Surface Modification of Ti Implants Used in Dental Applications

Gökçen Erdem[1], Özen Gürsoy[2], Aslı Günay Bulutsuz[3], Çiğdem Mercan[4], Ezgi Tan[5], A. Bülent Katiboğlu[6], Gökhan Orhan[2], Derya Dışpınar[2]

[1]Department of Oral and Maxillofıcial Surgery, Istanbul University, Istanbul, 34093, Turkey
[2]Department of Metallurgical and Material Engineering, Istanbul University, Istanbul, 34320, Turkey
[3]Department of Mechanical Engineering, Yıldız Technical University, 34220, Turkey
[4]Department of Oral and Maxillofıcial Surgery, Istanbul Aydın University, 34153, Turkey
[5]Chemistry Department, Istanbul University, Istanbul, 34320, Turkey
[6]Faculty of Dentistry, Beykent University, 34500, Turkey

Abstract

Titanium and its alloys are widely used in clinical applications because of mechanical properties, high corrosion resistance and biocompatibility properties. Recent researches about oral implantology are focused on decreasing of treatment duration of patient. Modified surface of titanium dental implant screw is the most important factor which decreases the duration by expediting osseointegration. Increasing roughness of surface of dental implant screw with acid etching is one of the surface modification methods. In this study, Ti specimens were immersed in three different acid solutions in different temperatures and held for different durations. Then, the specimens were examined with SEM to observe change of its surface roughness. Weight changes were also recorded.

1. Introduction

Titanium is widely preferred in clinical medicine and dentistry because of mechanical properties, high corrosion resistance and biocompatibility. Ti reacts with oxygen in the air to form a stable thin film of TiO_2. The TiO_2 layer protects Ti from corrosion. However, this layer gets unstable when Ti material is exposed to reducing environment and corrosion can occur. Ti surface can be modified with acids. Surface topography of implants in dental applications is quite important for osseointegration. Modified surface of dental implant increases, osseointegration enhances, and so length of treatment period of patients gets shorter in applications. Surface modification can be performed by many methods such as sandblasting-acid etching (SLA), plasma spraying, coating etc. SLA is most performed technic in all of these. However, most recent studies have shown that sandblasting process before etching could endanger health of patient because of leaving residues in SLA process. So, studies have focused on acid etch modification without sandblasting. HCl, H_2SO_4, HF, HNO_3 etc. are some of the acids used in the process.

2. Experimental Procedure

In this study, the effect of etching with different acid concentrations and with different time on the surface morphology of Ti6Al4V (Grade 5) alloy was investigated. For this purpose, two different experimental study were carried out. In the first one, sulfuric acid (H_2SO_4) solution was prepared at different concentrations: 48, 60, 75 and 95% for Ti6Al4V alloy plate samples with dimensions of 10x10x2 mm^3. The samples were treated with H_2SO_4 concentrations for different durations: 30, 60, 180 min. at the room temperature in order to comparing the etching effect. The initial and final weights of the samples were measured and the weight change per unit area (Δ) was calculated. Surfaces of untreated samples and treated samples with the highest Δ value for each concentration were examined by scanning electron microscopy (SEM). The chemical composition of the alloy is shown in Table 1. In the second one, H_2SO_4 solution was prepared at concentration of 48% for Ti6Al4V alloy cylindrical samples with dimensions of π x 3^2 x 20 mm^3. These samples were treated with concentration of 48% H_2SO_4 solution for different durations: 30, 60, 90 and 180 minutes at the room temperature and 60°C in order to comparing the etching effect. However, was not calculated for second step of the experimental study, Δ values were not calculated but whole samples were examined by SEM.

Table 1. Chemical composition of the T6Al4V alloy (wt. %).

Al	V	H	N	O	Fe
6.17	4.19	0.0026	0.005	0.065	0.042

3. Results and Discussion

In the first stage of the work, the weight loss in the unit area (Ϫ) for each sample was calculated. As it is seen in Figure 1, the lowest values for the 30th minute and the highest values for 180th minute were calculated for all samples in solutions at different concentrations. For each concentration, almost linear correlation was found between the etching time and the weight loss in the unit area.

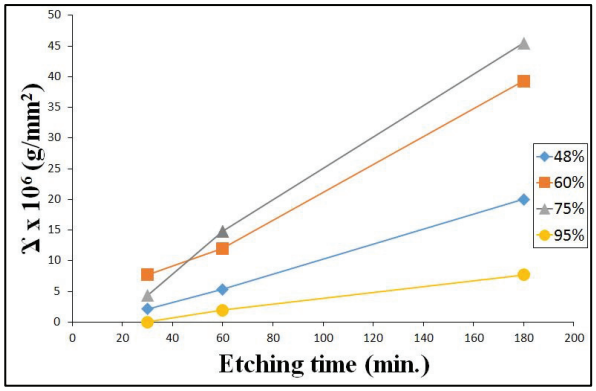

Figure 1. The effect etching time on weight loss in the unit area.

In the second stage of the study, the effect of H_2SO_4 solutions at different concentrations (48, 60, 75 and 95%) on the implant material surface was investigated. As can be seen in Figure 2, the sample in 75% concentration H_2SO_4 solution was showed the highest Ϫ value at 60 and 180 min. The sample in 48% H_2SO_4 solution show the highest Ϫ value at 30th minute. Contrary to expectations, the samples in 95% H_2SO_4 solution had the lowest Ϫ value for each etching time.

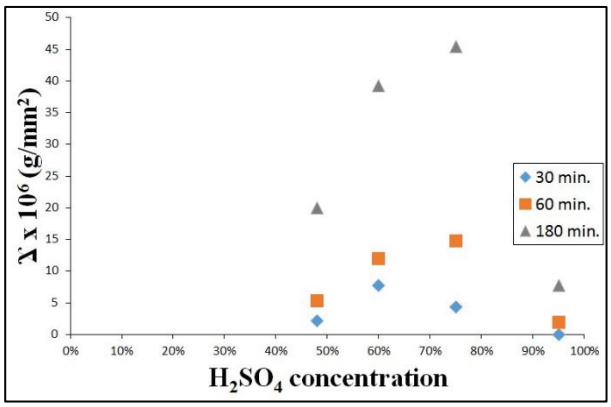

Figure 2. Effect of acid concentration on weight loss in unit area.

The highest Ϫ values were obtained for all the sample in the different concentration of H_2SO_4 solution at 180 minutes etching time. SEM analyzes of the samples was shown in Figures 3 and 4.

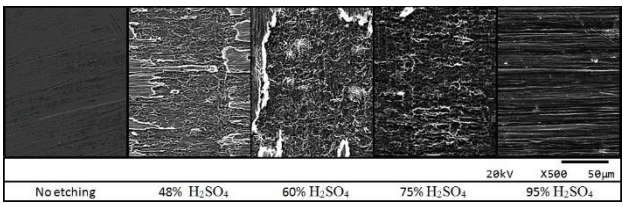

Figure 3. SEM images of 180 minute etched samples (X500).

As shown in Figs. 3 and 4, the maximum roughness on the surface was found the sample in 75% H_2SO_4 solution, and least roughness occurred the sample in the concentration of 95% H_2SO_4 solution. As conclusion, Ϫ values results were found coherent with SEM images.

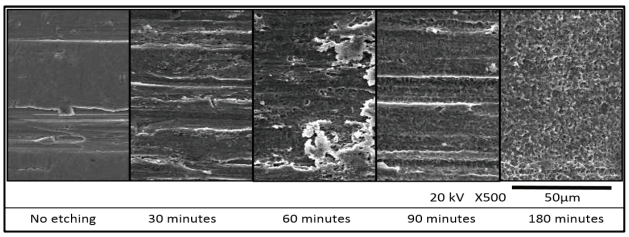

Figure 4. SEM image of 180 minute etched sample in concentration of 48% H_2SO_4 solution (X500).

For the second study, the maximum roughness on the surface was found the sample in 48% H_2SO_4 solution during 180 minutes at 60°C according to SEM.

4. Conclusion

Acknowledgment

References

[1] S. Ban, Y. Iwaya, H. Kono, H. Sato, Dental Materials, 22, 1115-1120, (2006)
[2] P. S. Vanzillotta, M. S. Sader, I. N. Bastos, G. d. A. Soares, Dental Materials, 22, 275-282, (2006).
[3] X. Yang, Y. Chen, F. Yang, F. He, S. Zhao, Dental Materials, 25, 473-480, (2009).
[4] S. Cho, K. Park, "The removal torque of titanium screw inserted in rabbit tibia treated by dual acid etching", Biomaterials, 24, 3611-3617, (2003).
[5] F. M. He, G. L. Yang, Y. N. Li, X. X. Wang, S. F. Zhao, "Early bone response to sandblasted, dual acid-etched and H_2O_2/HCl treated titanium implants: an experimental study in the rabbit", Int. J. Oral Maxillofac. Surg., 38, 677-681, (2009).