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MODIFIKACIJE POVRŠINE ZUBNIH IMPLANTATA I NJIHOV UTICAJ NA PROCES OSEOINTEGRACIJE

MODIFICATIONS ON THE DENTAL IMPLANT SURFACES AND THEIR INFLUENCE ON THE OSTEOINTEGRATION PROCESS

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Sažetak

Uvod: *Dentalna implantacija predstavlja proces ugradnje zubnih implantata u kost pacijenta na mestima gde nedostaje jedan zub ili više zuba. Da bi implantacija bila uspešna, potrebno je da dođe do procesa oseointegracije, što znači da zubni implantat postavljen u kost treba da stvori vezu sa košću. Uspeh procesa oseointegracije zavisi od više faktora, među kojima je i biološka modifikacija materijala od kojeg je implantat napravljen. Neuspeh u oseointegraciji vodi do periimplantitisa i odbacivanja implantata.*
Cilj: *Cilj rada bio je da se dokaže uticaj hemijskih elemenata koji se pojavljuju na površini titanijumskih implantata na pojavu periimplantitisa, koji utiče na proces oseointegracije prilikom dentalne implantacije. Predmet ovog istraživanja bila je analiza novih, sterilnih implantata, kao i njihovo poređenje sa odbačenim, odnosno neuspelim implantatima.*
Materijali i metode: *Za potrebe naučnog istraživanja korišćen je skenirajući elektronski mikroskop (SEM), koji je omogućio detaljnu analizu površine implantata. Analiza je rađena na novim, fabričkim, kao i na neuspelim, obačenim implantatima. Skenirajući elektronski mikroskop vrsta je elektronskog mikroskopa koja proizvodi slike uzorka skeniranjem njegove površine fokusiranim snopom elektrona.*
Rezultati: *Posledica taloženja mnogih minerala (npr. Mg, P) jeste veća otpornost na habanje na površini implantata. Tragovi zagađivača Na, zajedno sa C, N, Ca, Al i O, takođe su otkriveni na titanijumskoj površini odbačenih, neuspelih implantata.*
Svi ovi elementi negativno utiču na uspeh implantacije i čine uzrok neuspešne terapijske procedure implantacije.
Zaključak: *Kontaminacija dentalnih implantata ključni je faktor za uspeh/neuspeh implantacije. Tragovi organskih i neorganskih zagađivača mogu se naći uprkos procesu čišćenja implantata, površinskoj obradi Ti, supstancama poput kiseline i peska.*

Ključne reči: *implantat, neuspeh, oseointegracija, periimplantitis, uspeh*

Abstract

Introduction: *Dental implantation is a process of implanting dental implants into the bone of a patient, in places where one or more teeth are missing. For successful implantation, the process of osteointegration has to happen, which means that the dental implant placed in the bone should create a connection with it. The success of the osteointegration process depends on several factors, one of which is a biological modification of the material from which the implant is made. As a failure, it can occur during peri-implantitis.*
Aim: *The present study aimed to prove the influence of the foreign body on osteointegration during dental implantation, that is, the cause of peri-implantitis. The subject of our research was the analysis of new, sterile implants and their comparison with fallen, lost implants*
Materials and methods: *For this scientific research we used a scanning electron microscope, which allows a detailed analysis of the implant surface. The analysis was performed on brand new, as well as on failed implants. A Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning its surface with a focused beam of electrons.*
Results: *As a consequence of the deposition of many minerals (like Mg, and P), a higher wear resistance occurs on the implant surface. Traces of contaminant Na along with carbon, N, Ca, Al and O were also detected on the Ti surface of the failed implants, which are fallen implants.*
All these elements negatively affect the implantation success and are the cause of unsuccessful implant treatment.
Conclusion: *Dental implant contamination is a key factor for the success/failure of implantation. Traces of organic and inorganic contaminants can be found, despite the implant cleaning process and surface treatment of Ti, substances such as acid and sand.*

Key words: *implant, failure, osteointegration, peri-implantitis, success*

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Uvod

Zubni implantati koriste se za zamenu izgubljenih zuba, odnosno za zamenu korena izgubljenih prirodnih zuba. Nakon perioda od tri meseca do šest meseci, ugrađeni implantat postiže oseointegraciju u kost – tada možemo reći da je implantacija uspela i da je telo domaćina prihvatilo „strano“ telo[1]. U suprotnom, razvija se upala oko implantata (periimplantitis), dolazi do odbacivanja implantata i neuspešne implantacije[2].

U prošlosti je postojao konsenzus da oseointegracija predstavlja homeostazu između zubnog implantata, napravljenog od titanijuma i okolne kosti. Takođe, smatralo se da je uzrok periimplantitisa upalni proces uzrokovan zubnim plakom sa gubitkom periimplantne kosti. U istraživanjima sprovedenim u protekloj deceniji navodi se nova teorija, prema kojoj je oseointegracija posledica procesa upale kao kontrolisane inflamatorne reakcije organizma na prisustvo stranog tela. Iako je implantat strano telo, telo ga najčešće prihvata zbog plemenitih materijala od kojih je napravljen.

Pojedina istraživanja zasnivaju se na ulozi koju oslobađanje materijala povezanog sa implantatima, posebno čestica titanijuma i nusproizvoda korozije, u okolno tkivo ima u pojavi i napredovanju periimplantitisa[3].

Cilj rada bio je da se dokaže uticaj hemijskih elemenata koji se pojavljuju na površini titanijumskih implantata na pojavu periimplantitisa, koji utiče na proces oseointegracije prilikom dentalne implantacije. Predmet ovog istraživanja bila je analiza novih, sterilnih implantata, kao i njihovo poređenje sa odbačenim, odnosno neuspelim implantatima.

Materijali i metode

Za potrebe ovog naučnog istraživanja korišćen je elektronski mikroskop, kojim je urađena detaljna analiza površine implantata. Analiza je obavljena kako na novim, tako i na odbačenim implantatima. Skenirajući elektronski mikroskop (SEM) vrsta je elektronskog mikroskopa koja proizvodi slike uzorka skeniranjem njegove površine fokusiranim snopom elektrona. Elektroni stupaju u interakciju sa atomima u uzorku, proizvodeći različite signale koji sadrže informacije o topografiji površine i sastavu uzorka. Elektronski snop skenira se u rasterskoj grafici, a položaj zraka kombinuje se sa intenzitetom detektovanog signala da bi se proizvela slika.

Introduction

Dental implants are used to replace lost teeth, or rather replace the roots of lost natural teeth. After 3 to 6 months, the placed implant achieves osteointegration in the bone and it is said that the implantation is successful and the body has accepted the "foreign" body[1]. Otherwise, inflammation continues around the implant referred to as peri-implantitis and the body rejects the implant and implantation fails[2].

In the past, there was a wide consensus that osteointegration represents homeostasis between the dental implant, made of titanium, and the surrounding bone, while bone loss was thought to be the cause of peri-implantitis, an inflammatory process caused by dental plaque. Contemporary researches present a new theory, according to which the osteointegration of an inflammatory process is the cause of the foreign body reaction and bone loss in response to the inflammatory process.

Furthermore, some researchers regarded the role of the release of implant-related material into the surrounding tissue, particularly titanium particles and corrosion byproducts, in the initiation and progression of peri-implantitis[3].

The aim of the study was to prove the influence of the foreign body on osteointegration during dental implantation, that is, the cause of peri-implantitis. The subject of our research was the analysis of new, sterile implants and their comparison with fallen, lost implants.

Materials and method

For this scientific research, we used an electron microscope, which allows detailed analysis of the surface of an implant. The analysis was performed on the new, as well as on the fallen implants. Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning its surface with a focused beam of electrons. Electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the intensity of the detected signal to produce an image. In the most common SEM mode, secondary electrons emitted by atoms excited by the electron beam are detected by a secondary electron detector (Everhart-Thornley detector). The number of secondary electrons that can be detected, and thus the signal intensity, depend, among other things, on the sample topography.

U najčešćem SEM režimu, sekundarni elektroni koje emituju atomi pobuđeni elektronskim snopom detektuju se pomoću sekundarnog detektora elektrona (Everhart–Thornley detektor). Broj sekundarnih elektrona koji se mogu detektovati, a samim tim i intenzitet signala, zavisi od topografije uzorka, između ostalog. Neki SEM mogu postići rezolucije veće od jednog nanometra. Uzorci se posmatraju u visokom vakuumu u konvencionalnom SEM-u ili u niskom vakuumu ili vlažnim uslovima u promenljivom pritisku ili ambijentalnom SEM-u, i u širokom opsegu kriogenih ili povišenih temperatura sa specijalizovanim instrumentima.

Laboratorija za elektronsku mikroskopiju ima za cilj proučavanje morfologije i hemijskog sastava različitih materijala u visokom ili niskom vakuumu. Analiza uzoraka obavljena je SE i/ili BSE detektorom, sa dobrom pripremom uzoraka i postignutom rezolucijom više od 5 nm. Hemijska analiza vršena je pomoću EDS detektora koji može detektovati elemente od Be do Pu, sa maksimalnom rezolucijom od 125 eV. Korišćenjem ove metode dobijena je kvalitativna i kvantitativna hemijska analiza postavljenog uzorka[4].

Prvu grupu ispitivanih zubnih implantata činili su čisti implanti, koje karakteriše *TiPurePlus Pl-Line* površina. To znači da je implantat čišćen peskarenjem; sam implantat napravljen je od čistog titanijuma stepena 4, po specijalnoj, precizno definisanoj tehnologiji. Ovi implantati imaju konusni dizajn, sa zaobljenim vrhom.

SC/SCKS implantati dostupni su u standardnim prečnicima (3,25/3,75/4,1/4,5/5,5 mm) i dužinama (7/8,5/10/11,5/13/15 mm) implantata.

Dizajn druge grupe ispitivanih implantata cilindričnog je oblika, sa dvostrukom olovnom žicom i dva spiralna antirotirajuća žleba.

Implantat je u nivou kosti, heksagonalnog oblika, sa ravnom glavom i mikronitima. Telo je na vrhu suženo sa obrnuto proporcionalnim nitima. Vrh implantata je kupastog oblika, bez otvora i sa žlebovima.

Rezultati i diskusija

Taloženje mnogih minerala (npr. Mg, P) dovodi do veće otpornosti na habanje površine implantata. Otkriveni su i tragovi zagađivača Na, zajedno sa C, N, Ca, Al i O, na titanijumskoj površini odbačenih, neuspelih implantata.

Some SEMs can achieve resolutions better than 1 nanometer. Samples are observed in high vacuum in conventional SEM, or low vacuum, or wet conditions in variable pressure or ambient SEM, and at a wide range of cryogenic, or elevated temperatures with specialized instruments.

An electron microscopy laboratory aims to study the morphology and chemical composition of various materials in high or low vacuum. Analyzing the samples can be done by SE and/or BSE detector, and with good sample preparation, we can achieve a resolution better than 5 nm. The chemical analysis is performed with an EDS detector that can detect elements from Be to Pu, with a maximum resolution of 125 eV. By using this method, a qualitative and quantitative chemical analysis of the placed sample is obtained[4].

Our examined dental implants are characterized by a TiPurePlus Pl-Line surface. This means that the implant is sandblasted clean, while the implant itself is made of grade 4 pure titanium, with special, precisely defined technology used. These implants have a conical design, with a rounded tip.

SC/SCX implants are available in standard diameters (3.25/3.75/4.1/4.5/5.5 mm) and lengths (7/8.5/10/11.5/13/15 mm)) of the implants.

The design of the other examined group of implants is cylindrical in shape, with a double lead wire and two spiral anti-rotation grooves.

It is an implant at the bone level. With a hexagonal shape. Its head is straight and has microfilaments. The body is tapered at the top with inversely proportional threads. The top of the implant has a domed shape, without a hole and with grooves.

Results and discussion

Along with the deposition of various minerals (for example Mg, P), which lead to the greater wear resistance of the implant surface, traces of contaminant Na along with carbon, N, Ca, Al and O were also detected on the Ti surface of the failed implants, i.e. the fallen implants. Also, there were traces of Na detected on the implant surfaces.

All these elements negatively affect the success of implantation and are the cause of its failure.

On failed implants surface Si was detected along with P, Ca, Na, S, Cl, Zn and copper (Cu) on the Ti surface.

Tragovi Na takođe su otkriveni na površini odbačenih implantata.

Svi ovi elementi negativno utiču na uspeh implantacije i razlog su zbog kojeg ona može biti neuspešna.

Si je detektovan na neuspelim implantatima, zajedno sa P, Ca, Na, S, Cl, Zn i bakrom (Cu), na titanijumskoj površini. Smatra se da površinski zagađivači mogu pojačati inflamatorni odgovor menjajući proces zarastanja, što dovodi do promene površine oksidnog sloja i neuspeha oseointegracije.

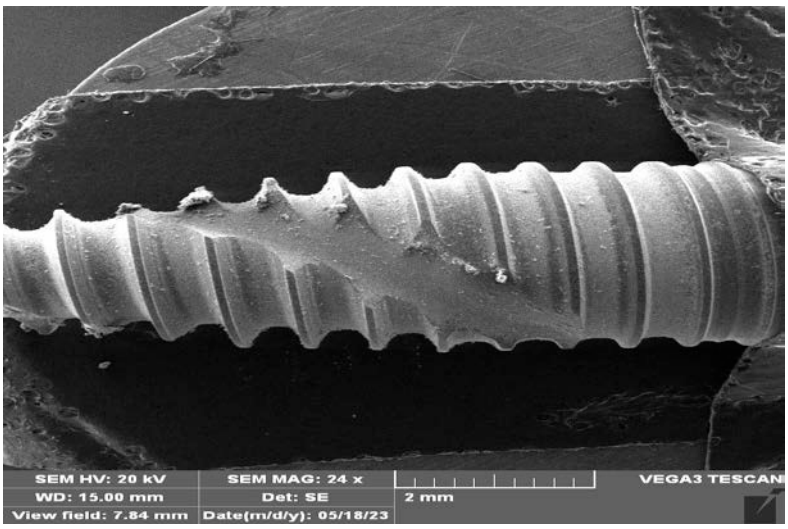
Prisustvo Si verovatno je posledica procesa pasivizacije u kojem je Si korišćen kao premaz, ili prilikom tretiranja titanijumskih površina.

U prvom test sistemu pronađena je velika količina kontaminacije Ca, što je i morfologija sigurno potvrdila. Nivo kontaminacije koju izaziva Ca od 0,0005% dovoljan je da inhibira formiranje apatita.

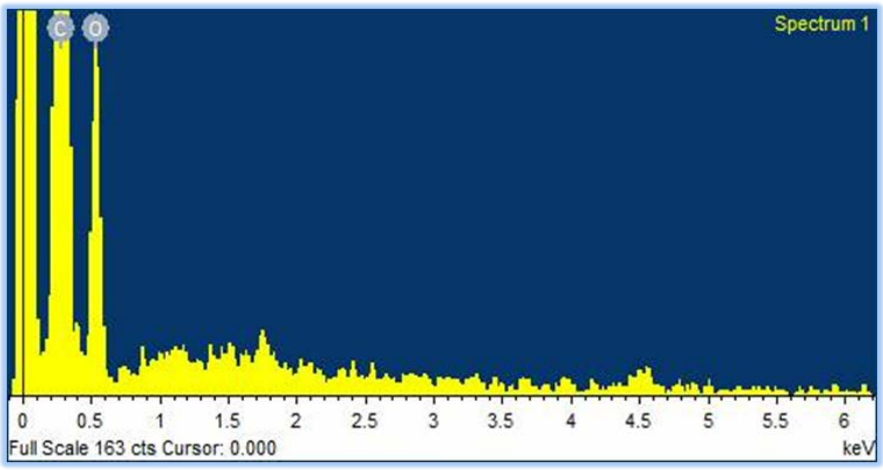
It is thought that surface contaminants may enhance the inflammatory response, alter the healing process that further leads to oxide layer surface alteration and osteointegration failure.The presence of Si is probably due to the passivation process where Si was used as a coating, or during Ti surfaces treatment.

A large amount of Ca contamination was found in the first test system, which morphology confirmed for sure. Even Ca contamination level of 0.0005% was sufficient to inhibit apatite formation.

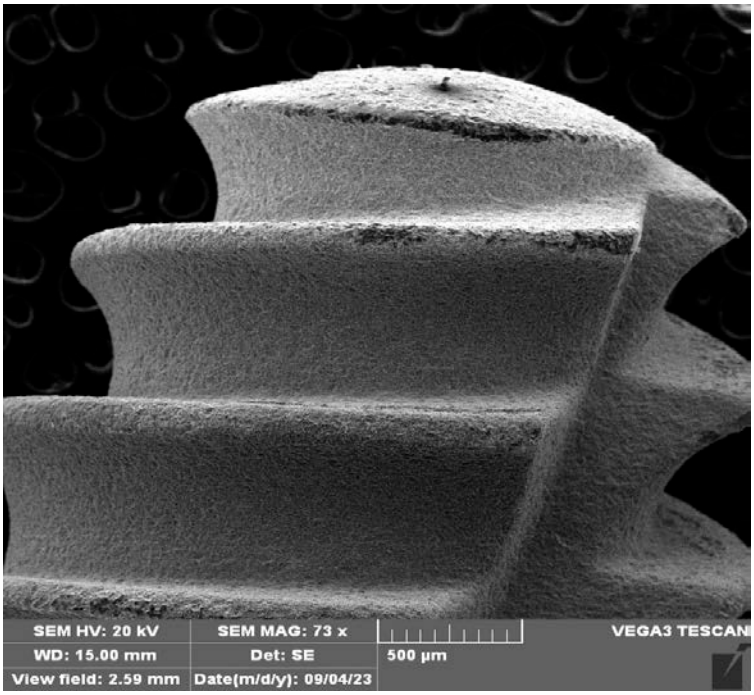
Traces of organic and inorganic contaminants can be found from the implant cleaning process, and surface treatment of Ti, like acid and sand[5].



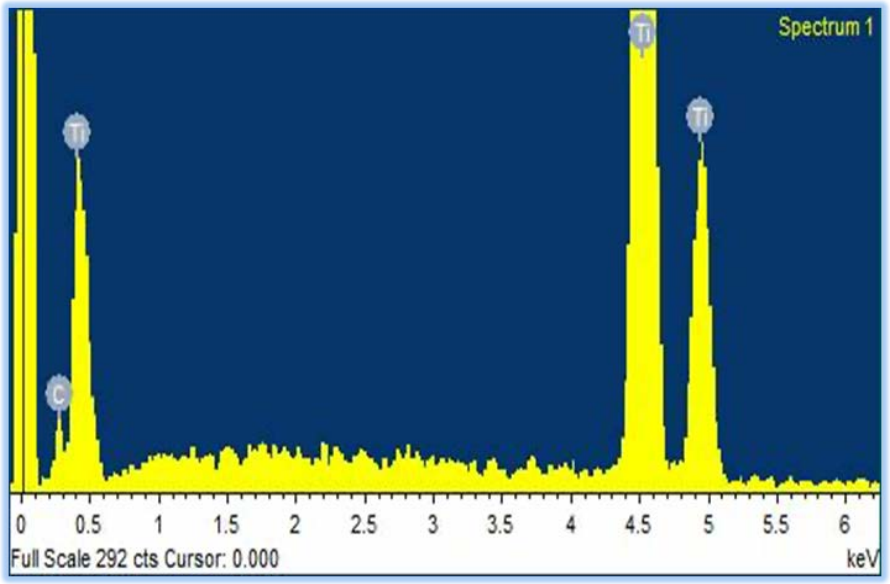
Slika 1a. Novi implantat iz prve grupe
Figure 1a. New implant from the first group



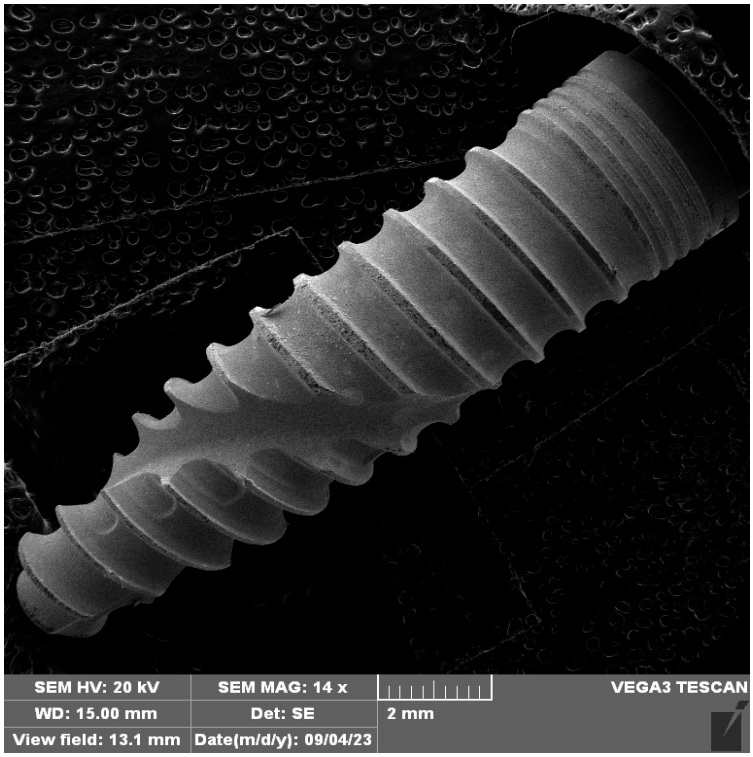
Slika 1b. Hemijska analiza novog implantata iz prve grupe
Figure 1b. Chemical analysis of a new implant from the first group



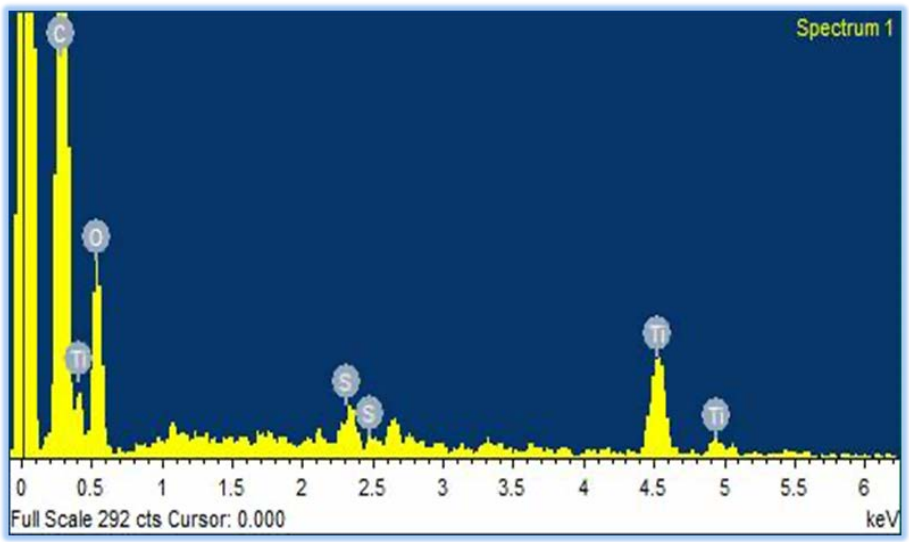
Slika 2a. Odbačeni implantat iz prve grupe
Figure 2a. Rejected implant from the first group



Slika 2b. Hemijska analiza odbačenog implantata iz prve grupe
Figure 2b. Chemical analysis of a rejected implant from the first group

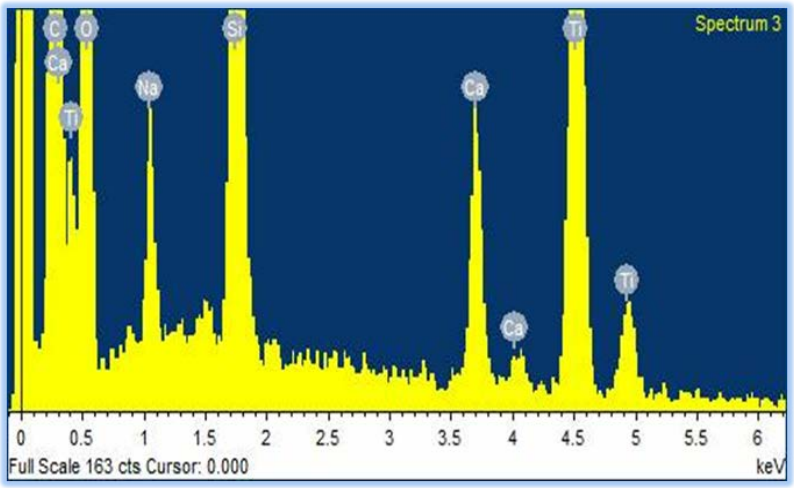


Slika 3a. Novi implantat iz druge grupe
Figure 3a. New implant of the second group



Slika 3b. Hemijska analiza novog implantata iz druge grupe
Figure 3b. Chemical analysis of a new implant from the second group

Slika 4a. Odbačeni implantat iz druge grupe
Figure 4a. Rejected second group implant



Slika 4b. Hemijska analiza odbačenog implantata iz druge grupe
Figure 4b. Chemical analysis of a rejected implant from the second group

Tabela 1. Preliminarni rezultati hemijskih elemenata na površini odbačenih implantata
Table 1. Preliminary results of chemical elements on the surface of rejected implants

Zagađivač A polluter	Način kontaminacije Method of contamination	Pozitivan efekat Positive effect	Negativan efekat Negative effect
Ca (kalcijum, calcium)	U toku čišćenja During cleaning	Kontakt kosti i implantata Bone and implant contact	Inhibira formiranje apatita Inhibition of apatite formation
P (fosfor, phosphorus)	U toku čišćenja During cleaning	Proizvodi citokine i matične ćelije Produces cytokines and stem cells	Habanje površine implantata Wear of the implant surface
S (sumpor, sulfur)	Pljuvačka, u kiselini za čišćenje Saliva, in cleaning acid		Promena površine na implantatu – oksidni sloj Surface change on the implant - oxide layer

Tragovi organskih i neorganskih zagađivača mogu se naći u procesu čišćenja implantata, površinske obrade Ti, kiselinom i peskom[5].

Zagađivači mogu biti korisni za zubne implantate i/ili imati štetne efekte na njih. Osim toga, mogu promeniti površinsku energiju, hemijsku čistoću, debljinu i sastav oksidnog sloja. Takođe je poznato da je najčešća kontaminacija titanijumske površine implantata ovim elementima potencijalno povezana sa defektima na implantatima. Kontaminacija implantata povezana je sa elementima koji se nalaze u tragovima; takvi su npr. N, Ca, P, Cl, S, Na, Si i F, organski ugljenik i bakterijske ćelije. Međutim, ima i zagađivača poput Si i P koji su korisni za zubne implantate, budući da mogu ubrzati oseointegraciju[6,7].

Postoji razlika među implantatima različitih proizvođača. Implantati se čiste drugačije, tj. svaka kompanija koristi različite metode čišćenja implantata pre nego što ih stavi u prodaju; otuda ima razlika u ceni implantata. Najvažniji je način na koji je implantat očišćen. S obzirom na to da sam implantat ima mnoge nepravilnosti, defekte ili izbočine koje je ponekad veoma teško očistiti, može biti odbačen zbog infekcije periimplantitisa uzrokovane kontaminacijom njegove površine[8].

Zaključak

Kontaminacije zubnih implantata usko su povezane sa neuspehom implantacije. Ukratko, može se zaključiti da zagađivači mogu biti korisni za zubne implantate i/ili imati štetne efekte na njih.

Zahvalnica: Nema**.**

Sukob interesa: Nema**.**

Finansijska podrška: Nema**.**

Contaminants may be beneficial and/or cause adverse effects on dental implants. They can change the surface energy, chemical purity, thickness and composition of the oxide layer. It is also known that the most common elemental contamination of Ti surfaces potentially associated with implant defects are trace elements of N, Ca, P, Cl, S, Na, Si and F, some organic carbons and bacterial cells/ by-products. However, some of the contaminants such as Si and P are beneficial for dental implants that promote osteointegration[6,7].

There is a difference in implants from different manufacturers. All implants are cleaned differently, that is, each company uses different methods of cleaning the implant before it is put on sale. Therefore, there are different prices of implants and the most important thing is the way the implant was cleaned. The implant itself has many irregularities, i.e. depressions, and protrusions that are sometimes very complex to clean, since the implant may break out, infection and peri-implantitis caused by the contamination of the dental implant surface itself may occur[8].

Conclusion

This research is intended for both manufacturers and doctors, which further increases its importance and value. Dental implant contaminations are closely related to implant failures. To summarize, it can be concluded that contaminants may be beneficial and/or cause adverse effects on dental implants.

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