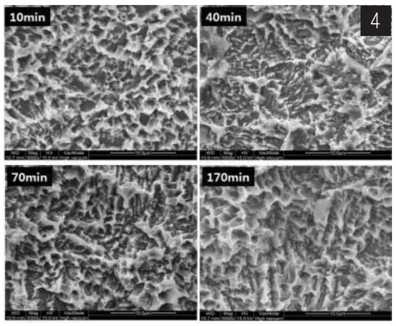
2



3



4



5

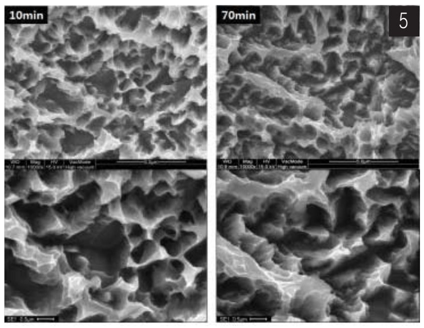


Fig. 1. Changes in Surface Roughness with the Passage of Acid-Etching Surface Treatment Time

Fig. 2. Changes in Implant Diameter with the Passage of Acid-Etching Surface Treatment Time

Fig. 3. Distribution of the Oxide Film in the 10- and 70-Minute Acid-Etching Surface Treatments (30x Magnification)

Fig. 4. Electron Microscopic Images of the Large Dents of 5-10 μm in the 40-Minute Treatment Group (5000x Magnification)

Fig. 5. Electron Microscopic Images of the micropores of less than 1 μm in the 10- and 70-Minute Treatment Groups (10000x and 20000x Magnifications)

Dr. Soohong Kim

- *Representative Researcher at the Cowellmedi−affiliated Organizational biotechnology research Institute*
- *Cowell USC Dental Clinic Director*
- *School of Dentistry of USC, Periodontology Fellowship*

and a length of 10 mm was placed. The maximum insertion torque in the counter-sink-drilled control group was 45 Ncm; and in the non-counter-sink-drilled experimental group, 80 Ncm.

In both the experimental and control groups, no change in the shape of the oxide film was observed in most of the screw area, except in the thread tips. In the maximum thread diameter of the experimental and control groups, a negligible portion of the minute projections in the upper section of the oxide film was slightly compressed (Figs. 6 and 7).

3. Discussion

3.1. Micropore Formation with the Passage of the Surface Treatment Time

The Ra change with the passage of the surface treatment time was greatest in the 70-minute treatment group, followed by the 170- and 120-minute groups. The implant diameter gradually decreased to up to 90 minutes in proportion to the acid etching time, and then abruptly decreased. The maximum Ra increased by 0.4525 μm in the 70-minute treatment group. The oxide film distribution in the 70-minute treatment group was generally even. In terms of the microstructure of the oxide film with the passage of time, the 40-minute and longer treatment groups showed large (5-10μm) dents. Inside these large dents, less-than-1μm micropores were formed in the 60-minute and longer treatment groups. Accordingly, the 70-minute treatment group was confirmed to have had an oxide film with both macropores and micropores, and that the entire implant surface had an even roughness.

BIC is an important assessment variable in implant-bone fusion, and has been reported to be promoted through surface roughness, surface energy and hydrophilic properties. Since these factors should apply to the entire surface of implants, even distribution of the oxide film is crucial.

The assessment of the properties of the surface oxide films of implants currently in the market confirmed a severe deviation in the distributions of their micropores and the macropores and in their roughness. In addition, the authors' recent study on the hydrophilic property of SLA implants showed that an extreme hydrophilic property could be maintained through an alkali cleaning method. Moreover, in this study, the hydrophilic property of the surface that had both micropores and macropores increased more effectively through alkali cleaning rather than through RBM surface treatment or anodizing surface treatment. Therefore, the even microstructure of the 70-minute treatment group was confirmed to be the most favorable for maintaining the hydrophilic property.

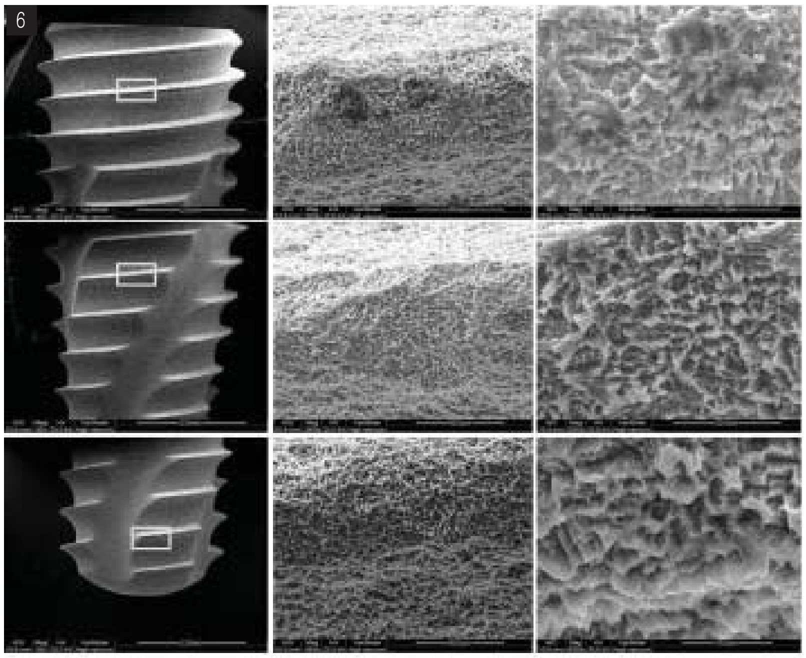
3.2. Changes in the Shape of the Oxide Film During Its Placement

On the first-grade swine rib bone, an INNO implant that was acid-etched for 70 minutes and had a diameter of 4 mm and a length of 10 mm was placed. The maximum insertion torque in the non-counter-sink-drilled experimental group was 80 Ncm, and no change in the shape of the oxide film was observed. In the greatest area of the screw, including the inner-diameter area, absolutely no transformation was observed. Considering that the negligible portion of the minute projections in the maximum diameter of the thread was slightly compressed, the effect of the changes in the shape of the oxide film on the bone fusion was considered minimal.

4. Conclusion

The completeness of the SLA surface treatment varied according to the time factor in the acid etching process. The optimal treatment time was confirmed to have been 70 minutes. Under this condition, up to 0.4525 μm of minute projections and micropores were formed, and the oxide film was confirmed to have been free from abrasion or transformation at a maximum insertion torque of 80 Ncm.

6



7

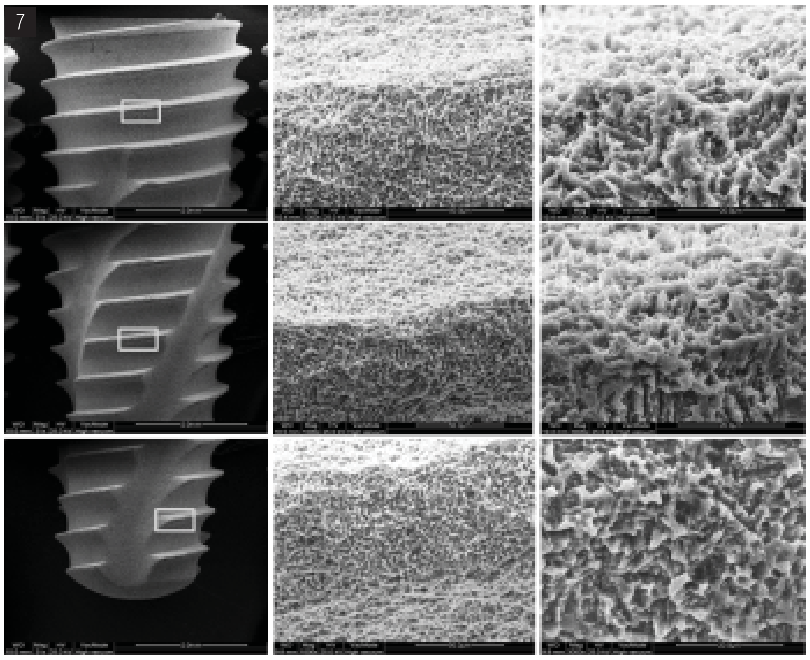


Fig. 6. Electron Microscopic Images of the Changes in the Upper, Middle and Lower Sections of the Oxide-Film in the Control Group after the Counter-Sink Drilling on the First-Grade Swine Rib Bone (30x, 1000x, and 300x Magnifications)

Fig. 7. Electron Microscopic Images of the Changes in the Upper, Middle and Lower Sections of the Oxide-Film in the Experimental Group after the Non-Counter-Sink Drilling on the First-Grade Swine Rib Bone (30x, 1000x, and 300x Magnifications)