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REVIEW ARTICLE

IMPACT OF DENTAL IMPLANT SURFACE UV-PHOTOFUNCTIONALIZATION ON OSSEOINTEGRATION AND ANTIBACTERIAL PROPERTIES: SYSTEMATIC REVIEW

Naira Ghambaryan^{1*}

- ¹. Lecturer Department of Oral and Maxillofacial Surgery, Yerevan State Medical University after M. Heratsi, Yerevan, Armenia

* **Corresponding author:** Naira Ghambaryan, Lecture, Department of Oral and Maxillofacial Surgery, Yerevan State Medical University after M. Heratsi, Yerevan, Armenia;
e-mail: a.jilavyan@icloud.com

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Abstract

The quality of a dental implant depends on the properties of the surface and contributes to the osseointegration of the implant into the bone tissue. In modern implantology, titanium and titanium alloys are widely used for the manufacture of various implants due to their good mechanical properties and biocompatibility. TiO from fabricated implants may lose its ability to bioactively integrate into bone after storage for less than 2 weeks, during which degradation of biological activity occurs. To optimize osseointegration, various methods are proposed for modifying the surface of implants by creating titanium-based micro- or nanostructures.

The purpose of this review is to discuss Ultraviolet Photofunctionalization of implant surface modifications, its effect on osseointegration and antibacterial properties. The following databases were included in the systematic search of the relevant literature: PubMed, Embase, AWMF Online, National Clearing House, International Guidelines Network and Cochrane Library. The following search criteria were used: surface modifications of implants, improve osseointegration of dental implants using ultraviolet photofunctionalization, effect of UV-photofunctionalization to improve antibacterial properties of dental implants, photofunctionalization of implants in the complex of prevention of peri-implantitis. A total of 50 articles were included that examined the effect of the application of UV radiation on dental implants were included in our study.

The results of a systematic review showed Ultraviolet Photofunctionalization helps improve osseointegration of implants and has antibacterial properties which is critical for implantologists, and to assist clinicians in selecting the most appropriate implants to improve implant success and survival.

Keywords: surface modifications of implants; UV-photofunctionalization; antibacterial properties of dental implants.

Introduction

Dental implants have now become the standard procedure for replacing lost teeth, providing many benefits, the long-term survival rates of dental implants

are excellent.¹ However, primary implant failure due to insufficient osseointegration occurs in 1-2% of patients during the first few months due to peri-implantitis, secondary implant failure develops several years after successful osseointegration in about 5% of patients.^{2,3}

Among the factors that play an important role in the osseointegration of a titanium dental implant is the implant surface, and it is known that with the use of various methods of implant surface modification, the osseointegration process can be optimized.⁴

To accelerate early osseointegration and increase the efficiency of bone-to-implant contact, biomedical research is aimed at modifying the bioactive properties of the surface.⁵

The TiO surface of the implant is able to integrate with the bone. The surface layer of a titanium implant turns into titanium dioxide (TiO₂) immediately after exposure to oxygen or atmospheric air.⁴

Titanium implants are subject to temperature fluctuations during production, transport and storage. TiO from fabricated implants may lose its ability to bioactively integrate into bone after storage for less than 2 weeks, during which degradation of biological activity occurs.⁶ This action renews the biological reactivity of titanium implants, which was lost after production and storage in air, improves the osteointegration properties of the implant surface.

Coating the surface of a dental implant promotes osseointegration of the implant into the bone tissue.⁷⁻⁹

The fact that modification of the implant surface can affect the success of osseointegration has been proven in various studies.^{10,11}

Implant surface modification is used to change the surface energy, resulting in improved hydrophilicity, increased cell proliferation and growth, and an accelerated osteointegration process.^{4,12}

All of the above methods lead to an increase in the surface area of the implant while contributing to the improvement of the hydrophilicity of the surface.^{4,13}

According to Goyal et al., treatment of the surface of the implant can simultaneously increase the surface area of the implant, improve the migration of cells and the surface of the implant, and also strengthen the process of osteointegration.¹⁴

It has been shown that surface treatment of implants significantly increases the surface area and can have a good effect on implant osseointegration.¹⁵⁻¹⁷

Currently, to promote osseointegration for successful implant therapy, various methods of modification of titanium implants are used.¹⁸

Surface modification methods include oxidation or additive processes, such as obtaining micropits on the implant surface by plasma deposition of titanium powder, hydroxyapatite and calcium phosphate

deposition, surface acid treatment (SLA), as well as ion deposition methods, electrochemical treatments (anodic oxidation), micro-arc oxidation, vacuum procedures, physical methods: alkaline heat treatment (AH) and laser melting.¹⁹⁻²¹

UV irradiation, or photofunctionalization, is one of the latest surface treatment techniques to promote osseointegration of implants.²²

The phenomenon of photofunctionalization (FF), first described in 2009, is defined as a general phenomenon of titanium surface modification after ultraviolet (UV) irradiation, which changes the physical and chemical properties of the implant surface from hydrophobic to superhydrophilic, which positively influences osteointegration and strengthens the initial attachment of osteoblasts to the implant surface.^{23,24}

UV radiation has been used for many years in industrial and medical technology to disinfect various surfaces. The biological effects of exposure to UV radiation on implant surfaces are defined as photofunctionalization, which is a simple and effective method to promote osseointegration.²⁵

UV irradiation transforms the naturally hydrophobic properties of Ti surfaces into superhydrophilic ones.²⁶

Exposure to UV radiation generates surface energy on the surface of the TiO implant, which converts water into hydroxyl radicals, hydrogen and oxygen. Research data have shown that pre-treatment of titanium with UV light significantly increases its osteoconductivity due to improved UV catalytic removal of hydrocarbons from the TiO₂ surface, which implies the photofunctionalization of titanium, which allows faster and more complete establishment of bone-titanium integration.²⁷⁻²⁹ Ultraviolet radiation causes the formation of an electrostatic state of titanium surfaces, the transformation of the surface from hydrophobic to superhydrophilic, the activation of protein absorption, and an increase in the activity of fibroblasts and osteoblasts. Hydrophilicity can enhance the initial attachment of osteoblast cells to the implant surface.³⁰

The change in the properties of the implant surface from hydrophobic to hydrophilic during photofunctionalization was checked by lightly immersing the two implant surfaces in distilled water.³¹

Photofunctionalization was confirmed by observing how water rose on the surface of the photofunctionalized implant immediately after

immersion in water, the surface of the non-photofunctionalized implant remained hydrophobic.^{32,33}

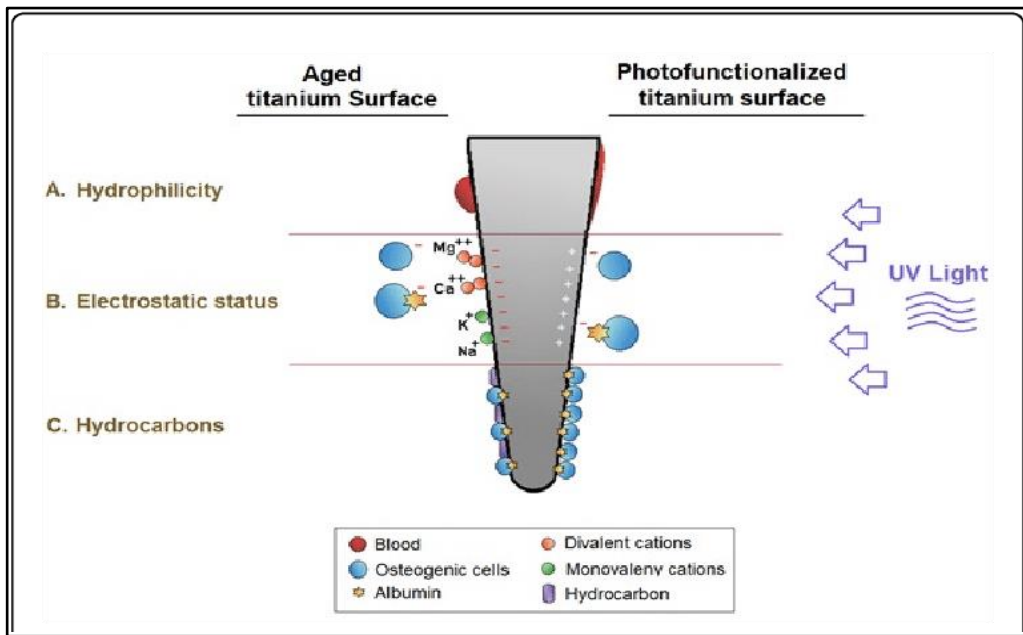


Figure 1. Schematic comparison between the physiochemical properties of the titanium's surface as received "aged" and the titanium's surface following PhF. **A)** Photofunctionalized surface shows much higher wettability across the implant surface than the non-treated surface. **B)** The surface charge on the UV treated surface becomes positive, allowing the negatively charged osteoblasts and stem cells to attach alone or through serum proteins. The non-treated surface is negatively charged and the only method of cells to attach is via bridging divalent cations (Mg^{++} , Ca^{++}). Monovalent cations (Na^{+} and K^{+}) competitively inhibit cell attachment. **C)** Photofunctionalization removes the hydrocarbon layer from the surface allowing for more protein absorption, and better attachment and spread of osteoblasts³⁴

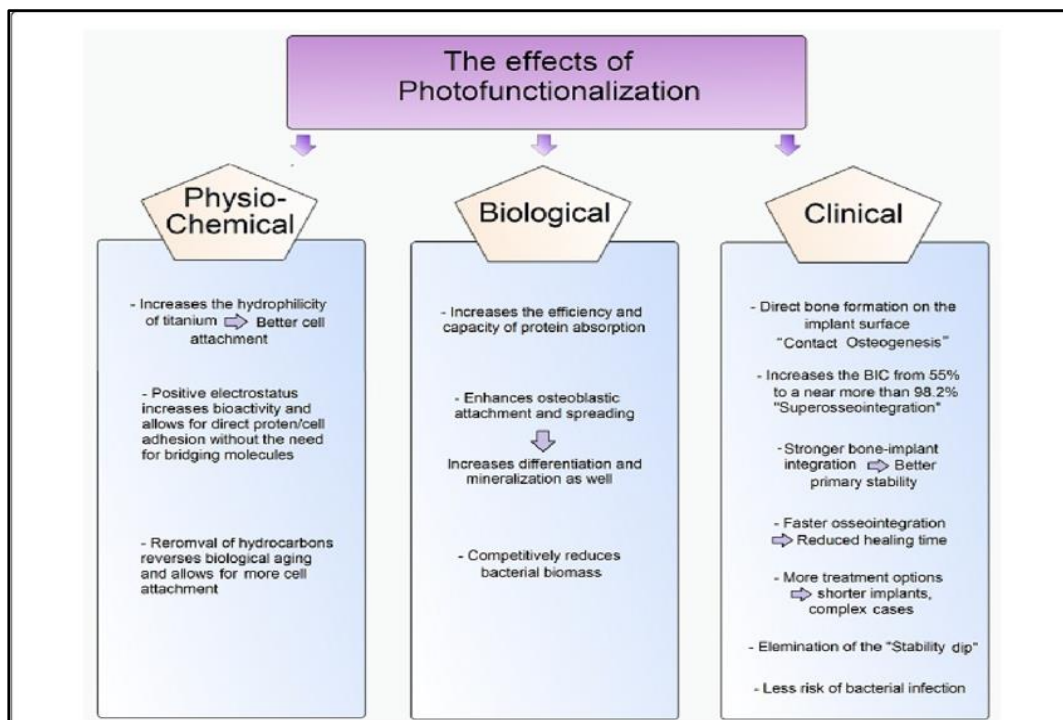


Figure 2. Effect of photofunctionalization on titanium and tissue, and clinical significance³⁴

Akiyoshi Funato and Takahiro Ogawa in 2013 for the first time in clinical cases studied the effect of photofunctionalization on implantation success, healing time, osseointegration rate and changes in the level of marginal bone around the implant 1 year after restoration. In this study, the authors reported that photofunctionalization accelerated and enhanced the osseointegration of titanium dental implants in a variety of clinically complex/impaired bone conditions and resulted in the preservation of the level of marginal bone around the implant s reported the need for long-term large-scale clinical studies.³⁵

The accumulation of pathogenic microorganisms on dental implants and their components can stimulate inflammatory reactions in peri-implant tissues. Bacterial infections remain the leading cause of implant failure.

Peri-implant mucositis and peri-implantitis are the most common complications of dental implants estimated at 29.48% and 9.25% of dental implants, respectively.³⁶

Dental implant placement takes place in an oral environment that harbors an abundance of biofilm-forming bacteria. Due to its transmucosal location, part of the implant structure is exposed to the oral cavity and there is no effective way to prevent bacterial attachment to the implant materials. The development of infections during the early healing phase is considered a risk factor for the osseointegration process, causing higher rates of early implant failure.^{37,38}

UV irradiation of titanium surfaces of implants demonstrated an antimicrobial effect, positively reduced the number of pathogenic bacteria in the periodontium due to enhanced photocatalytic properties, which.³⁹

Photofunctionalization also reduces the amount of attachment/accumulation of bacteria on the surface and components of the implant, thus may have an antimicrobial effect.⁴⁰⁻⁴²

A recent report showed that implants are exposed to a complex environment, microbiota of the oral cavity, photofunctionalization of Ti surfaces can reduce the attachment and formation of monotypic biofilms of *Staphylococcus aureus* and *Streptococcus pyogenes*, the main pathogens of implant infections.⁴³

It is known that ultraviolet radiation also has an antimicrobial effect due to photochemical reactions, affecting the DNA of bacteria.⁴⁴ Irradiation of titanium

surfaces with UV light showed an antimicrobial effect due to the enhancement of photocatalytic properties that suppress periodontopathogenic bacteria. UV radiation reduces the adhesion of bacteria to the surface of the TiO implant and can increase the attachment of epithelial cells to TiO.⁴⁵

Photofunctionalization of implants is currently also used in the complex of prevention and treatment of peri-implantitis.⁴⁶

UV treatment decomposes organic compounds and reduces bacterial adhesion of *Streptococcus sanguinis*.⁴⁷

Photofunctionalization not only increases the interaction of the implant surface with the surrounding bone, which promotes osseointegration, but at the same time minimizes bacterial colonization, reducing the risk of biofilm formation.

It is known that ultraviolet radiation also has an antimicrobial effect due to photochemical reactions, affecting bacteria. A recent report showed that UV-modification of Ti surfaces can reduce the attachment and uniform formation of biofilms of *Staphylococcus aureus* and *Streptococcus pyogenes*, the main causative agents of implant infections.⁴⁸

UV radiation reduces the adhesion of bacteria to the surface of the TiO implant, it can increase the attachment of epithelial cells to the surface of the implant and the formation of a biofilm, suppressing the growth of bacteria.⁴⁹

Due to UV, the adsorption of plasma proteins is enhanced and the attachment, distribution and proliferation of osteogenic cells are improved, which can reduce the time of dental implantation.⁵⁰

Conclusion

Various methods are adopted to improve osseointegration. UV photofunctionalization is one of the advanced methods for modifying the surface of implants. This method can change the wettability of the surface and eliminate hydrocarbons formed as a result of aging on the implant surface, can enhance cell migration, attachment and proliferation, promote osseointegration and compaction of coronal soft tissues, and also has an antibacterial effect by preventing the formation of biofilm on the implant components, thereby playing a role in the prevention of peri-implantitis. In order to exploit the results of UV photofunctionalization, additional

clinical trials targeting complex implantation cases are needed in the future.

Declarations

Conflicts of interest and financial disclosures

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval

The study was approved by the University ethics committee and was conducted in accordance with the Declaration of the World Medical Association.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Source of funding

The work was not funded.

REFERENCES

1. Smeets R, Stadlinger B, Schwarz F, et al. Impact of Dental Implant Surface Modifications on Osseointegration. *Biomed Res Int.* 2016;2016:6285620. doi:10.1155/2016/6285620
2. Chrcanovic BR, Albrektsson T, Wennerberg A. Reasons for failures of oral implants. *Journal of Oral Rehabilitation.* 2014;41(6):443–476. doi:10.1111/joor.12157
3. Smeets R, Henningsen A, Jung O, Heiland M, Hammächer C, Stein JM. Definition, etiology, prevention and treatment of peri-implantitis—a review. *Head and Face Medicine.* 2014;10(1, article 34):1-13. doi:10.1186/1746-160x-10-34
4. Kligman S, Ren Z, Chung CH, et al. The Impact of Dental Implant Surface Modifications on Osseointegration and Biofilm Formation. *J Clin Med.* 2021;10(8):1641. doi:10.3390/jcm10081641
5. Gómez-de Diego R, Mang-de la Rosa MDR, Romero-Pérez MJ, Cutando-Soriano A, López-Valverde-centeno A. Indications and contraindications of dental implants in medically compromised patients: update. *Medicina Oral, Patología Oral y Cirugía Bucal.* 2014;19(5):e483–e489. doi:10.4317/medoral.19565
6. Flanagan D. Photofunctionalization of Dental Implants. *J Oral Implantol.* 2016;42(5):445-450. doi:10.1563/aaid-joi-D-15-00145
7. Att W, Hori N, Takeuchi M, Ouyang J, Yang Y, Anpo M, Ogawa T. Time-dependent degradation of titanium osteoconductivity: an implication of biological aging of implant materials. *Biomaterials.* 2009;30(29):5352-63. doi:10.1016/j.biomaterials.2009.06.040
8. Shin YC, Bae JH, Lee JH, et al. Enhanced osseointegration of dental implants with reduced graphene oxide coating. *Biomater Res.* 2022;26:11. doi:10.1186/s40824-022-00257-7
9. Inchingolo AM, Malcangi G, Ferrante L, et al. Surface Coatings of Dental Implants: A Review. *J Funct Biomater.* 2023;14(5):287. doi:10.3390/jfb14050287
10. Smeets R, Stadlinger B, Schwarz F, et al. Impact of Dental Implant Surface Modifications on Osseointegration. *Biomed Res Int.* 2016;2016:6285620. doi:10.1155/2016/6285620
11. Barfeie A, Wilson J, Rees J. Implant surface characteristics and their effect on osseointegration. *Br Dent J.* 2015;218:E9. doi:10.1038/sj.bdj.2015.171
12. Jemat A, Ghazali MJ, Razali M, Otsuka Y. Surface Modifications and Their Effects on Titanium Dental Implants. *Biomed Res Int.* 2015;2015:791725. doi:10.1155/2015/791725
13. Smeets R, Stadlinger B, Schwarz F, et al. Impact of Dental Implant Surface Modifications on Osseointegration. *Biomed Res Int.* 2016;2016:6285620. doi:10.1155/2016/6285620
14. Goyal N, Priyanka RK. Effect of various implant surface treatments on osseointegration—a literature review. *Indian Journal of Dental*

- Sciences*. 2012;4:154–157. doi:10.5005/cods-5-2-34
15. Knabe C, Klar F, Fitzner R, Radlanski RJ, Gross U. In vitro investigation of titanium and hydroxyapatite dental implant surfaces using a rat bone marrow stromal cell culture system. *Biomaterials*. 2002;23(15):3235–3245. doi:10.1016/s0142-9612(02)00078-9
 16. Fouda MFA, Nemat A, Gawish A, Baiuomy AR. Does the coating of titanium implants by hydroxyapatite affect the elaboration of free radicals. An experimental study. *Australian Journal of Basic and Applied Sciences*. 2009;3:1122–1129. doi:10.1016/s0001-6918(02)00045-8
 17. Junker R, Dimakis A, Thoneick M, Jansen JA. Effects of implant surface coatings and composition on bone integration: a systematic review. *Clinical Oral Implants Research*. 2009;20(4):185–206. doi:10.1111/j.1600-0501.2009.01777.x
 18. Chang LC. Clinical Applications of Photofunctionalization on Dental Implant Surfaces: A Narrative Review. *J Clin Med*. 2022;11(19):5823. doi:10.3390/jcm11195823
 19. Yeo IL. Modifications of Dental Implant Surfaces at the Micro- and Nano-Level for Enhanced Osseointegration. *Materials (Basel)*. 2019;13(1):89. doi:10.3390/ma13010089
 20. Accioni F, Vázquez J, Merinero M, Begines B, Alcudia A. Latest Trends in Surface Modification for Dental Implantology: Innovative Developments and Analytical Applications. *Pharmaceutics*. 2022;14(2):455. doi:10.3390/pharmaceutics14020455
 21. Hou C, An J, Zhao D, et al. Surface Modification Techniques to Produce Micro/Nano-scale Topographies on Ti-Based Implant Surfaces for Improved Osseointegration. *Front. Bioeng. Biotechnol*. 2022;10:835008. doi:10.3389/fbioe.2022.835008
 22. Clinical Applications of Chang LC. Photofunctionalization on Dental Implant Surfaces: A Narrative Review. *J Clin Med*. 2022;11(19):5823. doi:10.3390/jcm11195823
 23. Wang RH, Fujishima KA. Light-induced amphiphilic surfaces. *Nature*. 1997;388:431. doi:10.1038/41233
 24. Att W, Ogawa T. Biological aging of implant surfaces and their restoration with ultraviolet light treatment: A novel understanding of osseointegration. *Int. J. Oral. Maxillofac. Implant*. 2012;27:753–761
 25. Hori N, Ueno T, Minamikawa H, et al. Electrostatic Control of Protein Adsorption on UV-Photofunctionalized Titanium. *Acta Biomater*. 2010;6:4175–4180. doi:10.1016/j.actbio.2010.05.006
 26. Att W, Ogawa T. Biological aging of implant surfaces and its restoration using UV light treatment: a novel and breakthrough understanding of osseointegration. *Int J Oral Maxillofac Implants*. 2012;27:753-761
 27. Tabuchi M, Hamajima K, Tanaka M, Sekiya T, Hirota M, Ogawa T. UV Light-Generated Superhydrophilicity of a Titanium Surface Enhances the Transfer, Diffusion and Adsorption of Osteogenic Factors from a Collagen Sponge. *Int J Mol Sci*. 2021;22(13):6811. doi:10.3390/ijms22136811
 28. Hirota M, Ikeda T, Tabuchi M, Iwai T, Tohna I, Ogawa T. Effect of ultraviolet-mediated photofunctionalization for bone formation around medical titanium mesh. *J Oral Maxillofac Surg*. 2014 Sep;72(9):1691-702. doi:10.1016/j.joms.2014.05.012
 29. Ogawa T. Ultraviolet photofunctionalization of titanium implants. *Int J Oral Maxillofac Implants*. 2014;29(1):e95-102. doi:10.11607/jomi.te47
 30. Gittens RA, Scheideler L, Rupp F, et al. A review on the wettability of dental implant surfaces II: Biological and clinical aspects. *Acta Biomater*. 2014;10(7):2907-18. doi:10.1016/j.actbio.2014.03.032
 31. Tsujita H, Nishizaki H, Miyake A, Takao S, Komasa S. Effect of Plasma Treatment on Titanium Surface on the Tissue Surrounding Implant Material. *Int J Mol Sci*. 2021;22(13):6931. doi:10.3390/ijms22136931
 32. Jemat A, Ghazali MJ, Razali M, Otsuka Y. Surface Modifications and Their Effects on Titanium Dental Implants. *Biomed Res Int*. 2015;2015:791725. doi:10.1155/2015/791725
 33. Lee JB, Jo YH, Choi JY, et al. The Effect of Ultraviolet Photofunctionalization on a Titanium Dental Implant with Machined Surface: An In Vitro and In Vivo Study. *Materials (Basel)*. 2019;12(13):2078. doi:10.3390/ma12132078

34. Elkhidir YAH, Cheng Y. Achieving Superoosseointegration: The Photofunctionalization Effect. *Dentistry*. 2017;7:435. doi:10.4172/2161-1122.1000435
35. Funato A, Ogawa T. Photofunctionalized dental implants: a case series in compromised bone. *Int J Oral Maxillofac Implants*. 2013;28(6):1589-601. doi:10.11607/jomi.3232
36. Lee CT, Huang YW, Zhu L, Weltman R. Prevalences of peri-implantitis and peri-implant mucositis: Systematic Review and meta-analysis. *J. Dent.* 2017;62:1–12. doi:10.1016/j.jdent.2017.04.011
37. Mohajerani H, Roozbayani R, Taherian S, Tabrizi R. The Risk Factors in Early Failure of Dental Implants: a Retrospective Study. *J Dent (Shiraz)*. 2017;18(4):298-303
38. Kang DY, Kim M, Lee SJ, et al. Early implant failure: a retrospective analysis of contributing factors. *J Periodontal Implant Sci*. 2019;49(5):287-298. doi:10.5051/jpis.2019.49.5.287
39. Ishii K, Matsuo M, Hoshi N, Takahashi SS, Kawamata R, Kimoto K. Effects of Ultraviolet Irradiation of the Implant Surface on Progression of Periimplantitis—A Pilot Study in Dogs. *Implant. Dent.* 2016;25:47–53. doi:10.1097/ID.0000000000000332
40. Yamada Y, Yamada M, Ueda T, Sakurai K. Reduction of biofilm formation on titanium surface with ultraviolet-C pre-irradiation. *J. BioMater. Appl.* 2014;29:161–171. doi:10.1177/0885328213518085
41. de Avila ED, Lima BP, Sekiya T, et al. Effect of UV-photofunctionalization on oral bacterial attachment and biofilm formation to titanium implant material. *Biomaterials*. 2015;67:84–92. doi:10.1016/j.biomaterials.2015.07.030
42. Jain S, Williamson RS, Marquart M, Janorkar AV, Griggs JA, Roach MD. Photofunctionalization of anodized titanium surfaces using UVA or UVC light and its effects against *Streptococcus sanguinis*. *J. Biomed. Mater. Res. B Appl. BioMater.* 2018;106:2284–2294. doi:10.1002/jbm.b.34033
43. Barão VAR, Costa RC, Shibli JA, Bertolini M, Souza JGS. Emerging titanium surface modifications: The war against polymicrobial infections on dental implants. *Braz Dent J*. 2022;33(1):1-12. doi:10.1590/0103-6440202204860
44. Abdullatif FA, Al-Askar M. Does Ultraviolet Radiation Exhibit Antimicrobial Effect against Oral Pathogens Attached on Various Dental Implant Surfaces? A Systematic Review. *Dent J (Basel)*. 2022;10(6):93. doi:10.3390/dj10060093
45. Bono N, Ponti F, Punta C, Candiani G. Effect of UV Irradiation and TiO₂-Photocatalysis on Airborne Bacteria and Viruses: An Overview. *Materials (Basel)*. 2021;14(5):1075. doi:10.3390/ma14051075
46. Ishii K, Matsuo M, Hoshi N, Takahashi SS, Kawamata R, Kimoto K. Effect of ultraviolet irradiation of the implant surface on progression of periimplantitis—a pilot study in dogs. *Implant Dent*. 2016;25:47–53. doi:10.1097/ID.0000000000000332
47. Ahn SJ, Han JS, Lim BS, Lim YJ. Comparison of ultraviolet light-induced photocatalytic bactericidal effect on modified titanium implant surfaces. *Int J Oral Maxillofac Implants*. 2011;26(1):39-44
48. Jain S, Williamson RS, Marquart M, Janorkar AV, Griggs JA, Roach MD. Photofunctionalization of anodized titanium surfaces using UVA or UVC light and its effects against *Streptococcus sanguinis*. *J. Biomed. Mater. Res. B Appl. BioMater.* 2018;106:2284–2294. doi:10.1002/jbm.b.34033
49. Yamada Y, Yamada M, Ueda T, Sakurai K. Reduction of biofilm formation on titanium surface with ultraviolet-C pre-irradiation. *J. BioMater. Appl.* 2014;29:161–171. doi:10.1177/0885328213518085
50. Yeo IL. Modifications of Dental Implant Surfaces at the Micro- and Nano-Level for Enhanced Osseointegration. *Materials*. 2019;13:89. doi:10.3390/ma13010089

ԱՏԱՄՆԱՅԻՆ ԻՄՊԼԱՆՏԻ ՄԱԿԵՐԵՍԻ ՈՒՆՏՐԱՄԱՆՈՒՇԱԿԱԳՈՒՅՆ
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ՀԱԿԱՔԱԿՏԵՐԻԱԿ ՀԱՏԿՈՒԹՅՈՒՆՆԵՐԻ ՎՐԱ. ԳՐԱԿԱՆՈՒԹՅԱՆ ԱԿՆԱՐԿ

Նաիրա Դամբարյան¹

- ¹. Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի վիրաբուժական ստոմատոլոգիայի և դիմաձնոտային վիրաբուժության ամբիոնի դասախոս, Երևան, Հայաստան

Ամփոփում

Ատամնային իմպլանտի որակը կախված է մակերեսի հատկություններից և նպաստում է իմպլանտի օստեոինտեգրմանը ոսկրային հյուսվածքի մեջ: Ժամանակակից իմպլանտոլոգիայում տիտանի և տիտանի համաձուլվածքները լայնորեն օգտագործվում են տարբեր իմպլանտների արտադրության համար՝ շնորհիվ իրենց լավ մեխանիկական հատկությունների և կենսահամատեղելիության: TiO-ից պատրաստված իմպլանտները կարող է կորցնել ոսկորին բիոակտիվ կերպով ինտեգրվելու իր ունակությունը 2 շաբաթից պակաս պահեստավորումից հետո, որի ընթացքում տեղի է ունենում կենսաբանական ակտիվության դեգրադացիա: Օստեոինտեգրացիան օպտիմալացնելու համար առաջարկվում են իմպլանտների մակերեսը փոփոխելու տարբեր մեթոդներ՝ ստեղծելով տիտանի վրա հիմնված միկրո կամ նանոկառուցվածքներ:

Այս ակնարկի նպատակն է քննարկել իմպլանտի մակերեսի ուլտրամանուշակագույն ֆոտոֆունկցիոնալացումը, դրա ազդեցությունը օստեոինտեգրման և հակաբակտերիալ հատկությունների վրա: Համապատասխան գրականության համակարգված որոնման մեջ ներառվել են հետևյալ տվյալների բազաները՝ PubMed, Embase, AWMF Online, National Clearing House, International Guidelines Network և Cochrane Library: Օգտագործվել են որոնման հետևյալ չափանիշները՝ իմպլանտների մակերեսային փոփոխություններ, ատամնաբուժական իմպլանտների օստեոինտեգրացիայի բարելավում ուլտրամանուշակագույն ֆոտոֆունկցիոնալացման միջոցով, ուլտրամանուշակագույն ֆոտոֆունկցիոնալացման ազդեցությունը ատամնաբուժական իմպլանտների հակաբակտերիալ հատկությունների բարելավման համար, իմպլանտների ֆոտոֆունկցիոնալացում պերիիմպլանտիտի կանխարգելման համալիրում: Ընդհանուր առմամբ 50 հոդված է ներառվել, որոնք ուսումնասիրել են ատամնաբուժական իմպլանտների վրա ուլտրամանուշակագույն ճառագայթման կիրառման ազդեցությունը, ներառվել են մեր ուսումնասիրության մեջ: Համակարգված վերանայման արդյունքները ցույց են տվել, որ ուլտրամանուշակագույն ֆոտոֆունկցիոնալացումը օգնում է բարելավել իմպլանտների օստեոինտեգրումը և ունի հակաբակտերիալ հատկություններ, ինչը կարևոր է իմպլանտոլոգների համար և օգնել կլինի բժիշկներին ընտրել ամենահարմար իմպլանտները՝ բարելավելու իմպլանտների հաջողությունն ու գոյատևումը:

**ВЛИЯНИЕ УФ-ФОТОФУНКЦИОНАЛИЗАЦИИ ПОВЕРХНОСТИ ДЕНТАЛЬНОГО ИМПЛАНТАТА
НА ОСТЕОИНТЕГРАЦИЮ И АНТИБАКТЕРИАЛЬНЫЕ СВОЙСТВА: СИСТЕМАТИЧЕСКИЙ
ОБЗОР**

Наира Гамбарян¹

- ¹. Преподаватель кафедры хирургической стоматология челюстно-лицевой хирургии, Ереванский государственный медицинский университет им. М. Гераци, Ереван, Армения

Աբստրակտ

Качество дентального имплантата зависит от свойств поверхности и способствует остеоинтеграции имплантата в костную ткань. В современной имплантологии титан и титановые сплавы широко используются для изготовления различных имплантатов благодаря своим хорошим механическим свойствам и

биосовместимости. TiO из изготовленных имплантатов может потерять способность биоактивно интегрироваться в кость после хранения менее 2 недель, в течение которого происходит деградация биологической активности. Для оптимизации остеоинтеграции предлагаются различные методы модификации поверхности имплантатов путем создания микро- или наноструктур на основе титана.

Целью данного обзора является обсуждение ультрафиолетовой фотофункционализации модификаций поверхности имплантатов, ее влияния на остеоинтеграцию и антибактериальные свойства. В систематический поиск соответствующей литературы были включены следующие базы данных: PubMed, Embase, AWMF Online, National Clearing House, International Guidelines Network и Cochrane Library. В качестве критериев поиска использовались следующие критерии поиска: модификация поверхности имплантатов, улучшение остеоинтеграции дентальных имплантатов с помощью ультрафиолетовой фотофункционализации, эффект УФ-фотофункционализации для улучшения антибактериальных свойств дентальных имплантатов, фотофункционализация имплантатов в комплексе профилактики периимплантита. Всего в наше исследование было включено 50 статей, в которых рассматривалось влияние применения УФ-излучения на зубные имплантаты.

Результаты систематического обзора показали, что ультрафиолетовая фотофункционализация влияет способствует улучшению остеоинтеграции и обладает антибактериальными свойствами, что имеет решающее значение для имплантологов, а также помогает клиницистам в выборе наиболее подходящих имплантатов для улучшения успеха и выживаемости имплантатов.