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SLIKE MORFO-ELEMENTARNOG SASTAVA POVRŠINE IMPLANATA U ZAVISNOSTI OD METODE ČIŠĆENJA

MORPHO-ELEMENTAL COMPOSITION FEATURES OF IMPLANT SURFACE DEPENDING ON THEIR CLEANING METHODS

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Sažetak

Uvod: *Prisustva mikroskopskih delova različitih elemenata dovodi do kontaminacije površine implanata i razvoja periimplantitisa.*
Cilj rada: *Ispitivanje mikrostrukture, kvalitativnog i kvantitativnog elementarnog sastava implanata, zavisno od efekta čišćenja različitih tipova implanata koji su nađeni kod bolesnika sa periimplantitisom.*
Metode: *Ispitivane su površine 12 implanata: TiU-nite (Nobel BioCare, Švedska), SLA (Xive, Dentsply Implants, Nemačka) i RBM (BioHorizons, SAD), koje su obrađene uz pomoću tri različite metode: Er laserom Cr; YSGG (Waterlase MD, Biolase, SAD), dijamantskim borerom, (Comet, Nemačka) i četkicom (Neobiotech, Koreja).*
Rezultati: *su pokazali da bez obzira na tip površine implanta, najprefinjenija tehnika čišćenja bila je laser tehnika: kada je makrostruktura očišćena, mikroprostori su ostali čisti, a sastavni elementi implanta nisu sadržali spoljašnje opiljke. Dijamantski borer delovao je najtraumatičnije: mikrostruktura i makrostruktura bile su poremećene, prisutnim usecima i zarezima, dijamantske čestice bile su nađene u strukturi implanata, pri čemu je ugljenik dominirao u spektru mikroelemenata.*
Upotreba četkice takođe je dovela do poremećaja u makrostrukturi- i mikrostrukturi površine, pri čemu je detektovan nikl (Ni) u spektru mikroelemenata.
Zaključak: *Rezultati ove pilot studije mogu poslužiti kao osnova za dalje, detaljnije istraživanje i unapređenje načina čišćenja površine implanata.*

Ključne reči: *implant, površina implanata, metoda čišćenja laser, titanijumska četkica, dijamantsko svrdlo, periimplantitis*

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Abstract

Background: *The issue of clinical importance in the development of periimplantitis in the presence of microscopic particles and contaminants on the surface of implants is to be studied.*
Objective: *based on the study of the microstructure and the qualitative and quantitative elemental composition, the cleaning effectiveness for different types of surfaces of implants obtained from patients with periimplantitis was researched.*
Methods: *surfaces of 12 implants were investigated: TiU-nite (Nobel BioCare, Sweden), SLA (XiVE, Dentsply Implants, Germany) and RBM (BioHorizons, USA), which were processed in three ways: with Er laser; Cr; YSGG (Waterlase MD, Biolase, USA), diamond burr, (Comet, Germany); brush (Neobiotech, Korea).*
Results: *regardless of the type of surface, the gentlest cleaning method was laser: when the macrostructure was broken, the microroughness remained, and the composition of elements did not contain extraneous inclusions. Diamond burr was the most traumatic: macro and microstructure breakdowns, the presence of grooves and notches, the introduction of diamond particles into the implant structure have been detected; carbon has dominated in the elemental spectrum. The use of the brush also led to disturbances in the macro- and microstructure of the surface; nickel (Ni) was detected in the microelement spectrum.*
Conclusion: *practical implication: the results of this pilot study are the basis for further more detailed research.*

Key words: *implant, implant surface, the cleaning method, laser, titanium brush, diamond burr, periimplantitis*

Uvod

Dentalni implanti postali su jedna od najpopularnijih metoda za rehabilitaciju pacijenata sa parcijalnom i totalnom bezubošću. Stanje površine implanata značajno određuje inicijalna faza biološke reakcija tokom njihovog ugrađivanja i utiče na proces njihovog koštanog zarastanja[1]. Utvrđeno je da rast i diferencijacija osteoblasta zavise direktno od mikrostrukture implanata: hrapava površina može da ubrza process osteointegracije i poveća procenat preživljavanja implanata[2,3]. Međutim, sa početkom nošenja protetskih nadoknada na dentalnim implantima, javlja se rizik od periimplantitisa –akutne i hronične inflamacije tkiva koje okružuje implant[1,4,5]. Utvrđeno je da, uprkos mehaničkim uzrocima (habanje) implant može podleći procesima korozije koji su uzrokovani formiranjem kiseline od strane bakterija u dentalnom biofilmu i lipopolisaharidne aktivnosti pljuvačke. U isto vreme, otpuštanje nanočestica gvožđa i jona titanijuma ima citotoksični efekat na leukocitno- makrofagni sistem pacijenta[6], što na kraju utiče na kvalitet i vreme oseointegracije, kao i na imunološki status pacijenta, i uspeh lečenja.

Zna se da je glavna stavka sprovođenja efikasne terapije periimplantitisa što raniji početak sveobuhvatnog pristupa oboljenju sa eliminacijom infektivnih agenasa, uz dodatnu korektivnu i regenerativnu baziènu i hiruršku terapiju. Trenutno, mehaničko uklanjanje granulacija i sanacija površina implanata obećavajuće su metode [7-10].

U isto vreme, nisu pronađeni radovi vezani za ovu studiju, koji se bave uticajem tretmana na stanje površine implanata i razvoja periimplantitisa.

Cilj rada bazira se na studiji mikrostrukture od koje su napravljeni implanti i određivanja njihovog kvalitativnog i kvantitativnog elementarnog sastava, kao i uticaja čišćenja površine različitog tipa implanata kod pacijenta sa evidentiranim periimplantitisom.

Introduction

Currently, dental implantation is becoming one of the most popular methods for the rehabilitation of patients with partial and complete adentia. The condition of the implant surface significantly determines the initial phase of biological reactions during its installation and affects the boneimplant healing process[1]. It was found that the growth of osteoblasts and their differentiation on the implant surface directly depends on implant's microstructure: a rough surface can accelerate the process of osteointegration and thereby increase survival rate[2,3]. However, after the patient began using orthopedic constructions based on dental implants, there is a risk of periimplantitis: acute and chronic inflam-mation in the area of the tissues surrounding an implant1[4,5]. It has been established that, in addition to mechanical causes (wear), the implant may undergo corrosion processes caused by both the acid-forming properties of bacteria in the biofilm and the lipopolysaccharide activity of saliva. At the same time, the release of metallic iron nanoparticles and titanium ions has a cytotoxic effect on the patient's leukocyte-macrophage system[6]. This, in turn, affects the quality and timing of osseointegration and the patient's immune status and the treatment success.

It is recognized that the main points of ensuring the effectiveness of periimplantitis therapy are the earliest start and comprehensive approach: elimination of the infectious agent, corrective and regenerative non-surgical and surgical treatment. Currently, mechanical removal of granulations and sanitation of implant surfaces are considered as a promising method[7-10].

At the same time, we did not find any works devoted to the study of the influence of the treatment on the state of the surface of implants and the development of periimplantitis.

Objective based on the study of the microstructure of materials and the determi-nation of their qualitative andquantitative elemental composition, to study the effectiveness of cleaning the surface of different types of implants obtained from patients with periimplantitis evidences.

Materijal i metode

Studijom su ispitivane površine 12 implanata tri različita proizvođača: TiU-nite (Nobel BioCare, Švedska) SLA (XiVE, Dentsply Implants, Nemačka) i RBM (BioHorizonts, SAD), izrađeni od legure titatnijuma TI-6AL-4V, klase V (G5Ti).

Studijsku grupu (n=9) su činile površina implanata kod pacijenata sa dijagnostikovanim periimplantitisom, kod kojih su implanti su ugrađeni 3 do 5 godina pre početka studije. Studijom su analizirane dve zone svakog implanta: zona koja je u bila u direktnom kontaktu sa granulacionim tkivom, i zona koja je čišćena jednom od sledeće tri metode: (1) primenom ErCr lasera; laser YSGG (Waterlase MD, Biolase, SAD) talasne dužine od 2780 nm, snage 1,5 W, frekvencije 15 Hz; (2) primenom fino zrnastog dijamantskog svrdla; (3) primenom četkice za čišćenje površine implanata, napravljene od nikl-titanijumske legure (Neobiotech, Koreja). Kontrolnu grupu (n=3) su činili novi implanti, upakovani u originalno pakovanje proizvođača.

Analiza morfološke strukture površine implanata obavljena je u Centru za kolektivne usluge „Laboratorija za elektronsku mikroskopiju" Sibirskog Federalnog Univerziteta, na elektronskom mikroskopu JOEL JSM 7001-F (Japan). Parametri uvećanja su bili 1 500x i 5 000x.

Kvalitativna i kvantitativna analiza elemenata površine implanata vršena je energijom disperzivbog X- zračnom spektrofotometrijskom metodom (EDX) na INCA energetskom disperzionom spektrofotometrija Energy Penta FETx3 (Oxford Instruments, Engleska). Metod se zasniva na sledećem: uzorci su bombardovan visokoenergetskim elektronima (1-50 kEV, najčešće 10-15 kEV, što rezultuje emisijom X zraka sa njihove površine. Analizom karakteristika radijacije X zraka, određen je sastav elmenata koji ulazi u strukturu površine implanata, i u kom odnosu.

Mala veličina uzorka (u formi pilot studije) nije dozvolila kompletnu statističku analizu dobijenih rezultata.

Material and methods

This study analyzed surfaces of 12 implants of three different manufacturers: TiU-nite (Nobel BioCare, Sweden), SLA (XiVE, Dentsply Implants, Germany) and RBM (BioHorizons (USA), the main material was titanium alloy of Ti-6Al-4V 5 class (G5Ti).

The study group (n=9)included implants obtained from patients with a diagnosis of periimplantitis and a period of operation of 3-5 years.The surface of each implant was divided into two zones: directly in contact with the granulation tissue and processed using one of the following cleaning methods:ErCr laser; YSGG (Waterlase MD, Biolase, USA) with a radiated wavelength of 2780 nm, a power of 1.5 W, a frequency of 15 Hz, diamond burr (fine grain), (Comet Germany); a brush to clean the implant surfaces made of Ni-Ti alloy (Neobiotech, Korea). The control group (n = 3) was composed of new implants in the manufacturer's package.

The study of the morphological composition of the surface was carried out at the Center for Collective Use "Laboratory of Electron Microscopy" of the Siberian Federal University using scanning electron microscopy on a JEOL JSM 7001-F plant electron microscope (Japan). Magnification parameters used were x1500 and x5000.

Qualitative and quantitative elemental analysis of the surface of the implants was performed by the energy dispersive X-ray spectroscopy (EDX) method on an INCA Energy Penta FETx3 energy dispersive spectrometer (Oxford Instruments, England). The method is based on the following principle: the sample under study is bombarded by high-energy electrons (1–50 keV, usually 10–15 keV), as a result of which X-ray emission from its surface occurs. Based on the characteristic x-ray radiation analysis results, it was determined which elements are included in the implant surface composition, and in which quantitative ratios.

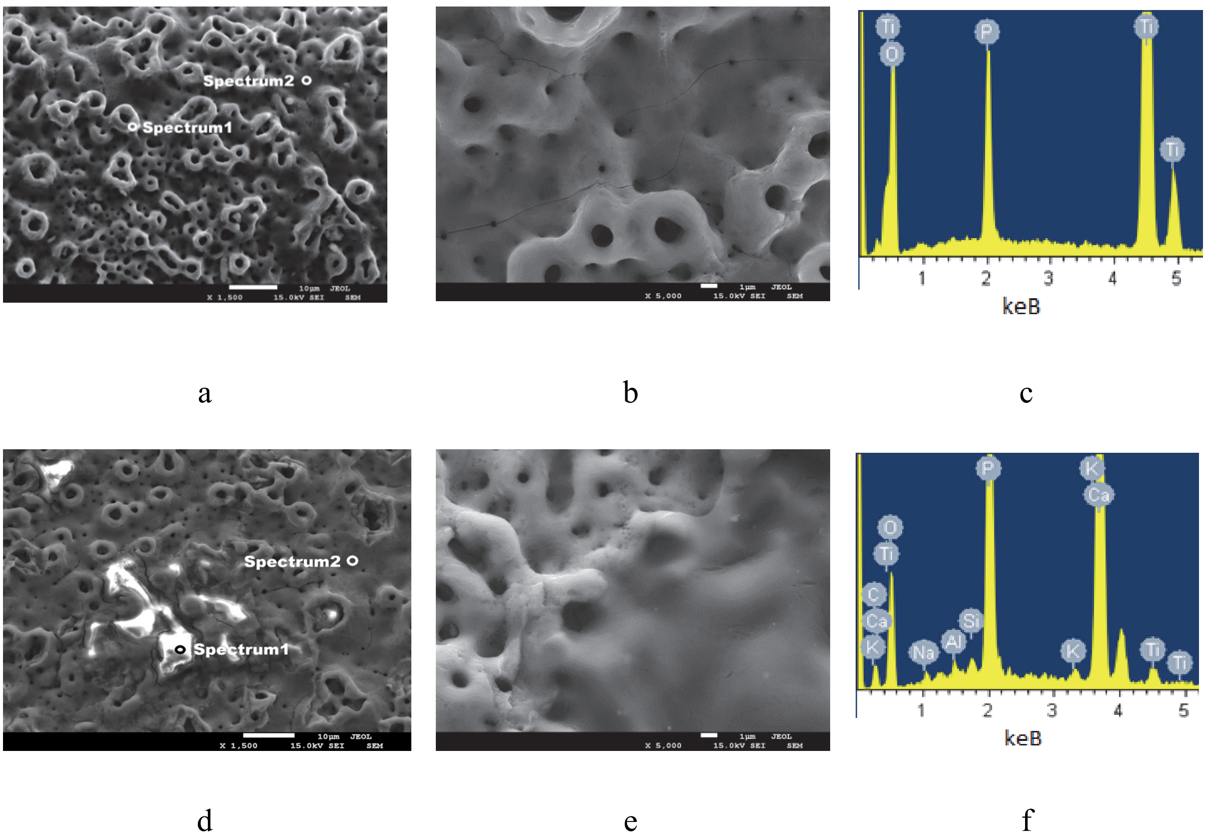
A narrow sample of indicators (pilot survey format) did not allow for complete statistical processing of the data obtained.

Rezultati istraživanja i diskusija

Studija je izvršena na implantima sa TiUn-ite površinom (Nobel BioCare, Švedska) koje se odnose na površinu uzoraka koji su referentni (novi, koji su u pakovanju proizvodjača) i imaju finu strukturu sa porama (Slika 1a), koja je bila gruba na nivou nanoskale, sa produženim mikrokrakovima (Slika 1b). Površina implanata istog proizvođača, dobijena od bolesnika sa periimplantitisom, takođe je imala mikroporoznosti (Slike 1c i, 1d). U isto vreme, kvalitativna i kvantitativna analiza sastavnih elemenata otkrila je tragove impregnacije fosforom (P) na površini referentnog implanta. Takođe su nađeni i ugljenik (C), kalcijum (Ca), fosfor (P), aluminijum (Al) i silicijum (Si). Tipičan spektar koji je uzet sa površine implanta, odnosi se na hemijske elemente detektovane u ovoj regiji (Slike 1 c, 1f).

Research results and discussion

The study of implants with a TiU-nite surface (Nobel BioCare, Sweden) revealed that the surface of reference samples (new ones contained in the manufacturer packaging) had a fine-pore structure (Fig. 1a) which was rough at the nanoscale level, with extended microcracks (Fig. 1b). The surface of the implant from the same manufacturer, obtained from a patient with periimplantitis, also had microporosity (Fig.1c, d). At the same time, the qualitative and quantitative analysis of the composition of elements revealed that traces of phosphorus (P) impregnation were present on the surface of the reference implant, and also carbon (C), calcium (Ca), phosphorus (P), aluminum (Al) and silicon (Si) were detected on the surface of the implants used. Typical spectra taken on implant surfaces reflect chemical elements present in these areas (Fig. 1 c, f).

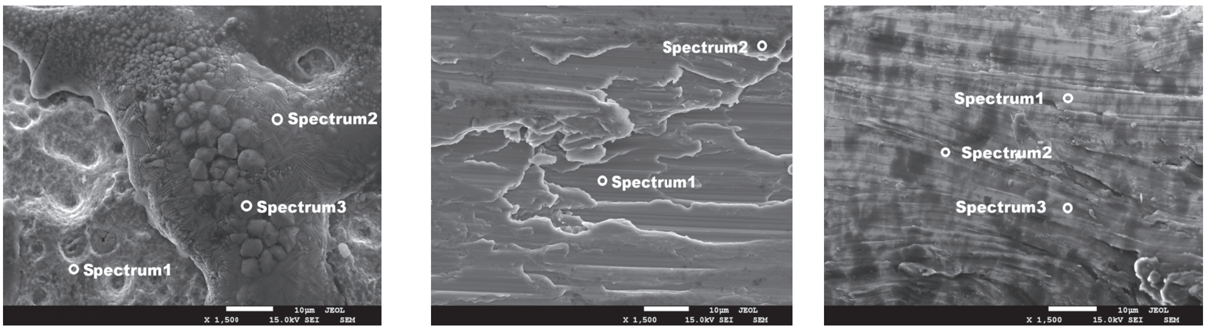


Slika 1. Elektomikroskopska slika tipične površine TiU-nite i tipičan spektar: a, b, c – kontrolni implant; d, e, f – implant sa dijagnozom periimplantitisa : *uvećanje 1,500 x (a, d); uvećanje 5000 x (b, e)*

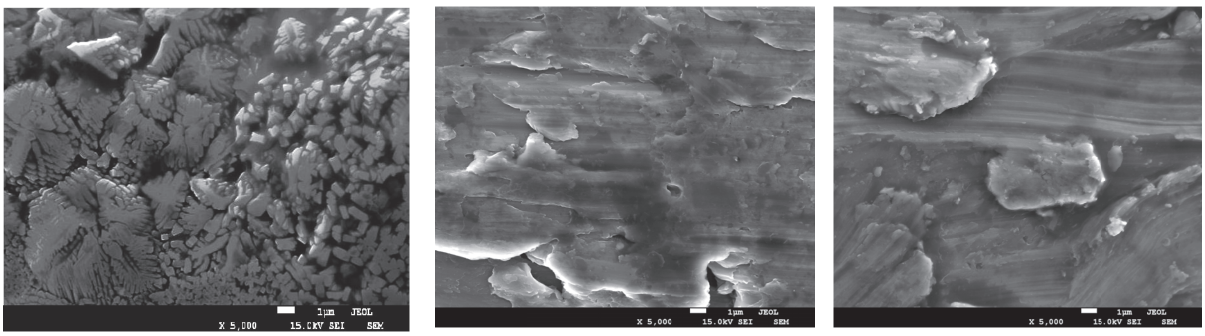
Figure 1. Electron microscopic image of a typical TiU-nite surface and typical spectrum: a, b, c - control implant; d, e, f - implant with a diagnosis of periimplantitis. *Note: magnification x1500 (a, d), magnification x5000 (b, e)*

Površina TiU-nite implanta imala je tragove niti nakon laserskog tretmana, morfološki se videla restrukturacija, ali se zadržala njegova mikroporozivnost (Slike 2 a i, 2d). Elementarni sastav činili su titanijum (Ti) i kiseonik (O), i mala količina fosfora (P). Nakon tretmana dijamantskim svrdlom, početna tridimenzionalna struktura je izgubljena; površina je postala glatka na makronivou, ali mikroporoznosti nije bilo (Sike 2.b i, 2e); titanijum (Ti) i značajni procenat ugljenika (C) otkriveni su na površini. Nakon četkanja površine implanta, mikrostruktura i makro struktura imale su znake slične onima koji su opisani nakon korišćenja dijamantskog svrdla: originalna 3D mikrostruktura je nestala; hrapavost na niovu nanoskale je bila je očuvana (Slike 2c i, 2f); elementarni sastav uključivao je ugnjenik (C), titanijum (Ti) i nikl (Ni).

The surface of the TiU-nite implant had traces of reflow after laser treatment, and it was morphologically restructured, but retained its microporosity (Fig. 2 a, d).The elemental composition contained titanium (Ti) and oxygen (O), and a small amount of phosphorus (P). After treatment with a diamond burr, the initial three-dimensional structure was lost; the surface became smooth at the macro level, and microporosity was not detected (Fig. 2.b, e); titanium (Ti) and a significant level of carbon (C) were revealed on the surface. After the surface was brushed, the micro and macro structures had signs similar to those described during diamond burr processing: the original 3D microstructure has disappeared; the roughness at the nanoscale level has been preserved (Fig. 2c, f); the elemental composition included carbon (C), titanium (Ti) and nickel (Ni).



a b c



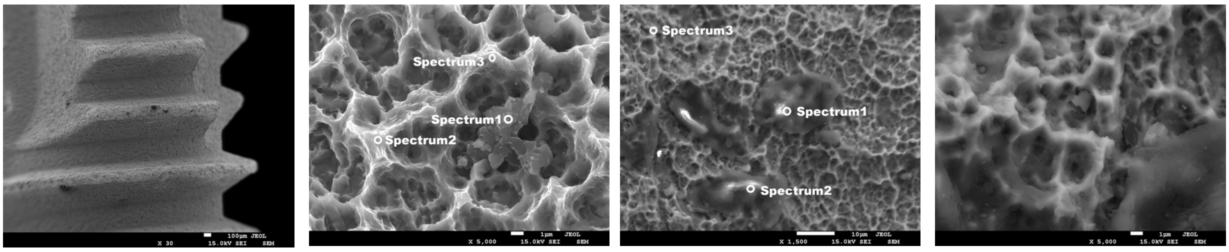
d e f

Slika 2. Elektomikroskopska slika površine TiU-nite implanta koja je tretirana: a, d – laserom;
b, e – dijamantskim svrdlom; c, f – specijalnom četkicom. *Poruka: uvećanje 1,500 x (a, b, c); uvećanje 5000 x (d, e, f)*

Figure 2. Electron-microscopic image of the TiU-nite implant treated surface with: a, d – laser; b, e – diamond burr; c, f – a special brush. *Note: magnification x1500 (a, b, c), x500 (d, e, f)*

Ispitivanje površine SLA XiVE implanata (Dentsply Implants, Nemačka) otkriva heterogenu površinu sa mikropukotinama (Slike 3a i, 3b), zbog značajne količine mikroelemenata u detektovanom spektrumu, koji uključuje kiseonik (O), ugljenik (C), titanijum (Ti), minimalne koncentracije kalcijuma (Ca), kalijuma (K), aluminijuma (Al), silicijuma (Si), sumpora (S), cinka (Zn) i hlora (Cl). Na površini implanata, koji su dobijeni od bolesnika sa kliničkim simptomima periimplantitisa (Slike 3c i, 3d), mikrohrapavost je održana kao i kvalitativni sastav elemenata mikrospektruma.

Examination of the SLA XiVE implants (Dentsply Implants, Germany) surface revealed a heterogeneous surface with microroughness (Fig. 3a, b) due to the significant amount of microelements in the spectrum detected, which included oxygen (O), carbon (C), titanium (Ti), minimum concentrations of calcium (Ca), potassium (K), aluminum (Al), silicon (Si), sulfur (S), zinc (Zn) and chlorine (Cl). On the surface of implants, obtained from patients with signs of periimplantitis (Fig. 3c, d), the microroughness was maintained as well as the qualitative composition of the microelement spectrum.



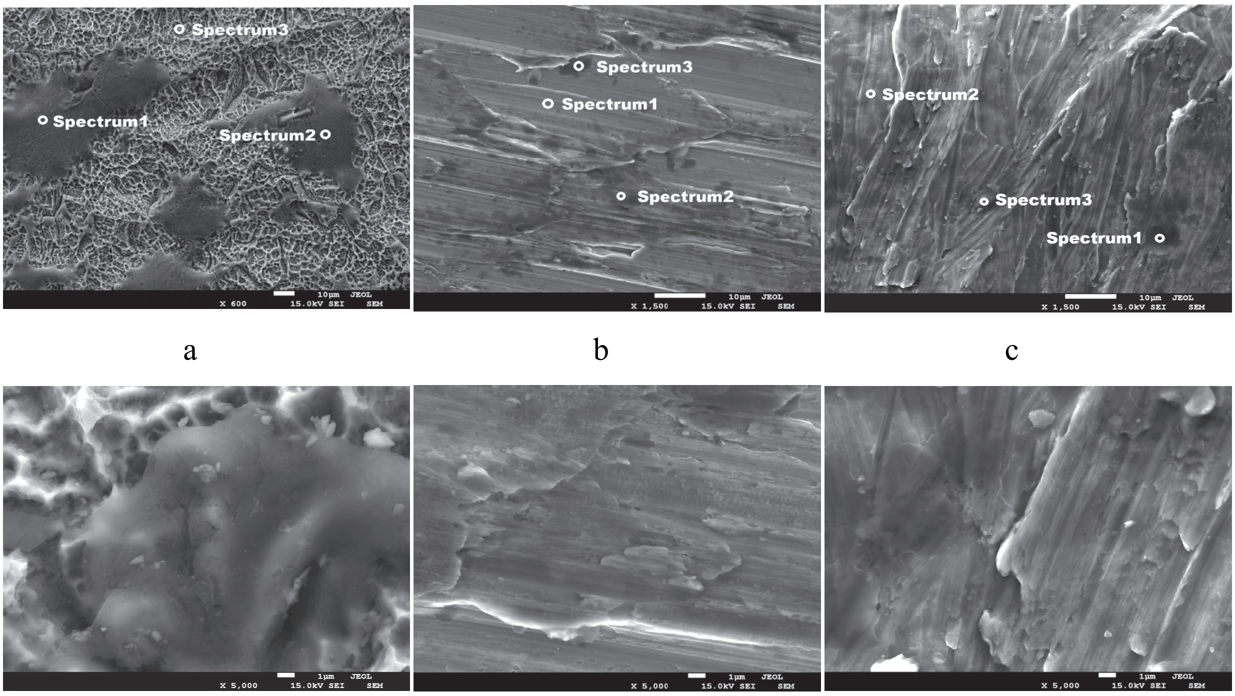
a b c d

Slika 3. Elektomikroskopska slika površine SLA implanta: a – opšti pregled; b – referentni implant; c, d – implant dobijen od bolesnika sa periimplantitisom. *Poruka: uvećanje 1,500 x (a, c); uvećanje 5000 x (b, d)*

Figure 3. Electron-microscopic image of the surface of SLA implants: a – general view; b – reference implant; c, d – implant obtained from a patient with periimplantitis *Note: magnification x1500 (a, c), x5000 (b, d)*

Nakon laserskog tretmana površine SLA implanta, otkriveni su tragovi topljenja i mikropukotine (Slike 4a i, 4d), kao i prisustvo titanijuma (Ti), kiseonika (O) i ugljenika (C). Nakon tretmana dijamantskim svrdlom, površina je izgubila svoju mikrostrukturu i makrostrukturu, a tragovi u vidu ureza i žlebova su otkriveni (Slike 4b, i 4e); titanjium (Ti) i ugljenik (C) preovladavaju u elementarnom sastavu. Nakon četkanja, otkriveno je da je sačuvana makrostrukura sa kompletnim gubitkom hrapavosti na mikro nivou. Brazde koje je napravila četkica (Slike. 4 c i, 4f) vide se na površini; Titanijum (Ti) i ugljenik (C) detektovani su u elementarnom spektru.

After the laser treatment of the SLA implant surface, traces of surface melting and microcracks (Fig.4a, d) and the presence of titanium (Ti), oxygen (O) and carbon (C) were revealed. After treatment with a diamond burr, the surface lost its macro- and microstructure, traces in the form of notches and grooves were detected (Fig. 4b, e); titanium (Ti) and carbon (C) prevailed in the composition of elements. After brushing, it was revealed that macrostructure has been preserved, with complete loss of roughness on the micro level. The furrows left by the brush (Fig. 4 c, f) were visualized on the surface; titanium (Ti) and carbon (C) were detected in the element spectrum.



Slika 4. Elektomikroskopska slika površine SLA implanta koja je tretirana: a, d – laserom; b, e – dijamantskim svrdlom; c, f – četkicom. *Poruka: uvećanje 1,500 x (a, b, c); uvećanje 5000 x (d, e, f)*

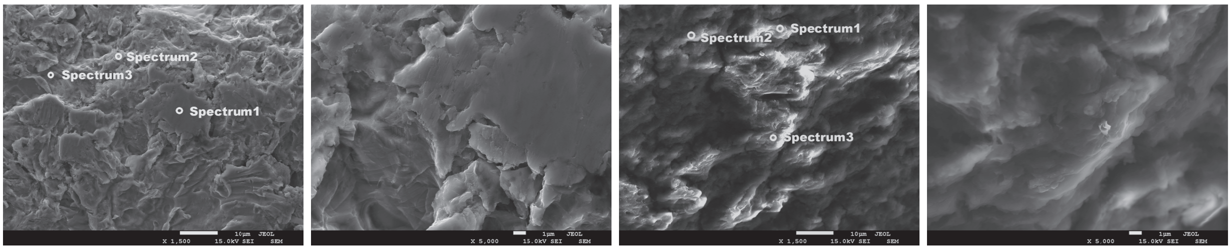
Figure 4. Electron-microscopic image of the SLA implants surface after the treatment: a, d – with a laser; b, e – diamond burr; in, e – brush. *Note: magnification x1500 (a, b, c), x5000 (d, e, f)*

Studija na površini RBM implanata BioHorizons (SAD) otkrila je da referentni uzorci imaju mikrohrapavu strukturu; titanijum (Ti) je dominirao u njihovom elementarnom sastavu, ali nađeni su i: fosfor (P), kalcijum (Ca), aluminijum (Al) i vanadijum (V). Površina implanta dobijenog od pacijenta sa periimplantitisom takođe je imala mikrophrapavost i inkliuzije sa strane (Slika 5c, d), dok se spektar elemenat sastojao od kiseonika (O), ugljenika (C), sumpora (S), i malih količina fosfora (P) i kalcijuma (Ca).

Nakon tretmana laserom, površina RBM je zadržala je svoju mikrostrukturu, ali su prikazani tragovi topljenja (Slike. 6a i, 6d). Ttitanijum (Ti) i kiseonik (O) su dominirali su u elementarnom spektrumu, vanadijum (V) i kalcijum (Ca) su takođe su detektovani. Nakon obrade dijamantskim svrtdlom, površina je kompletno izgubila svoju makrostrukturu i mirostruktutru (Slika 6b). Ttragovi u vidu brazdi zareza, kao i zarezna brazeda načinjena svrdlom videli su se na površini implanta (Slika 6e). Ugljenik (C) i titanijum (Ti) bili su dominatntni u mikroelementarnom spektrumu; kiseonik (O), aluminijum (Al) i vanadijum (V) takođe su bili prisutni.

The RBM study results for BioHorizons implants (USA) surface has revealed that the reference samples had a structure with microroughness; titanium (Ti) prevailed in their elemental composition; phosphorus (P), calcium (Ca), aluminum (Al) and vanadium (V) were present. The surface of the implant obtained from a patient with periimplantitis also had microroughness and foreign inclusions (Fig. 5c, d), the spectrum of elements expanded due to oxygen (O), carbon (C), sulfur (S), minor amounts of phosphorus (P) and calcium (Ca).

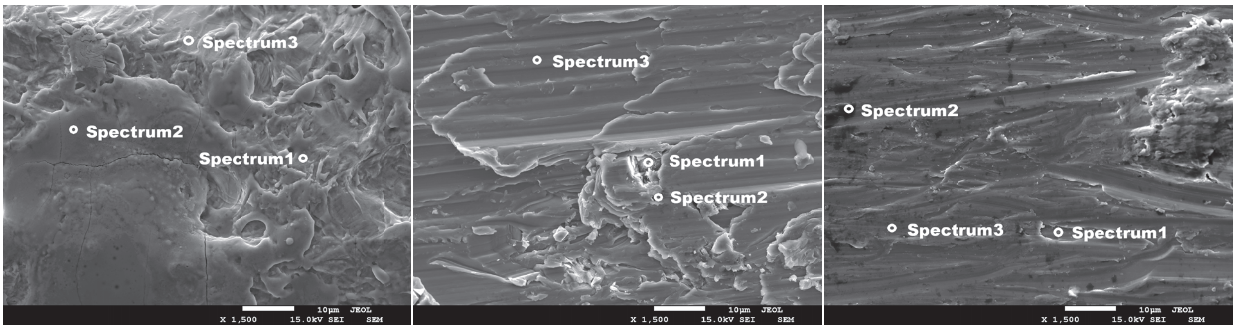
After treatment with an RBM laser, the surface retained its microstructure, traces of melting were shown (Fig. 6a, d), titanium (Ti) and oxygen (O) dominated in the elemental spectrum, and vanadium (V) and calcium (Ca) were also detected. After processing with a diamond burr, the surface completely lost its macro- and microstructure (Fig. 6b); traces of the tool in the form of furrows and notches, as well as the cutting burr fragment embedded in the implant surface (Fig. 6e) were detected; carbon (C) and titanium (Ti) dominated in the microelements spectrum; oxygen (O), aluminum (Al) and vanadium (V) were also present there.



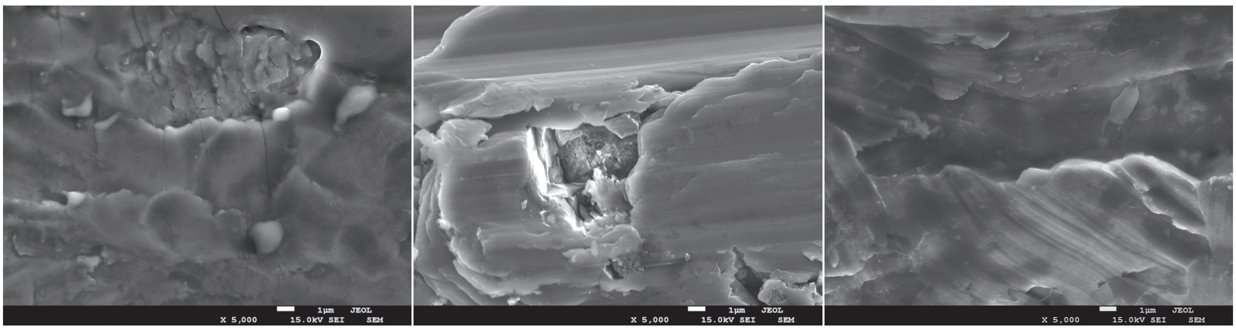
a b c d

Slika 5 . Elekto-mikroskopska slika površine RBM implanata BioHorizons: a, b – referentni implant; b, d – implant dobijen od bolesnika sa periimplantitisom. *Poruka: uvećanje 1,500 x (a, c); 5000 x (b, d)*

Figure 5. Electron-microscopic image of RBM surface of BioHorizons implants: a, b – reference implant; b, d – implant obtained from a patient with periimplantitis. *Note: magnification x1500 (a, c), x5000 (b, d)*



a b c



d e f

Slika 6. Elektomikroskopska slika površine RBM implanta tretiranih: a, d – laserom; b, e – dijamantskim svrdlom; b, f – četkicom. *Poruka: uvećanje 1,500 x(a, b, c); 5000 x (g, d, e)*

Figure 6. Electron-microscopic image of RBM surface of implants treated with: a, d – laser; b, e – diamond burr; b, f – brush. *Note: magnification x1500 (a, b, c), x5000 (g, d, e)*

Nakon četkanja, površina je paraktično izgubila svoju mikrostrukturu, svoje mikroskopske nepravilnosti i žlebovi su zapaženi (Slike 6c i6e), a ugljenik (C), titanijum (Ti), kiseonik (O) i nikl (Ni) preovladavali su u elementarnom sastavu.

After brushing, the surface practically lost its microstructure, microscopic irregularities and grooves were noted (Fig. 6c, e), carbon (C), titanium (Ti), oxygen (O) and nickel (Ni) prevailed in the composition of elements.

Diskusija

Trenutno, pitanje kliničkog značaja prisustva mikroskopskih čestica i kontaminacija površine dentalnih implanata ostaje otvoreno. Utvrđeno je da je prisustvo sledećih elemenata: titanijuma (Ti), aluminijuma (Al) i vanadijuma (V) karakteristično za gradus 5 titanijumsku leguru, koja se koristi u proizvodnji implanata[11,12], što je takođe zapaženo u ovoj studiji, nakon analize podataka sa površine RBM BioHorizons implanata.

U isto vreme, poređenje morfološke slike površine tri tipa novih implanata sa kvalitativnim i kvantitativnim elementarnim sastavom otkrilo je značajnu razliku u mikroelementarom spektrumu: tri, na površini TiU-nite implanta (Nobel BioCare, Švedska), do deset na površini SLA implanta XiVE (Dentsply Implants, Nemačka). Spektar mikroelemenata na površini implanata, koji su u upotrebi, proširen je na osam na površini TiUnite implanata, a ostao isti na površini SLA implanata. Prisustvo kalcijuma (Ca), fosfora (P) i kiseonika (O), koji su smatrani markerima osteosintetičkih procesa[5,13], detektovano je u najvećoj količini na površini TiU-nite implanata, a mnogo manja količina je detektovana je na površini SLA implantaa.

Komparativna analiza stanja implanata nakon tretmana otkrila je sličnu šemu za sve tipove površina: nakon laserskog tretmana primećeno je topljenje i zaglađivanje makrostrukture primećeno, dok je održavanje mikrostrukture (hrapavosti) na nano nivou variralo u stepenu ozbiljnosti, i značajno je smanjen broj mikroelemenata u spektrumu; prevalencije kiseonika (O) i titanijuma (Ti). Otkriven je poremećaj u makrostrukturi i mikrostrukturi nakon tretmana dijamantskim svrdlom, bez obzira na tip implanata, uključujući gubitak njihove strukture, prisustvo žlebova i zareza, ubacivanje dijamantskih čestica u strukuru implanata; ugljenik (C) i titanijum (Ti) dominirali su u elementarnom spektrumu. Proces četkanja vodio je do značajnog, ali ne tako izraženog, kao nakon tretmana dijamantskim svrdlom, poremećaja mikrostukture i makrostrukture površine implanata. Spaktar identifikovanih elementa je uključivao je titanijum (Ti), ugljenik (C), kiseonik (O) i nikl (Ni).

Stoga rezultati ove pilot studije delimično potvrđuju podatke nekoliko izvora iz literature i osnova su za naredna detaljnija istraživanja.

Discussion

Currently, the question on the clinical significance of the presence of microscopic particles and contaminants on the surface of dental implants remains open. It has been established that the presence of elements of titanium (Ti), aluminum (Al) and vanadium (V) is a characteristic of the Grade 5 titanium alloy used in the manufacture of implants[11,12] that was also noted in the present study when analyzing data on RBM surface of BioHorizons implants (USA).

At the same time, a comparison of the morphological picture with the qualitative and quantitative composition of elements of the three types of new implant surface revealed significant differences in the spectrums of microelements: from three on TiU-nite surfaces (Nobel BioCare, Sweden) to ten on SLA surface of XiVE implants (Dentsply Implants, Germany). The spectrum of microelements on the surface of implants that were in use expanded to eight on the TiU-nite surface and remained the same on SLA surfaces of the implants. The presence of calcium (Ca), phosphorus (P) and oxygen (O), which are considered markers of osteosynthetic processes[5,13], is detected in the largest amounts on the TiU-nite surface, and there is much smaller amount of them on the SLA surface.

A comparative analysis of the condition of implants after treatment revealed a similar pattern for all types of surfaces: after laser treatment, the melting and smoothing of the macrostructure were observed while maintaining the microstructure (roughness) at the nanolevel at varying degrees of severity, and significant narrowing of the quantity of microelements in spectrums: the prevalence of oxygen (O) and titanium (Ti). There were revealed macro- and microstructure disturbances after treatment with a diamond burr, irrespective of the type of surface, including loss of their structure, the presence of grooves and notches, the introduction of diamond particles into the implant structure; carbon (C) and titanium (Ti) dominated in the elemental spectrum. Brush processing also led to significant, though not as pronounced as after burr treatment, disruption of the macro- and microstructure of surfaces; the spectrum of identified elements included titanium (Ti), carbon (C), oxygen (O) and nickel (Ni).

Thus, the results of this pilot study partially confirm the data of a few literature sources and are the basis for further more detailed research.

Zaključak

Na osnovu studije mikrostrukture materijala i određivanja kvalitativnog i kvantitativnog elementarnog sastava tri tipa površine implanata, nađeno je da je tretman laserom najnežniji metod čišćenja njihove površine bez obzira na tip implanata. Pod njihovim uticajem, mikrostruktura je delimično promenjena (fenomen topljenja i zaglađivanja), ali je makrostruktura sačuvana, a elementarni sastav ne sadrži spoljne inkluzije koje mogu biti značajne za osteointegraciju implanata.

Najštetniji metod bilo je čišćenja dijamantskim svrdlom, bez obzira na tip površine. Otkriven je poremećaj njihove makrostrukture i mikrostrukture, do potpunog gubitka primarne strukture površine implanta, uz, prisustvo žlebova i zareza, sa upadanjem dijamantskih čestica u strukuru implanata. Ugljenik (C) je dominirao u spektrumu hemijskih elemenata, pa može biti smatran markerom ovih oštećenja.

Korišćenje specijalnih četkica takođe vodi do poremećaja makrostukture- i mikrostrukture površine implanta, mada je manje izraženo, sa prisustvom nikla (Ni) u značajnoj količini u hemijskom spektrumu, pa se nikl (Ni) može smatrati markerom ovog metoda čišćenja.

Rezultati ove pilot studije mogu biti osnova za dalje i detaljnije istraživanje najadekvatnijeg načina čišćenja površine implanta.

Conclusion

Based on the material microstructure study and the determination of the qualitative and quantitative elemental composition of the three types of implant surfaces, it was found that the gentlest method of cleaning the surface, regardless of its type, is laser treatment. Under its influence, the microstructure is partially disturbed (the phenomena of melting, smoothing), but the macrostructure is preserved, and the composition of elements does not contain extraneous inclusions, which may be significant for osseointegration of the implant.

The most damaging was the method of cleaning with diamond burr: after its impact, regardless of the type of surface, there were revealed macro- and microstructure disturbances, up to their loss, the presence of grooves and notches, the introduction of diamond particles into the implant structure, and carbon (C) dominated in the spectrum of chemical elements that can be considered as a marker of these violations.

The use of a special brush also led to macro- and microstructure disruption of the implant surface, although less pronounced; a significant level of nickel (Ni) was detected in the microelement spectrum, which can be considered as a marker of this cleaning method.

The results of this pilot study are the basis for further and more detailed research.

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