Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 5 [3] February 2016: 103-107

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

REVIEW ARTICLE **OPEN ACCESS**

A Review of Modified Titanium Nanoparticle Applications in Dental Implantation

[1]Masoud Bamedi.* [2] **Mohammad Ayoub Rigi Ladiz,** 3**Sirous Risbaf Fakour**.
[1]Oral and Dental Disease Research Center, Zahedan University of Medical Science, Zahedan Iran
[2]Oral and Dental Disease Research Center, Zahedan University of Medical Science, Zahedan Iran
[3]Oral and Dental Disease Research Center, Zahedan University of Medical Science, Zahedan Iran
***Corresponding author:bamadim@yahoo.com**

ABSTRACT

Nowadays, dental implantation is one of the most common offers to replacement of the missing teeth, therefore during last few decades many efforts have been done to improve nano-technological methods in dental implants to fabricate more efficient materials with less inducing allergy, bacterial inflammation, and corrosion, even with bone healing properties. As Titanium widely used in dental implants, it made us to make a review as a study of some new articles surrounding titanium nano- particles and nano-modified titanium surfaces which have been reported to possess better characteristics than titanium in different perspectives. Some of them are highlighted in this review. Information was gathered from Google Scholar, Pub Med, and some dental databases.In conclusion, As innovative fabrication design of titanium into verified titanium nano- particles may be a great factor in the long-term health of dental implants, Many studies carried out to produce new modified material based on titanium. Ultimately most of them demonstrate the eligibility of new products than titanium itself in various aspects
Keywords: *"titanium, nano technology, nano-particles, nano-modification, dental implants, anti bacterial properties.*

Received 02.12.2015 Revised 26.12.2015 Accepted 12.01.2016

INTRODUCTION

Titanium and necessity of renovation in modern dental implantation

Titanium and its alloys play as a good material to fuse tightly to bone to protect dental prosthetics utilized widely in dental implants today [1], data in Table 1 illustrates the highly used commercial titanium alloys today[2-3], However, there are still some restrictive conditions that may cause hipper sensitivity, corrosion, bacterial infections, and unpleasant Cell Interactions which may reject dental implantations and reduce best life time of it [4] In a review article performed in 2012, mainly 3 aspects of titanium based on published articles were considered briefly described below[4] :

- Some titanium environmental reactions mentioned, and concluded the formation of passive oxide film on the surface of titanium causes corrosion resistance in aqueous solution, and magnified the importance of implant surface properties such as roughness, chemistry, and cell proliferation induction. As a result, Titanium corrosion reported in variety clinical relevance is significantly less than other metals may use in dental implants, but there are still some limitations.
- Research performed about titanium activations was gathered to emphasize the importance of Modification of titanium surface. The clinical usage of micro-, and nano- material with biologically active properties, to improve dental titanium-based implants, seems promising perspective in future dental implantations.
- Studies about Titanium cell interaction and Titanium bio film interaction, by mentioning some new articles, revealed the importance of modification of titanium to decrease inflammations and bacterial infections, and to improve osseointegration, bone regeneration and bone healing. [4]

Up to now, many studies revealed the better properties of novel modified titanium-based materials than pure common titanium alloys. As an example, in 2004 Katti revealed the considerably improved bone adhesion abilities of bioactive coating titanium-based particles rather than conventional pure titanium alloys [6]. In some related articles coating the pharmacological particles on titanium is recommended, for

example, Bisphosphonate loaded on titanium enhanced mechanical fixation in rat tibia [7] and modified gold titanium surface increased skeleton fixation [8]

TIO2 As nanostructured titanium with greater properties

Titanium nanostructure showed the great potential of better bon integration and regeneration properties[17-18]. The nanostructure creation effectively micro and nano-sized particles could be unleashed from the surface of a titanium implant. Recently, some studies have been done to produce, and improve micro-to-nano scale titanium implants, and evaluate and improve their effects on bone stem cells, which briefly mentioned In table 2. Production of micro-nano-hybrid surface of titanium offers greater implant surface properties which make nano modified titanium more appealing. Studying and reviewing such researches and results, may lead scientists to fabricate novel effective nanostructure titanium implants [9-11]. In this regard, the study of TiO(2) nanotube layers(70nm-100nm) declared the greater antibacterial activity of these nano particles to prevent Streptococcus bacteria [12].in a study performed in 2011, TiO(2) Micro-nano-hybrid surfaces were produced and treated by UV light , As many studies emphasized the impact of UV light on titanium bioactivity promotion. [13-15], and the results illustrated the titanium higher antibiological aging properties[16]. These researches present a great promising perspective of having better dental implants with long term stability and bon healing abilities and fewer cons.

Modification of titanium surface by nano- techniques

Up to now, many nanotechnology methods investigated for improving dental Implants, including Surface modifications, fictionalization and topography, Nanocomposites for bone regeneration, and Assessing implant osseointegration. Although, it is still a technical challenging matter to find out reliable techniques to the fabrication of dental implants [19], nanotechnology is promising field of study to have better materials for implantations. As an example, sandblasted TiO2 particles have better property than ceramics in dental composits[20-21]. Efforts to changing anodic polarization of Titanium surface is another instance [22]. Many approaches have been carried out that suggest the exploitation of effective modified materials in dental implantations.

As implant surface physicochemical characterizations play critical role in biological interactions, many components have been coated on titanium to improve nanostructure properties notably, such as, the utilization of thin nanocrystal of calcium phosphate on titanium [23].

In a study performed in 2015, in a comparative manner, cell adhesion of three differently modified titanium , conventional, laser and Nano technology methods titanium, were evaluated and results were indicated the good osteoconductivity of Nano-particles and their potentially superior future prospect[24].

Titanium electrochemically modified by anodic oxidation and hydroxyapatite (HA) electrochemical deposition represents some characterization of better implantation composite, also for promotion of titanium biocompatibility exploit of nano-sized HA is recommended [25]

Antibacterial property of modified nano- titanium

Now a day, study about dental implantation showed good stability after osseointegration, though some case of failures is reported. According to a review of dental implants and infection performed in 2009, there are deferent factors having effective role in failure of dental implant, as briefly considered below. Approximately estimated Failure and success of dental implants are mentioned in Table 3[26].

- Implant Surface roughness purity and sterility
- Mechanical overloading and Premature loading of implant
- Internal biology, systematic condition and disease of the patients, such as bacterial infection and hypersensitivity to implant materials.

Up to now, Many studies indicate the effect of bacterial infection and failure of dental implants, therefore, from past up to now many studies have been done to increase the anti bacterial properties of implant materials such as titanium, for example, the antibacterial impact of Titanium hollow cylinder implants carried out in 1987 as a proem of continuing researches [27].

In modern investigations many efforts tried to use nanotechnology and novel nano particles of titanium, among these efforts, studies about taking advantages of silver nano particles to improve titanium antibacterial activities are significant. The great antimicrobial properties and incorporation of silver nano particles narrated in dental implants which have mentioned some study about titanium modified with nano silvers [30].

Deposition of silver nano particles on titanium and silver nano particle-filled hydrogen titanate nanotube layer on metallic titanium surface are the other investigations proved great antibacterial effect of titanium [31-32]. Furthermore, the novel antibacterial aspect of produced halogenated furanone-loaded poly (L-lactic acid) nano particles coated on microarc-oxidized titanium described a potentially promising

method for prevention of early peri-implant infection [33]. After all, from antibacterial aspect, nano-modified titanium implants are more recommended than pure titanium in dental applications.

CONCLUSION

Although titanium and its alloys physically, chemically, and biologically are preferable for dental implantation, Modifying titanium to improve their properties is indispensable prerequisite for the development and clinical use of implants. According to many studies, It is undeniable that renovation of titanium in to novel nano- titanium particles may improve the antibacterial, osseointegration, and durability of dental implans. According to many studies, coating variety different nano particles and changing surface of titanium by using unique nano- technological methods revealed the antibacterial, osseointegration, and durability properties of modified titanium-based dental implans. Ultimately, it seems that utilization of nano-modified titanium in modern dentistry has bright future.

Commercial pure titanium in biomedical usage	Type	Properties	Reference
Ti-Grad 1 Ti-Grad 2 Ti-Grad 3 Ti-Grad 4 TI6Al7Nb Ti6Al4V, Ti-6Al-4V or Ti 6-4Ti- Ti-13Nb-13Zr TMZF (Ti–12Mo–6Zr–2Fe) Ti–15Mo	Alpha Alpha Alpha Alpha Alpha- Beta Alpha -Beta Alpha- Beta Beta	➢ Good biocompatibility, and Mechanical properties ➢ Corrosion resistance ➢ High Tensile strength ➢ low modulus of elasticity	[3][2][5]

Table1: common titanium alloys and their characterizations.

TiO2 nano-structure particles	Properties	Case of study	Reference
100-nm nodules 300-nm nodules 500-nm nodules	➢ promoted osteoblast but not fibroblast function ➢ greater strength	Wistar rats	[9]
TiO2 (14nm) TiO2 (108nm) TiO2 (196nm)	➢ a negative impact on viability, adhe-sion, migration, proliferation, and differentiation of mesenchymal (MSC)	Wistar rats	[10]
150 nm TiO2 10 nm TiO2 5nm TiO2	➢ NPs were more reactive and biopersistent than MPs in liver ➢ Antioxidant activity, specially, in the case of 5 nm TiO2 ➢ No compensative activity in damaged liver ➢ Better antibacterial property	Wistar rats	[11] [12]

Table2: Nanostructured titanium in different sizes

Implant stability	Estimated percent	Duration	Reference
✓ mandibular implants ✓ maxillary implants	91% 81%	5-9 years years after placement	[28]
implant fixture			

✓ Common implants ✓ Branemark dental implants ✓ Implants within edentulous patients ✓ Implants within partially dentate patients	2% 7.7% 7.6% 3.8%	After osseointegration After 5 year	[29]

Table3: Estimated Success and failure of dental implants in some reports

REFERENCES

1. Misch, Carl E. Contemporary Implant Dentistry. St. Louis, Missouri: Mosby Elsevier, (2007)
2. Lautenschlager, E.P.; Monaghan, P. Titanium and titanium alloys as dental materials. Int. Dent. J. 1993, 43, 245–253.
3. Vydehi Arun Joshi. Titanium Alloys: An Atlas of Structures and Fracture Features. CRC Press, 2006
4. Mutlu Özcan and Christoph Hämmerle, Titanium as a Reconstruction and Implant Material in Dentistry:Advantages and Pitfalls,
5. Carlos Oldani and Alejandro Dominguez, Titanium as a Biomaterial for Implants
6. Katti, K. (2004). Biomaterials in total joint replacement. *Colloids and Surfaces B: Biointerfaces,* Vol.39, No.3, (December 2004), pp. 133-142, ISSN 09277765
7. Wermelin, K.; Aspenberg, P.; Linderback, P.; Tengvall, P. Bisphosphonate coating on titanium screws increases mechanical fixation in rat tibia after two weeks. *J. Biomed. Mater. Res. A* **2008**, *86A*, 220–227.
8. Zainali K1, Danscher G, Jakobsen T, Baas J, Møller P, Bechtold JE, Soballe K. Assessment of modified gold surfaced titanium implants on skeletal fixation. J Biomed Mater Res A. 2013 Jan;101(1):195-202. doi: 10.1002/jbm.a.34307. Epub 2012 Jul 30.
9. Kubo K, Tsukimura N, Iwasa F, Ueno T, Saruwatari L, Aita H. Cellular behavior on TiO2 nanonodular structures in a micro-to-nanoscale hierarchy model. *Biomaterials*. 2009;30(29):5319–5329
10. Hou Y1, Cai K, Li J, Chen X, Lai M, Hu Y, Luo Z, Ding X, Xu D. Effects of titanium nanoparticles on adhesion, migration, proliferation, and differentiation of mesenchymal stem cells. Int J Nanomedicine. 2013;8:3619-30. doi: 10.2147/IJN.S38992. Epub 2013 Sep 23.
11. Bruno ME1, Tasat DR, Ramos E, Paparella ML, Evelson P, Rebagliati RJ, Cabrini RL, Guglielmotti MB, Olmedo DG. Impact through time of different sized titanium dioxide particles on biochemical and histopathological parameters. J Biomed Mater Res A. 2014 May;102(5):1439-48. doi: 10.1002/jbm.a.34822. Epub 2013 Jun 21.
12. Cui CX1, Gao X, Qi YM, Liu SJ, Sun JB. Microstructure and antibacterial property of in situ TiO(2) nanotube layers/titanium biocomposites. J Mech Behav Biomed Mater. 2012 Apr;8:178-83. doi: 10.1016/j.jmbbm.2012.01.004. Epub 2012 Jan 15..
13. Aita H, Hori N, Takeuchi M, et al. The effect of ultraviolet functionalization of titanium on integration with bone. Biomaterials. 2009;30:1015–1025.]
14. Miyauchi T, Yamada M, Yamamoto A, et al. The enhanced characteristics of osteoblast adhesion to photofunctionalized nanoscale TiO2 layers on biomaterials surfaces. Biomaterials. 2010;31:3827–3839.
15. Ueno T, Yamada M, Suzuki T. Enhancement of bone-titanium integration profile with UV-photofunctionalized titanium in a gap healing model. Biomaterials. 2010;31:1546–1557.
16. Iwasa F1, Tsukimura N, Sugita Y, Kanuru RK, Kubo K, Hasnain H, Att W, Ogawa TTiO2 micro-nano-hybrid surface to alleviate biological aging of UV photofunctionalized titanium. Int J Nanomedicine. 2011;6:1327-41. doi: 10.2147/IJN.S22099. Epub 2011 Jun 28.
17. Yamada M1, Ueno T, Tsukimura N, Ikeda T, Nakagawa K, Hori N, Suzuki T, Ogawa T. Bone integration capability of nanopolymorphic crystalline hydroxyapatite coated on titanium implants. Int J Nanomedicine. 2012;7:859-73. doi: 10.2147/IJN.S28082. Epub 2012 Feb 17.
18. Ogawa T1, Saruwatari L, Takeuchi K, Aita H, Ohno N.Ti nano-nodular structuring for bone integration and regeneration. J Dent Res. 2008 Aug;87(8):751-6.
19. Antoni P. Tomsia, Maximilien E. Launey, Janice S. Lee, Mahesh H. Mankani, Ulrike G.K. Wegst, and Eduardo Saiz,Nanotechnology Approaches for Better Dental Implants. Int J Oral Maxillofac Implants. 2011; 26(Suppl): 25–49
20. Le, Guehennec L.; Soueidan, A.; Layrolle, P.; Amouriq, Y. Surface treatments of titanium dental implants for rapid osseointegration. Dental Materials. 2007; 23(7):844–854. [PubMed: 16904738]

21. Ivanoff CJ, Hallgren C, Widmark G, Sennerby L, Wennerberg A. Histologic evaluation of the bone integration of TiO2 blasted and turned titanium microimplants in humans. Clinical Oral Implants Research. 2001; 12(2):128–134. [PubMed: 11251662]
22. Beutner R, Michael J, Schwenzer B, Scharnweber D. Biological nano-functionalization of titanium-based biomaterial surfaces: a flexible toolbox. Journal of the Royal Society Interface. 2010; 7:S93–S105.
23. Lavenus S1, Louarn G, Layrolle P. Nanotechnology and dental implants. Int J Biomater. 2010;2010:915327. doi: 10.1155/2010/915327. Epub 2010 Dec 28
24. Vignesh, Sanjna Nayar, Bhuminathan, Mahadevan, and S. Santhosh. Comparative evaluation of the three different surface treatments – conventional, laser and Nano technology methods in enhancing the surface characteristics of commercially pure titanium discs and their effects on cell adhesion: An in vitro study. J Pharm Bioallied Sci. 2015 Apr; 7(Suppl 1): S87–S91.
25. Kim KH1, Ramaswamy N. Electrochemical surface modification of titanium in dentistry. Dent Mater J. 2009 Jan;28(1):20-36
26. A.D. Pye , D.E.A. Lockhart , M.P. Dawson , C.A. Murray , A.J. Smith, A review of dental implants and infection. Journal of Hospital Infection (2009) 72, 104e110
27. Mombelli A, van Oosten M, Schurch Jr E, Lang NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol 1987;2: 145e151.
28. Quirynen M, De Soete, van Steenberghe D. Infectious risks for oral implants: a review of the literature. Clin Oral Implants Res 2000;13:1e19.
29. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated implants (I). Success criteria and epidemiology. Eur J Oral Sci 1998; 106:527e551.
30. Corrêa JM1, Mori M2, Sanches HL3, da Cruz AD1, Poiate E Jr1, Poiate IA Silver nanoparticles in dental biomaterials. Int J Biomater. 2015;2015:485275. doi: 10.1155/2015/485275. Epub 2015 Jan 15
31. Juan L1, Zhimin Z, Anchun M, Lei L, Jingchao Z, Deposition of silver nanoparticles on titanium surface for antibacterial effect. Int J Nanomedicine. 2010 Apr 15;5:261-7.
32. Liao J1, Anchun M, Zhu Z, Quan Y. Antibacterial titanium plate deposited by silver nanoparticles exhibits cell compatibility. Int J Nanomedicine. 2010 May 13;5:337-42.
33. Cheng Y1, Wu J, Gao B, Zhao X, Yao J, Mei S, Zhang L, Ren H. Fabrication and in vitro release behavior of a novel antibacterial coating containing halogenated furanone-loaded poly(L-lactic acid) nanoparticles on microarc-oxidized titanium. Int J Nanomedicine. 2012;7:5641-52. doi: 10.2147/IJN.S37022. Epub 2012 Nov 7.

CITATION OF THIS ARTICLE

M Bamedi, M Ayoub Rigi Ladiz, S Risbaf Fakour. A Review of Modified Titanium Nanoparticle Applications in Dental Implantation. Bull. Env. Pharmacol. Life Sci., Vol 5 [3] February 2016: 103-107