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Morphologic Change of Implant Surfaces Conditioned with Tetracycline-HCl

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Abstract. The purpose of treatment for peri-implantitis is to achieve structural and functional restoration of the lost supporting tissues around implants, including re-osseointegration. Both surgical and non-surgical approaches in combination with a variety of anti-microbial treatment regimens have been applied depending on the size and shape of the bone defect. Tetracycline-HCl (Tc) treatment has been considered as a effective chemical modality for decontamination and detoxification of contaminated implant surfaces. The aim of this study was to examine if Tc conditioning changes the microstructures of the modified surface of dental implants. Dental implants with (1) hydroxyapatite-coated surface (HAS) (Replace® select HA, Nobel Biocare AB, Göthenburg, Sweden), (2) TiO_2-blasted surface (TBS) (Astra TiOblast®, ASTRA Tech AB, Mölndal, Sweden) were used in this study. Tc treatment noticeably altered the surface of HAS and TBS. HAS and TBS were partially removed from the implant surface as early as 90 and 60 sec, respectively.

Introduction

Improved integration of bone tissues to implant surfaces have achieved by increasing rough surface of dental implants [1,2]. However, this appears to be predisposed to an increased risk of pathogenic bacterial infection and contamination with bacterial products, and it is extremely difficult to completely remove them from the surface [3].

One of the critical regimens that is required for the establishment of re-osseointegration is to decontaminate and detoxify the contaminated implant surfaces [4], and a variety of mechanical and chemical modalities have been used to achieve this goal [5-7]. Mechanical modalities using metal, titanium or plastic curettes, and an abrasive air-powder instrumentation have been impractical and ineffective especially for rough surfaced implants. Among the chemical modalities, Tc treatment has been widely used and regarded as an effective modality for the decontamination and detoxification of contaminated implant surfaces especially with increased roughness.

The aim of this study was to examine the effects of Tc treatment on the implant surface with specific regard to the microstructures of various modified dental implant surfaces. We report that it noticeably changes the microstructures of HAS and TBS.

Materials and Methods

Seven implants each with (1) hydroxyapatite-coated surface (HAS) (Replace® select HA, Nobel Biocare AB, Göthenburg, Sweden), (2) TiO_2-blasted surface (TBS) (Astra TiOblast®, ASTRA Tech AB, Mölndal, Sweden) were used.

Five implants from each group were fixed on a culture dish with cement to evaluate the effects of Tc conditioning on the implant surface. The middle area (approximately 5x5 mm^2) of each implant was rubbed with small sponge pellets soaked with Tc solution (50 mg/ml) for 30, 60, 90, 120, or 150 sec. The sponge pellet was changed with a new one every 30 seconds. As the control, two implants from each group were rubbed with sponge pellets soaked with distilled water for 0 or 150 sec. The treated sites were then thoroughly rinsed with distilled water for 1 minute, air dried, and coated with gold for 240 seconds under a base pressure below 0.1 Torr using an ion sputtering coater (Eiko, IB-3, Tokyo, Japan). The treated surface of the implants was observed and three photographs from three areas (approximately 1 mm apart) were taken from each treated area using a scanning electron microscope (SEM, Model S-2300, Hitachi Co., Tokyo, Japan).

Results

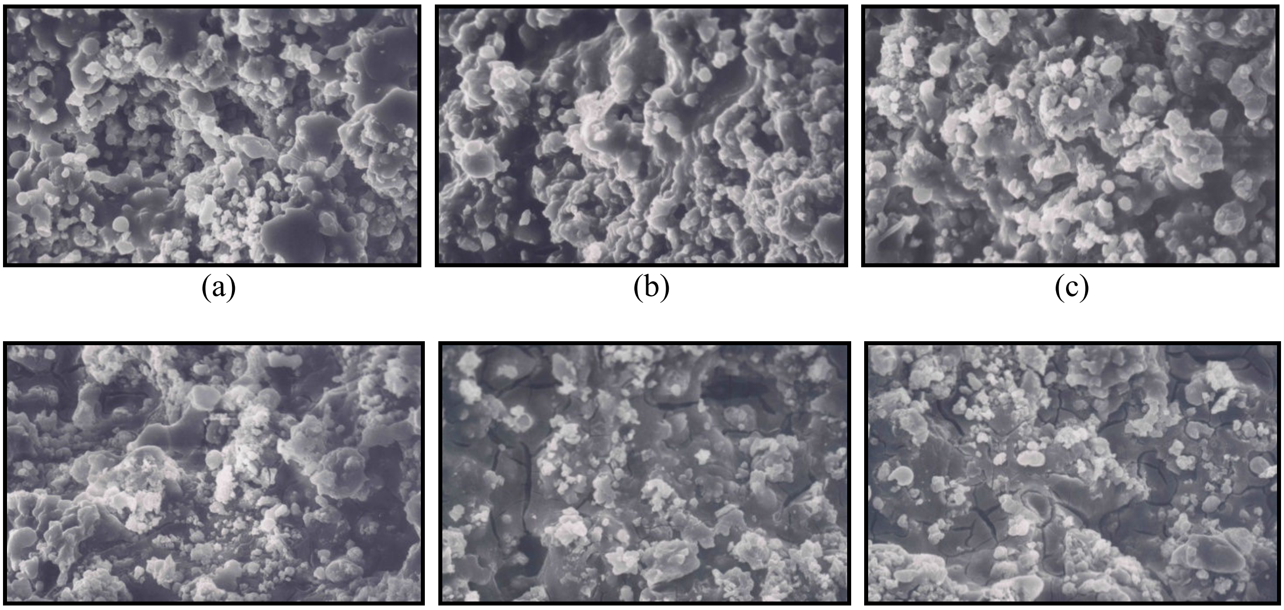
Control groups did not show any significant changes on the implant surface regardless of implant types and the duration of rubbing of the surfaces with sponges soaked with distilled water. Representative photographs only taken from untreated implants were included for control groups. Implant surface treated with Tc in the experimental groups repeatedly showed similar surface morphology, and their morphological characteristics and changes were described below.

1. Hydroxyapatite-coated surface (HAS)

Control groups demonstrated a typical hydroxyapatite-coated surface that is rough and isotropic surface with round particles (Fig. 1a). However, Tc conditioning caused significant changes. The specimen started to show crack lines at 90 sec (Fig. 1d), and significant loss of morphologic characteristics at 120 sec after Tc treatment. Further, the irregularity of HAS surface was decreased and the flattened areas became wider at 2 min (Fig. 1e).

2. TiO_2-blasted surface (TBS)

Control specimens showed a rough surface with small pits (Fig. 2a). The irregularity of TBS was increasingly decreased and the flattened areas became wider after Tc conditioning for 60 sec to 150 sec (Fig. 2c-2f).



(a) (b) (c)

(d) (e) (f)

Fig. 1 HA-coated surface (X2,000).

(a) No conditioning

(b) Conditioning for 30 sec. Note no remarkable change.

(c) Conditioning for 60 sec. Note no remarkable change.

(d) Conditioning for 90 sec. The cracks lines were shown.

(e) Conditioning for 120 sec. The surfaces showed the loss of particles.

(f) Conditioning for 150 sec. The irregularity was lessened and the flattened areas became wider.

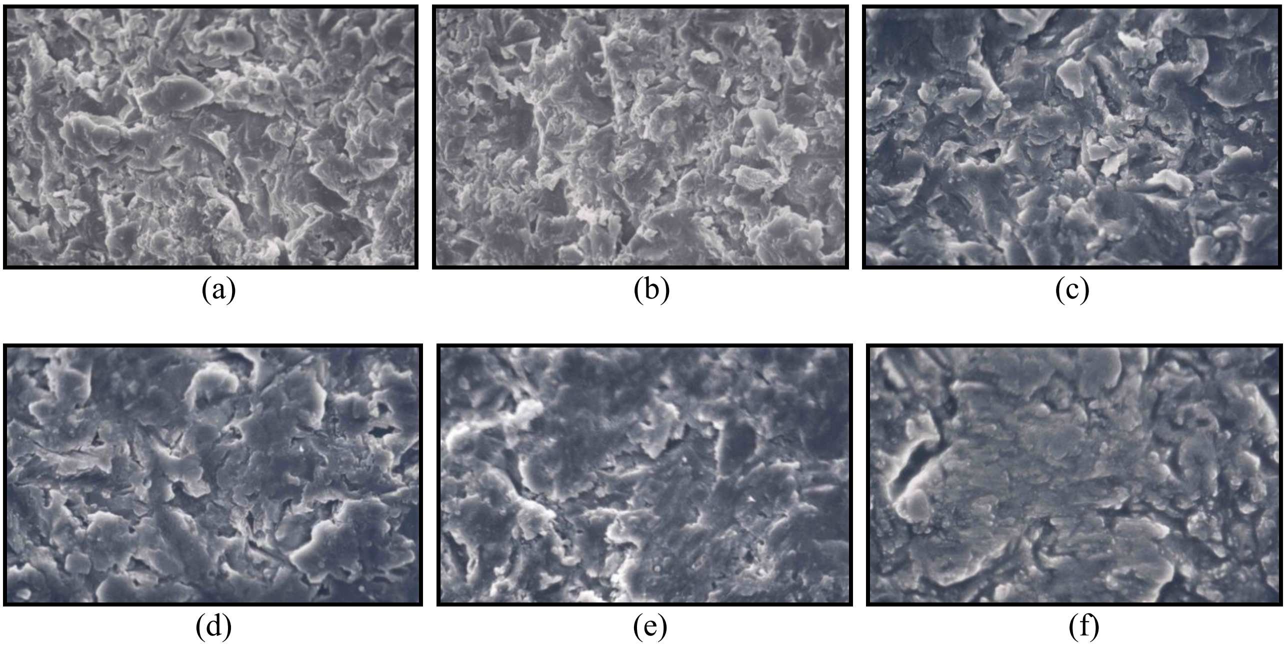


Fig. 2 TiO_2-blasted surface (X2,000).
(a) No conditioning
(b) Conditioning for 30 sec. Note no remarkable change.
(c) Conditioning for 60 sec. Melting appearance was observed.
(d) Conditioning for 90 sec. Note remarkable melting appearance.
(e) Conditioning for 120 sec. Note more remarkable melting appearance.
(f) Conditioning for 150 sec. The surface exhibited the loss of original characteristics.

Discussion

Chemical treatments have been applied to decontaminate and detoxify infected implant surfaces, and chemicals, such as citric acid, chlorhexidine, and tetracycline-HCl, have been widely used. Although citric acid was effective for the removal of endotoxins from the contaminated implant surface [3,7], it is chemically unstable in solution [8]. Chlorhexidine is also considered as a good conditioning agent, but tends to bind to endotoxins and form a complex that may hinder re-osseointegration [5]. Thus, tetracycline-HCl has been regarded as the most promising agent for implant conditioning and has several unique functional properties that would promote tissue repair and re-osseointegration [9].

In this study, we used a concentration of 50 mg/ml of Tc that has been applied to decontaminate and detoxify the infected root and implant surfaces [7], and also for demineralization of the root surface. In particular, this concentration has been known to promote active chemotaxis and proliferation of fibroblasts, while concentrations higher than 50mg/ml inhibit their migration and proliferation [10].

In general, chemical treatment of infected root and implant surfaces has been carried out for 3 minutes [11,12]. Consequently, we chose to rub the implant surface for two and half minutes with sponge pellets soaked with Tc solution. The purpose of rubbing was to mechanically remove microorganisms or endotoxin from the rough implant surface. Unlike previous studies in which cotton pellets were used for the same purpose [13], we decided to use sponge pellets over cotton pellets to eliminate the possibility of leaving any debris from cotton pellets that may interfere with re-osseointegration. In order to completely remove the chemical on the implant surface that may form a complex with endotoxins, the surface was thoroughly irrigated with distilled water for 1 min.

We demonstrated that Tc conditioning significantly altered the surfaces of HAS and TBS as early as 90 and 60 sec, respectively. These findings strongly suggest that the surface modifications made by HA coating and TiO_2 blasting are affected by Tc treatment. It is most likely that the acidity of tetracycline-HCl is responsible for the implant surface alteration.

The primary purpose of HA coating on the titanium implant surface is to promote osseointegration by increasing the biocompatibility and inducing osteoconductivity. Also, TiO_2 blasting the implant surface is used to enhance osseointegration by increasing the surface roughness. In both cases, their partial loss of the original surface microstructures after Tc treatment would diminish re-osseointegration unless the duration of Tc treatment is reduced to less than 90 and 60 sec, respectively. It is of interest to determine if Tc treatment for less than 90 seconds can effectively kill microorganisms, decontaminate and detoxify the infected implant surface in vitro as well as in vivo.

Conclusions

Tc treatment noticeably altered the surface of HAS and TBS. HAS and TBS were partially removed from the implant surface as early as 90 and 60 sec, respectively. Accordingly, the optimum duration of Tc treatment should be determined depending on the types of dental implants.

Acknowledgement

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References

[1] T. O. Albrektsson, C.B. Johansson, L. Sennerby: Periodontol 2000 Vol.4 (1994), p.58.

[2] L.F. Cooper, T. Masuda, S.W. Whitson, P. Yliheikkila, D.A. Felton. Int J Oral Maxillofac Implants Vol.14 (1999), p.37.

[3] D.K. Dennison, M.B. Hürzeler, C. Quinones, R.G. Caffesse: J Periodontol Vol.65 (1994), p.942.

[4] A.M. Roos-Jansaker, S. Renvert, J. Egelberg: J Clin Periodontol Vol.30 (2003), p.467.

[5] A. Krozer, J. Hall, I. Ericsson: Clin Oral Implants Res Vol.10 (1999), p.204.

[6] D. Thomson-Neal, G.H. Evans, R.M. Meffert: Int J Periodontics Restorative Dent Vol.4 (1989), p.300.

[7] M.H. Zablotsky, D.L. Diedrich, R.M. Meffert: Implant Dent Vol.1 (1992), p.154.

[8] J.M. Corley, W.J. Killoy: J Periodontol Vol.53 (1982), p.390.

[9] R.M. Meffert: Implant Dent Vol.1 (1992), p.25.

[10] M.J. Somerman, R.A. Foster, G.M. Vorsteg, K. Progebin, R.L. Wynn: J Periodontal Res Vol.23 (1988), p.154.

[11] S. Andreana: J Periodontol Vol.69 (1998), p.601.

[12] E. Muller, Y.M. González, S. Andreana: Implant Dent Vol.8 (1999), p.247.

[13] L.G. Persson, I. Ericsson, T. Berglundh, J. Lindhe: J Clin Periodontol Vol.28 (2001), p.258.