Efficiency of Cleaning the Various Types of Dental Implants' Surfaces (Tiu-Nite, Sla, Rbm) Using the Air-Flow Erythritol Method

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Abstract

The aim of the study is to compare the efficiency of cleaning of various implants' surfaces (TiU-nite, SLA, RBM) removed from patients diagnosed with peri-implantitis.

We studied 6 dental implants, where 3 were control group - one from each manufacturer and 3-experimental ones received from patients with peri-implantitis. Surface cleaning was performed using the Air-FlowHandy 3.0 perio (EMS) method, and an Erythritol filler. The cleaning efficiency was studied using scanning electron microscopy, and the elemental composition of the surface was evaluated. It is revealed that this method is the most effective in relation to the surface (RBM).

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Introduction

Implantation methods of treatment are currently quite successful and well-predicted, however, there is a risk of complications such as peri-implantitis.[1,2] The treatment success includes many factors, but the main point is the problem of cleaning the implant surface from microbes and granulation tissue. Currently, there are various methods of surface treatment, the main purpose of them is mechanical surface cleaning and microbial decontamination. There are studies on laser technologies for cleaning the surface of implants,[3-5] titanium brushes,[6-8] Air-flow methods, and all this in combination with antiseptic treatment.[9-11] Only laser cleaning methods do not require further antimicrobial treatment, because while using a laser, both mechanical cleaning and microbial decontamination occur simultaneously. We have previously published a study that shows the effect on the morphology and elemental composition of the surface of various types of implants when using the Er;Cr:YSGG 2780 nm laser.[12] However, air polishing methods, also, have potential and are promising. Considering these facts, the material Erythritol should be studied in more details, its unique properties do not cause a traumatic factor and are perceived by patients more comfortably and less painfully in contrast to the similar method, where a different powder is used as a filler – calcium bicarbonate, as well as from the methods of ultrasonic treatment.[11,13,14]

This material is used for subgingival treatment of teeth and the surface of titanium implants with a diagnosis of peri-implant pathology. However, the statistically significant difference in its effectiveness compared to the traditional ultrasound treatment was not found in the studies.[13,15] At the moment, there are no clear protocols for the treatment of peri-implantitis, and there are no data in the literature devoted to the study of the effect of mechanical treatment on the implant surface, depending on its type, and as a result, the prognosis for the treatment of peri-implantitis.

The aim of the study is to analyze the effectiveness of cleaning and changing of the morphological and element composition of various types of implant surfaces when using the Air-Flow method (Erythritol).

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Materials and methods

The study was performed on 6 samples of dental implants, of which 3 implants were taken for control from the package, and 3 implants were obtained from patients diagnosed with peri-implantitis. Thus, we studied 2 implants from three manufacturers with surfaces: 1- NobelBiocare (Sweden), the main material - pure titanium (G4Ti), TiUnite surface (anodized titanium dioxide); 2 - XIVEDentsply (Germany), pure titanium (G2Ti), SLA surface (sandblasting with aluminum oxide / acid etching); 3 - BioHorizons (USA), titanium alloy Ti-6Al-4V class 5 (G5Ti), RBM surface (hydroxyapatite blasting / acid etching).

All implants functioned from 3 to 10 years, and the removal of implants was performed according to the diagnosis of peri-implantitis. After removal, the implant surface was treated with Air-FlowHandy 3.0 perio (EMS) method, Erythritol filler, with the following characteristics: air pressure: 2.2 bar; water flow for cleaning: 41.5 ml/min, continuous surface treatment for 30 seconds. For control we used one implant from a sterile package from each manufacturer. 3 surfaces were examined: 1 - infected implant surface that was in direct contact with granulation tissue without treatment; 2 - infected surface which was treated with blasting using the Air-Flow method; 3 – completely new surface from the implant package – control. The study of the morphological composition of the surface was carried out in the Laboratory of electron microscopy of the Center for Collective Use of the Siberian Federal University using scanning electron microscopy methods on the electron microscope JEOL JSM 7001-F (Japan), equipped with an energy dispersion spectrometer. x30, x200, x1500 and x5000 magnifications were used. Qualitative and quantitative elemental analysis of the implant surface was performed using the energy-dispersive X-ray spectroscopy (EDX) method on the INCAEnergyPentaFETx3 spectrometer (Oxford Instruments, England). The method is based on the following principle: the test sample is bombarded with high-energy electrons (1-50 keV, usually 10-15 keV), resulting in X-ray emission from its surface. From the analysis of the characteristic X-ray radiation, it is determined which elements are included in its composition and in what quantitative ratios they are found.

A small sample of indicators (the pilot study format) did not allow to fully analyze the obtained data.

Results

A study of control implants with a TiUnite surface (NobelBioCare, Sweden) showed that the new samples (from the manufacturer's packaging) had a fine-pore structure (Fig.1a), on the nanoscale - rough, with extended microcracks that occur during anodizing (Fig. 1b).

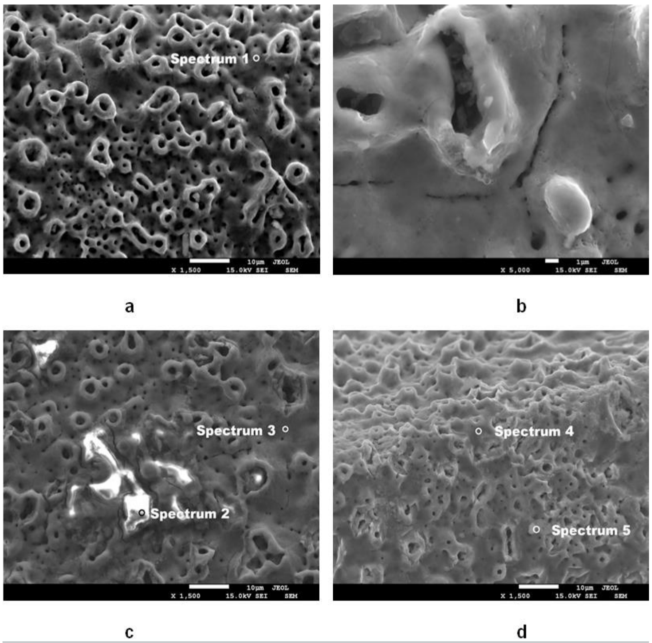


Figure 1. Electron microscopic image of TiUnite surface implants: a, b – control; c - diagnosed with peri-implantitis; d - after blasting using the Air-Flow method.
Note: magnification x1500 (a,c,d), x5000 (b).

№ Spectrum	C	O	Na	Al	Si	P	S	Cl	Ca	Ti
Control group										
1	-	34.14	-	-	-	8.08	-	-	-	57.77
Diagnosed with peri-implantitis										
2	4.26	66.72	-	-	-	4.76	-	-	-	24.27
3	20.08	57.04	0.70	0.40	0.77	2.51	0.16	0.41	10.20	7.73
After the blasting using the Air-Flow method										
4	-	70.00	-	-	-	4.16	-	-	-	25.84
5	20.08	57.04	0.70	0.40	0.77	2.51	0.16	0.41	10.20	7.73

Table 1. Elemental composition of the implants with the TiUnite surface, atom. %

Qualitative and quantitative microanalysis of the elemental composition on the surface of the control implant revealed Titanium (Ti), Oxygen (O) and traces of Phosphorus impregnation (P) (Fig. 1*a*, Table 1, spectrum 1), no extraneous contamination was detected.

The surface of the implant with peri-implantitis retains microporosity, and traces of contamination are found on it (Fig.1*c*) with the following elements – Titanium (Ti), Carbon (C), Calcium (Ca), Phosphorus (P), Aluminium (Al), Silicon (Si) and Oxygen (O) (Table 1, spectra 2, 3).

The surface of the TiUnite implant after blasting using the Air-Flow method became cleaner, but some areas of micro-contamination were preserved (Fig.1.*d*). The elemental composition of the cleared surface consisted of Carbon (C), Oxygen (O), Titanium (Ti), Phosphorus (P) (Fig.1.*d*, Table 1, spectrum 4). On the contaminated surfaces the range of elements was wider (Fig.1.*d*, Table 1, spectrum 5). At the same time, the primary microporous structure was preserved, but, nevertheless, Erythritol particles up to 10-12 microns were found on the surface, in the microporous structure of the implant, which was confirmed by the presence of high amounts of carbon and silicon in the spectrum 5.

The control implants SLA surface (XiVE, Dentsply Implants, Germany) had microroughnesses, heterogeny as a result of contamination (Fig.2.*a,b*) and significant spectrum of detected microelements, which includes Oxygen (O), Carbon (C), Titanium (Ti), insignificant concentrations of Calcium (Ca), Potassium (K), Aluminium (Al), Silicon (Si), Sulphur (S), Zinc (Z) and Chlorum (Cl) (fig.2.*b*, Table 2, spectra 1,2).

№ Spectrum	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti
						Control group						
1	49.30	23.54	0.41	-	0.72	1.88	-	0.18	-	-	0.49	23.17
2	-	-	-	-	-	-	-	-	-	-	-	100.00
						Diagnosed with peri-implantitis						
3	24.63	-	-	-	-	-	-	-	-	-	-	75.37
4	74.31	14.68	0.40	-	0.33	0.37	-	0.39	-	-	-	9.53
						After the blasting using Air-Flow method						
5	46.37	37.63	3.28	0.36	2.64	7.22	0.12		0.21	0.12	0.68	1.37
6	-	-	-	-	-	-	-	-	-	-	-	100.00

Table 2. Elemental composition of the implants with the SLA surface, atom. %

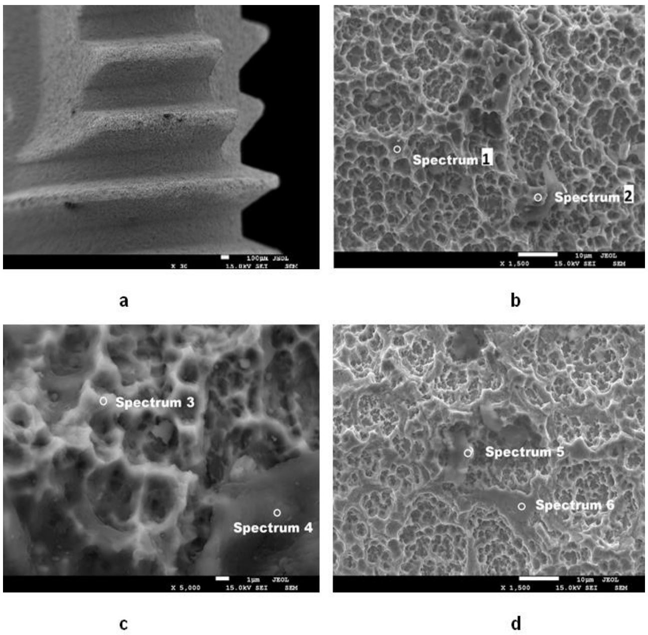


Figure 2. Electron microscopic image of SLA surface implants: a, b – control; c - diagnosed with peri-implantitis; d - after blasting using the Air-Flow method.
Note: magnification x30 (a), x1500 (b,d), x5000 (c).

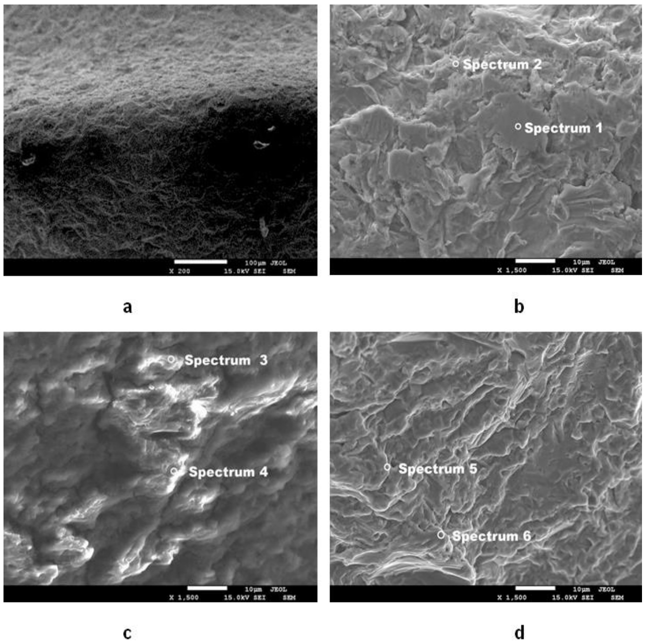
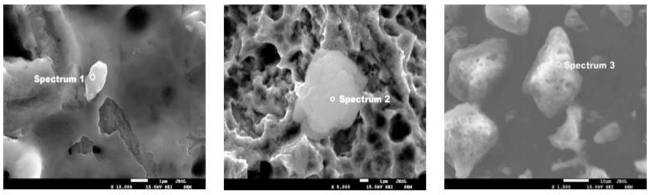


Figure 3. Electron microscopic image of RBM surface implants: a, b – control; c - diagnosed with peri-implantitis; d - after blasting using the Air-Flow method.
Note: magnification x200 (a), x1500 (b,c,d).

The implants SLA surface of the patient diagnosed with peri-implantitis remained microroughened with traces of contamination (Fig.2.*c*, table 2, spectra 3,4). After the blasting using the Air-Flow method the surface remained microroughened and became cleaner. However, there still could be found particles of Erythritol in microroughnesses and not entirely cleared contamination. (Fig. 2.*d*). Spectra showed high amounts of Carbon (C), Oxygen (O), Silicon (Si) (Table 2, spectrum 5). There was also Titanium (Ti) in the clear areas, which corresponded with the announced composition of control implants (Table 2, spectrum 6).

The results of the analyzes of control implants BioHorizons (USA) RBM surfaces showed that structure was microroughened, clean; Titanium (Ti), Aluminium (Al) and Vanadium (V) were predominating in the elemental composition, Carbon (C) was the only contaminant in major quantities (Fig. 3a,b) (Table 3, spectra 1,2).



a b c

Figure 4. Electron microscopic image and quantitative ratio of elements in point spectra: a - surface of TiUnite implant after the blasting using Air-Flow method; b - surface of the SLA implant after the blasting using Air-Flow method; c - powder particles of Erythritol.
Note: magnification x10000 (a), x5000 (b), x1500 (c).

№ Spectrum	C	N	O	P	S	Al	Ca	Ti	V
Control group									
1	-	-	-	-	-	0.90	-	96.03	3.07
2	8.66	-	-	-	-	2.20	-	81.53	3.21
Diagnosed with peri-implantitis									
3	53.34	24.62	20.98	0.23	0.50	-	0.05	0.29	-
4	59.26	22.09	17.50	0.31	0.68	-	0.06	0.11	-
After the blasting using Air-Flow method									
5	5.63	-	-	-	-	10.76	-	79.59	4.02
6	-	-	-	-	-	9.28	-	82.37	8.36

Table 3. Elemental composition of RBM surface implants, atom. %

The surface of the implant, obtained from the patient, diagnosed with peri-implantitis was, also, microroughened and contaminants, the spectrum of microelements widened and became the most extensive among the three types of studied surfaces (Fig.3.c, Table 3, spectra 3,4). After the blasting using Air-Flow method the RBM surface (Fig.3.d) was cleaner in comparison with TiU-nite (Fig.4a, spectrum 1) and SLA (Fig.4.b, spectrum 2) surfaces, which confirmed the absence of contaminants during the electromicroscopic examinations (Fig.3.d), (Table 3, spectra 5,6).

Spectrum	C	O	Si
Spectrum 1	42.96	47.26	9.78
Spectrum 2	86.31	13.26	0.43
Spectrum 3	10.43	64.57	24.49

Table 4. Elemental composition of particles, atom. %

The chemical formula of Erythritol - C4H10O4, it consists of Hydrogen, Carbon and Oxygen. Energy dispersive X-ray analysis allows to define elements from Boron (B) to (U), Hydrogen (H) is not included into this range that is why there is no Hydrogen in spectra. The particles and the Erythritol particle found on the surfaces of TiUnite (Fig.4a, Table 4, Spectrum 1) and SLA (Fig.4b, Table 4, Spectrum 2) implants have almost similar elemental composition. Thus, after the blasting using Air-Flow method a small number of Erythritol particles can be found on the implant's surface.

Discussion

Consequently, on the basis of acquired data we can say that the surface of new prepackaged implants is not ideal, it contains numerous chemical elements, about which the manufacturer does not usually warn, but it's a question to manufacturers. It is also based on the data acquired from literature.[16] The most contaminated surface among the researched was the SLA (Xive) surface.

The implants' surface of patients diagnosed with peri-implantitis is contaminated with numerous chemical elements, RBM surface being the most contaminated. Air-abrasive blasting method Air-Flow with Erythritol showed high capability of clearing the contaminated implant surface, besides the surface does not get damaged, and remains microroughened. However the investigation of Ti-Unite and SLA surfaces after the Air-Flow blasting showed undiluted particles of Erythritol, located in the microroughnesses, also traces of not entirely cleared contaminants were located. The RBM surface appeared to be cleaner, particles of Erythritol and contaminants traces were not located. This can be explained with the fact that the RBM surface, in comparison with Ti-Unite and SLA, is less microroughened and, as a result, is easier to clear. In conclusion, the Air-Flow method with Erythritol fits better for the blasting of RBM surface. Consequently, acquired results of this pilot research would become a base for further scientific researches.

Conclusions

According to the results of the obtained data, we can say that the blasting using Air-Flow Erythritol method was the most effective for the RBM surface. This type of surface was found to be the cleanest, which may be due to the less micro-roughness of this surface comparing to the other two.

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Declaration of Interest

The authors report no conflict of interest.

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