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Effects of Titanium Curette, Air Polishing and Titanium Brush on Implant Surface Roughness Using Scanning Probe Microscopy

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Abstract

Background: In peri-implant mucositis and peri-implantitis, inflammation extends to peri-implant tissue, which is associated with bone loss and can cause implant failure. To regain peri-implant tissue health, debridement and cleaning of implant surface without damaging it must be performed prior to any other treatment. Thus, this study aimed to assess the effect of titanium curette, air polishing and titanium brush on implant surface roughness.

Methods: In this in vitro, experimental study, 2 SNUC titanium implants with 6 mm diameter and 10 mm length were sectioned into 10 pieces. Implant pieces were randomly divided into 4 groups (n=5) for polishing with titanium curette, air polishing, titanium brush and no intervention (control group). Surface roughness was determined under a scanning probe microscope (SPM) by measuring Ra and Rz parameters. Data was analyzed using Kruskal-Wallis and Mann-Whitney tests at significance level (α) of 0.05.

Results: Ra and Rz values of the four groups were not significantly different ($P=0.002$). Air polishing group showed the lowest surface roughness and titanium curette group showed the highest surface roughness followed by titanium brush group, compared to control group.

Conclusions: Air polishing group showed the lowest surface roughness compared to control group but an appropriate debridement technique should be chosen based on the treatment chosen for peri-implantitis.

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Background

Patients often seek treatment to replace their lost teeth, improve their dental esthetics and function and increase their quality of life (1). Implant placement is becoming a common modality for dental rehabilitation in edentulous patients. Implant placement has a success rate of 88% in the maxilla and 93% in the mandible (2). Success of implant depends on osseointegration of implant in bone (3,4).

Despite high success rate, implant treatment can lead to certain complications and even failure. Implant failure is multifactorial (5). Peri-implant tissue is constantly exposed to bacterial plaque, pressure and prosthetic procedures (6-8). Presence of infection and inflammation in peri-implant tissue may cause implant failure (9). In peri-implant mucositis and peri-implantitis, inflammation extends to peri-implant tissue (9), which is associated with bone loss and can cause implant failure (5). Thus, plaque removal from the implant surface is required for long-term clinical success of implant (10). Implant surface changes the molecular and cellular activity of peri-implant structures. Thus, higher porosity in the surface allows for greater adhesion of molecules and enhances osseointegration (11-14). Bacterial adhesion is also enhanced as the result of porosities on implant surface, and as long as contamination and inflammation

Highlights

- The mean Ra and Rz values of curette group had significant different with air polishing and control groups
- The mean Ra and Rz values of air polishing group had significant different with titanium brush group
- The mean Ra and Rz values of titanium brush group had significant different with control group
- Results showed a significant difference in mean Ra among the four groups.
- The mean Rz values of the four groups were also significantly different.

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exist, wound healing is impaired. Thus, new bone regeneration and osseointegration require debridement of the lesion and cleaning of implant surface prior to resective or regenerative treatments (15).

An ideal mechanical implant cleaning method must eliminate bacteria without changing the implant surface because biocompatibility of implant may be compromised (16). Surface roughness of titanium implants may change the peri-implant soft tissue response and compromise the interaction of implant and peri-implant bone (16,17).

Several tools have been proposed for implant cleaning. Although no consensus has yet been reached regarding the most effective tool with the least damage to implant surface, it has been widely acknowledged that a tool used for dental implant cleaning should not damage the implant surface and should not cause implant surface roughness and plaque retention (18).

To date, several tools and techniques have been recommended to prevent bacterial colonization around gingiva and implant (19), including mechanical polishing by manual curettes and different materials (20). These tools can be made of plastic, fiber, carbon, stainless steel and titanium. Their efficacy has been studied for implant surface cleaning and possible modifications in implant or prosthesis, which can compromise implant survival (21,22). Cafiero et al studied implant neck in 50 tissue level implants and found a significant difference in surface roughness between air polished and control surfaces (23). Mengel et al (20) and Matarasso et al (9) reported that air polishing caused no change in implant surface. Matarasso et al evaluated changes in titanium implant neck and reported that titanium curette increased surface roughness (9). Mengel et al observed that titanium curette caused no damage to implant surface (20).

Given the inconsistency in the results of studies and availability of different techniques and tools for elimination of bacterial colonization in peri-implant tissue and significance of implant surface cleaning with minimal damage to implant surface, this study aimed to compare the effects of titanium curette, air polishing and titanium brush on implant surface roughness.

Materials and Methods

This in vitro, experimental study was conducted on 2 titanium implants (SNU Cone Dental Implant, Korea) with 6 mm diameter and 10 mm length. Five transverse sections with 2 mm thickness were made and the 5 segments were further sectioned vertically using a disc cutting machine (Fanavaran Pars, Tehran, Iran) (Figure 1).

Thus, 10 samples with 2 mm thickness were obtained from each implant. The exclusion criterion was destruction during sectioning, which did not occur in any sample. The samples (n=20) were coded and randomly divided into 4 groups of five each, namely, titanium curette (A), air polishing (B), titanium brush (C) and control (untreated, D).

$$n = \frac{(z_{1-\alpha/2}+z_{1-\beta})^2(\delta_1^2+\delta_2^2)}{d^2}$$

$$\alpha = 0.05 \rightarrow z_{1-\alpha/2} = 1.96$$

$$1\text{-}\beta = 0.80 \rightarrow z_{1-\beta} = 0.84$$

$$N = \frac{2\left(Z_{1-a/2}+Z_{1-b}\right)^2 *\ (\delta)^2}{d^2} =$$

$$\frac{2\left(1/96+0/84\right)^2 *\ (1)^2}{(1/8)^2} = 5$$

All the polishing was done by one person who was trained and tested and the values were validated and confirmed by a senior periodontist to minimize the observer bias. Samples were fixed to a clamp. In group A, titanium curette (Aesculap, Germany) was used with constant pressure and three consecutive contacts with the surface and a 5-mm range of motion on implant surface. In group B, air-polishing system with glycine powder (Perio-mate, NSK, Japan) was used with maximum air pressure of 5 k/cm^2, maximum water pressure of 2 k/cm^2 for 30 seconds and maximum power at 90° with 1 cm distance from the implant surface. In group C, titanium brush (Tigran Brush, Tigran Technologies AB, Sweden) was used with constant pressure at 800 rpm for 15 seconds. The pressure applied to implant in each procedure was similar to that applied to natural teeth in clinical setting. All procedures were performed by an experienced periodontist with the mean pressure applied in the clinical setting. Besides that, other factors including frequency of brushing motion and curette strokes on the surface, duration of air polishing and titanium brush use, power settings (air polishing), speed (titanium brush), distance and angle of use (air polishing) and range of motion (titanium curette) were all standardized. Three 10x10 μ^2 areas were randomly selected from the surface of each sample and their surface roughness was measured. Qualitative and quantitative assessments of surface roughness of samples were done using a scanning probe microscope (SPM) and non-contact atomic force microscopy (AFM; Dual Scope C-26, DME, Denmark) with a higher-than-2.5 μ accuracy. Ra and Rz are different parameters of roughness. The Ra (mean area of porosities) and Rz (mean height of porosities) values were calculated. Data was analyzed by the SPSS version 22 using the Kruskal-Wallis and Mann-Whitney tests.

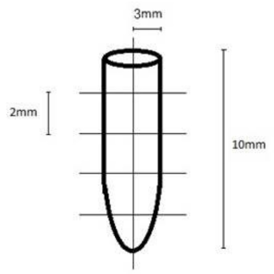

Figure 1. Transverse and Vertical Sections Through Titanium Implants.

Results

This study was conducted on 20 samples (created by sectioning of two titanium implants) divided into four groups of five each. Samples in each group were debrided and evaluated under SPM to calculate the Ra and Rz values (Tables 1 and 2, Figure 2). Since the assumption of homogeneity of variances was not met, Kruskal-Wallis test followed by Mann-Whitney test was used to perform data analysis.

The Kruskal-Wallis test results showed a significant difference in mean Ra among the four groups ($P = 0.002$). The mean Rz values of the four groups were also significantly different ($P = 0.002$). Mann-Whitney test was then performed. Table 3 shows the Mann-Whitney test results.

Discussion

Implant placement is commonly used for dental rehabilitation in edentulous patients (2). Despite its high success rate, implant treatment may be associated with certain complications or even failure. Several tools have been recommended for implant surface cleaning. There is a consensus that tools used for implant surface cleaning should not damage the implant surface or cause surface roughness (18). This study aimed to compare the effects of titanium curette, air polishing and titanium on implant surface roughness.

Table 1. Mean Variations of Surface Ra Roughness by Debridement Technique

Group	Mean	SD	Minimum	Maximum
A	188.80	52.746	129.00	244.00
B	654.20	125.13	531.00	805.00
C	208.80	110.81	101.00	347.00
D	683.20	35.63	659.00	744.00

Table 2. Mean Variations of Surface Rz Roughness by Debridement Technique

Group	Mean	SD	Minimum	Maximum
A	1279.20	300.68	804.00	1560.00
B	3260.00	715.96	2510.00	4250.00
C	1174.60	512.52	588.00	1830.00
D	3228.00	369.14	2830.00	3800.00

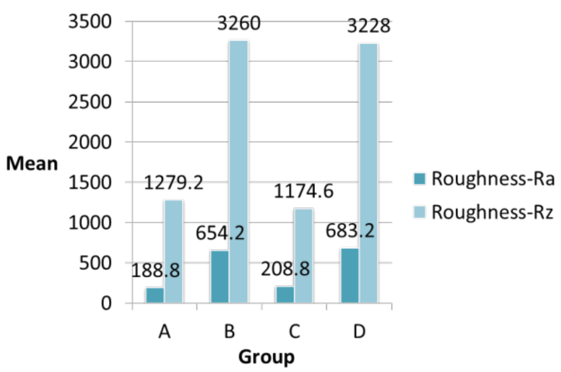

Figure 2. Mean Surface Roughness by Debridement Technique.

Table 3. *P* Value Calculated From the Comparison of the Surface Roughness of Different Groups by the Mann-Whitney Test

Rz[a] *P* Value	Ra[b] *P* Value	Compared Groups
0.008	0.008	A vs. B
0.841	0.99	A vs. C
0.008	0.008	A vs. D
0.008	0.008	B vs. C
0.841	0.841	B vs. D
0.008	0.008	C vs. D

[a] Rz: It is the arithmetic mean value of the single roughness depths of consecutive sampling lengths.
[b] Ra: It gives a good general description of the height variations in the surface
P value < 0.05 was considered significance level.

Our results showed that the control group had the roughest implant surface followed by air polishing group, while the titanium curette and titanium brush groups showed the smoothest surface. The slightest change in surface roughness (compared to the control group) was noted in the air polishing group and the greatest change was observed in the titanium curette and titanium brush groups.

Cafiero et al evaluated implant neck in 50 tissue level implants and found that titanium brush caused the highest surface roughness and air polishing caused the lowest surface roughness, with the difference between test and control (untreated) groups being statistically significant (23). The inconsistency of their results with ours may be due to the implant surface evaluated since we evaluated implant body while they evaluated implant neck. Mengel et al reported that titanium curette left no trace on the surface and eliminated only very tiny amounts from the surface (20). Their results are in disagreement with ours, which may be attributed to the load applied. They also reported that implant surface remained intact after polishing, which is in line with our results. Augthun et al reported that air abrasive system caused slight changes in implant surface at different levels (24), which is in agreement with our results.

Our results showed that although titanium curette and titanium brush created a smoother surface, they caused the greatest change in roughness when compared to the control group. In our study, air polishing yielded the roughest surface while the least changes in implant surface, as compared to the control group, were also noted in this group.

One limitation of our study was variation of implant diameter in different segments. To overcome this, of every 4 segments, one was randomly allocated to each group. Another limitation of this study was the use of one implant model. The need for mounting and fixing of the samples for debridement was another limitation of our study; we used clamps for this purpose to prevent damage to the implant surface during the process of mounting. Failure to measure roughness of the entire surface of samples was another limitation of our study. To overcome this, we measured roughness in three points on each surface and considered the mean value of the 3 measurements to be the measure of surface roughness. Changes in implant surface roughness are not necessarily similar to other changes in implant surface texture and assessment of these changes such as change in oxide layer thickness following the use of different modalities and their association with surface roughness was beyond the scope of our study.

Selection of modality depends on our intention and goal of treatment. Some in vivo studies reported a threshold Ra of 0.2 mm for surface roughness, so that in surfaces with lower Ra, bacterial accumulation significantly decreases while microbial plaque accumulation increases in those with higher Ra (18,25). Thus, if resective treatments are used or the implant surface is left exposed to facilitate cleaning, modalities yielding a smoother surface such as titanium curettes and brushes are preferred.

In addition, implant surface changes the molecular and cellular activity of the surrounding structures. Greater porosity of the surface enhances molecular adhesion and promotes osseointegration (11-14). Thus, if regenerative treatments are used and re-osseointegration is needed, air polishing with glycine powder will yield a rougher surface and is preferred.

Conclusions

Our results showed that although titanium curettes and brushes yielded a smoother surface, they caused a greater change in roughness compared to the control group. The roughest surface was obtained after air polishing while the least changes (compared to the control group) were also noted in the group receiving air polishing.

Authors' Contribution

All authors contributed to creating, processing and writing of manuscript.

Ethical Statement

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

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