Denfo Clinic Implant Surface Treatment Clinical Part

A look into the surface composition and morphology of SLA surface treatment implant that has been recently marketed

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1. Introduction

The surface property of dental implants has been known to be a major factor of osseointegration.[1]
To enhance clinical success rates, various implant surface treatments have been tried.[2-5]
The method of sandblasting and thermal acid etching surface treatment (SLA) has recently been used by many dental implant manufacturers.
In this study, the surface components and shapes of SLA dental implants that were produced in South Korea were compared and analyzed. Through X-ray photoelectron spectroscopy(XPS), stereo scanning electron microscopy (SEM) and surface roughness measurements, the uniformity of the sandblast and the completeness of the acid etching were examined. To confirm the surface migrations, the components of the surface eluate were analyzed using combustion ion chromatography (CIC).

2. Materials and methods

2-1. Materials

SLA implant products of A, B and C that are manufactured and sold by three Korean companies were prepared.

2-2. Stereo-SEM and Roughness Measurements

Using a stereo scanning electron microscope (stereo-SEM), a thin layer of gold was blasted on a cylindrical specimen with threads, and the surface of the specimen was magnified 800 times at 6 degrees to obtain stereo images of the surface roughness. The threaded portion was magnified 300 times to take photographs of it.

To check the surface roughness by section, the upper section was magnified 5,000 times. Three-dimensional (3D) wavelength-dependent roughness measurements were conducted on the upper and lower sections using the typical cut-off method. Using a Gaussian filter with a cut-off wavelength of kc = 31 μm, Sa, the unit roughness (the arithmetical mean of the projecting points on the average surface) of the 340x250μm surface; Sq, the average projecting surface on the average surface; and Rt, the maximum and minimum heights of the projecting plane were calculated.

2-3. X-ray Photoelectron Spectroscopy (XPS)

X-rays were irradiated on the surface of the specimen to measure the energy of the photoelectron emission.
The composition and the chemical bonding status of the specimen surface were measured, and the element components of the upper section were analyzed.

2-4. CIC Measurement

Using CIC ICS 3000 (Dionex, USA), surface migrations of the specimen implant were conducted with15 ml of ultrapure water at 60° C for 2 hours. Then the organic and inorganic molecular anions and cations in the eluate were separated and quantitatively analyzed.

3. Results

3-1. Stereo-SEM and Roughness Measurements

As shown in Fig. 1, the threaded portion had an even surface roughness in all the specimens. However, the shapes of the screws differed from each other. Product C had the thickest threaded portion, and the Cowellmedi product, the thinnest.

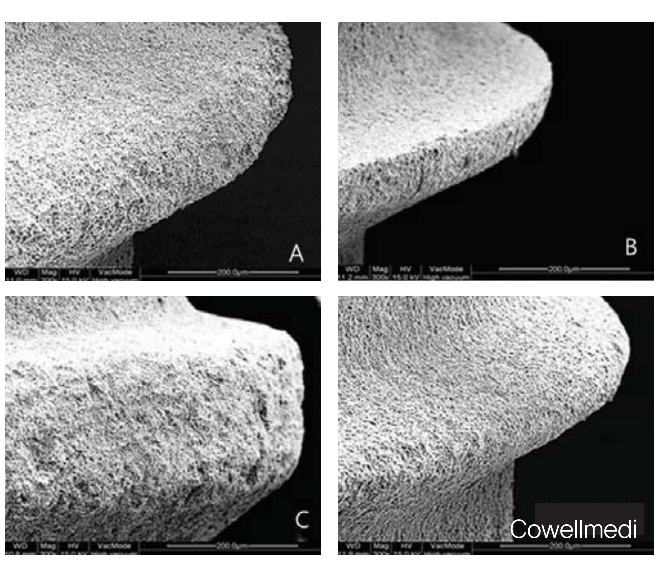

Fig. 1. Shapes of the Threaded Portion and Surface Roughness of Each Product

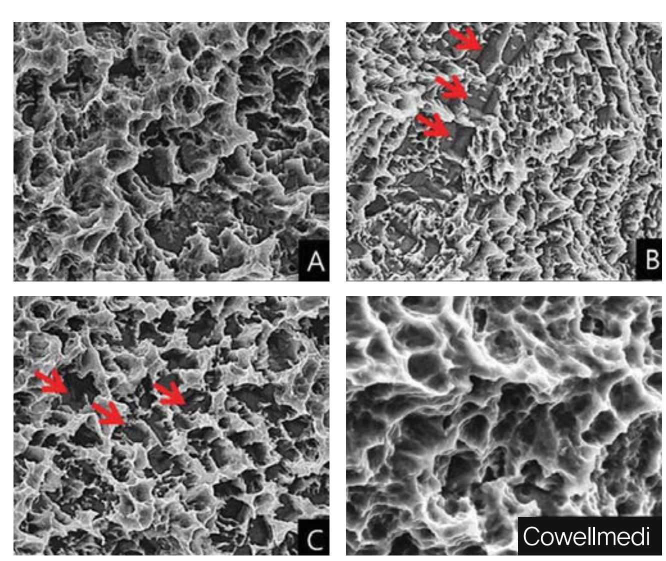

Fig. 2. 5000x-magnified SEM Images in the Upper Section of the Products

Reference

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Fig. 2 shows the 5,000x-magnified SEM images of the upper section of the implants.
Products B and C had insufficient depth of acid etching, so in the figure, they show a part of their sandblasting surface. In comparison, Product A and the Cowellmedi product show even acid etching surfaces. Product A shows the deepest sandblasting surface.

Fig. 3 shows the color stereo-SEM images of the products. Based on the images, the noncontact 3D surface roughness values were calculated, as seen in Table 1.

The mean surface roughness was 1.07-3.11 μm; the mean roughness of the projecting surface, 1.13-3.11 μm; and the difference between the maximum and minimum heights in the projecting plane, 11.64-31.86 μm. Product A had the greatest roughness, followed by products C, Cowellmedi and B.

In contrast, Product B had the greatest surface roughness uniformity in its upper and lower sections, followed by products Cowellmedi, C and A.

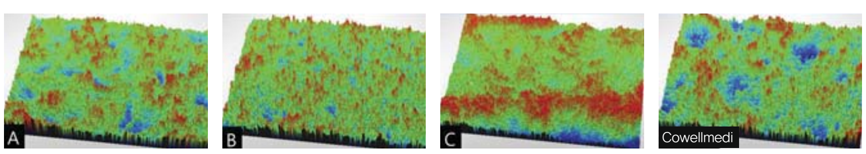

Fig. 3. Color Stereo-SEM Images of Each Product

Sample	Ra(μm)			Rq(μm)		Rt(μm)	
	Upper section	Lower section	⊿	Upper section	Lower section	Upper section	Lower section
A	2.47	3.11	0.64	3.12	3.97	25.89	31.86
B	1.07	1.13	0.06	1.36	1.43	11.64	11.88
C	2.65	2.09	0.56	3.42	2.67	27.84	20.38
Cowellmedi	1.80	1.95	0.15	2.27	2.52	18.49	19.83

Table 1. Ra, Rq and Rt Measurements in the Stereo-SEM Images

Sa: unit roughness (arithmetical mean of the projecting points on the average surface); Sq: average projecting surface on the average surface; and Rt: maximum and minimum heights of the projecting plane

3-2. Changes in the Surface Components

Fig. 4 shows the results of the XPS that was conducted for the surface components of the products.

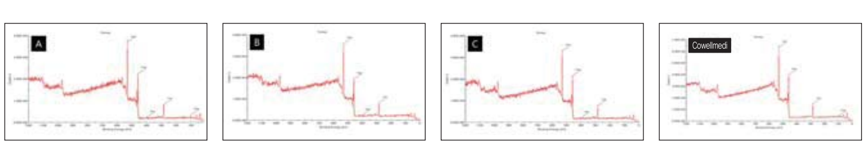

Fig. 4. Surface Component Test Through X-ray Diffraction

Sample	C1s	O1s	Ti2p	Si2p	N1s
A	34.12	45.05	15.11	5.24	0.47
B	31.84	46.49	15.22	4.87	1.57
C	32.19	47.58	17.58	2.65	N.D
Cowellmedi	27.19	50.81	17.61	4.4	N.D

Table 2. Quantitative Analysis of the Surface Components Through XPS

3-3. CIC Measurement

Using CIC ICS 3000 (Dionex, USA), similar types of ions were detected in all four products.

The results of the quantitative analysis are shown in Table 3. No foreign matter or acidic material was detected. The organic and inorganic molecular anions and cations were separated and quantitatively analyzed.

Sample	F^-	Cl^-	NO_2^-	SO_4^{2-}	Br^-	NO_3^-	PO_4^{3-}
A	N.D	0.024	0.027	0.002	N.D	0.031	N.D
B	N.D	0.027	0.019	0.002	N.D	0.030	N.D
C	N.D	0.071	0.020	N.D	N.D	0.023	N.D
Cowellmedi	N.D	0.024	0.020	N.D	N.D	0.032	N.D

Table 3. CIC (Combustion Ion Chromatograph)

4. Discussion

4-1. Surface Roughness and Completeness of the Acid Etching

The 5000x-magnified electron microscope images and color stereo-SEM images of the products showed different roughness levels.

The observation of the completeness of the acid etching confirmed that products B and C had deeply scraped metal areas that were not completely acid-etched through the sandblast process. The surface property has been reported to have affected the behavior of osteoblasts.[6-10] Therefore, even acid etching is required. Considering the limited size of the specimen in this study, additional studies with many specimens may be needed.

The observation of the surface roughness distribution confirmed that the difference in the Ra levels of the upper and lower sections of products A and C increased by about 0.6 μm with the increase in the surface roughness. Unlike the other products, Product C showed greater surface roughness in its upper section than in its lower section.

The difference in the surface roughness level seems to have been caused by the sandblast process that used various types and sizes of sand, and the air pressure.

Product A had the roughest surface, followed by products C, Cowellmedi and B.

Considering that Straumann's SLA active implants had a mean roughness of 1.75 μm with the acid etching surface shown in Fig. 5, Cowellmedi's INNO SLA implants seem to have been most similar to Straumann's SLA active implants among the specimen products.[11]

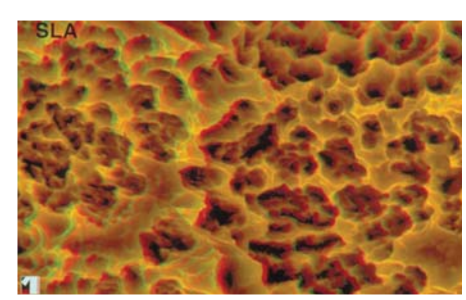

Fig. 5. Surface Electron Microscopic Images of Straumann's SLA Implants

4-2. Surface Components

The surface components were quantitatively analyzed using XPS. The surface components of the products were similar: about 30% carbon, 47% oxygen, 16% titanium and 4% silicon. Silicon seemed to have been affected by the silicon protection membrane during the acid etching process. The titanium and oxygen levels were the highest in the Cowellmedi product.

4-3. Eluate Components

From the CIC, similar ions were detected in the four products.
The components and quantities of these ions that did not affect the body, so they were confirmed to be safe.

5. Conclusion

The analysis of the SLA implants that have been introduced in the market confirmed that all of them had a rough surface and satisfactory acid etching uniformity in both their upper and lower sections.
In addition, no hazardous material that could inhibit bone regeneration was observed in their surface components and in the eluate, which confirmed that their manufacturers cleaned them excellently.