Sys Rev Pharm 2020; 11(2): 278 – 283
A multifaceted review journal in the field of pharmacy
E-ISSN 0976-2779 P-ISSN 0975-8453

The Development of Dental Implant with the Bioactive Covering on the Basis of Synthetic Complex with Biogenic Elements

[1,2,3]Markov Alexander

[1] Tyumen State Medical University, Tyumen, Russian Federation
[2] Limited Liability Company Scientific - Production Innovative Association "Multifunctional Medical Laboratory", Tyumen, Russian Federation
[3] Tyumen Industrial University, Tyumen, Russian Federation

Article History: *Submitted: 28.11.2019* *Revised: 18.01.2020* *Accepted: 16.02.2020*

ABSTRACT

This research work is devoted to the development of an innovative type of dental implant, with a surface as close as possible to bone tissue. The aim of our work was to create a prototype dental implant with a bioactive coating based on a synthetic complex with the most important biogenic elements that are actively involved in the biochemical processes of bone tissue regeneration, which should have a positive effect on the reparative regeneration of the bone tissue peri-implantation zone. After that the spectral analysis of prepared bone tissue's sample was conducted with the usage of the IK Fourier HITACHI TM 3000 spectrometer. After the completion of research and developments we elaborated and developed models of dental implants with bioactive covering on the basis of synthetic complex supplemented by biogenic elements approximate as much as possible to the composition and structure to the bone tissue what will influence in positive way the reparative regeneration of bone tissue around the implanted endoprosthetics and the formation of durable bone-metallic unit in the "implant-bone" contact, and consequently it has to provide the stability of set implants in the post-operational period.

Keywords: bioactive coating, nutrients, implant-bone, dental implant, osseointegration.

Correspondance:
Markov Alexander
Tyumen State Medical University, Tyumen, Russian Federation,
Limited Liability Company Scientific - Production Innovative Association "Multifunctional Medical Laboratory", Tyumen, Russian Federation,
Tyumen Industrial University, Tyumen, Russian Federation
Email id : alexdoktor@inbox.ru
DOI: 10.5530/srp.2020.2.43

INTRODUCTION

Before the beginning of this work the meticulous analysis of Russian and foreign sources was conducted where works of scientists involved with experimental and clinical researches in different areas of medicine dedicated to biological processes in bone tissue such as physiological and reparative were published [1, 5, 12, 13, 14, 19, 20].

Nowadays the high ability for osteo-integration is considered to be the most important feature that dental implants must possess [5, 8, 9, 12].

Per-Ingvar Branemark has become the first scientist to reveal bioinert features of titanium but time and technology move forward too [15]. Nowadays the tendency is determined that even if the implant is made of bioinert titanium alloy of medical purpose mark BT-6, bone tissue will react to the damage of bone tissue integrity by this implant all the same aggressively. Frequenly problems the above mentioned problems can be found among patients with lower bone's mineral density i.e. in cases of osteoporosis [16].

During the process of implantation in cases of stomatological practice the great number of different dental implants is used and they are successful in the majority of cases of patients with normal bone tissue structure though unsatisfactory results of the treatment are awaited. But due to the high prevalence of such disease as the osteoporosis in the whole world standard dental implants don't always help to achieve of the good result of patient's treatment.

As a result of this many scientists actively search for new kinds of implants. Different ways of improvement are offered such as a new design, new type of screw-thread, the roughness of implant's covering, but all of this doesn't solve the problem of aseptic instability and further loosening and migration of implanted endoprosthetics in early and further post implant period.

The analysis has determined the problem of durable fixation of dental implants in further post operational period. The reason of it is frequently the problem of affinity between implant and bone and more specifically the interaction of implant-bone contact that can be described as "own-alien", including the basis of osteopenic syndrome and more often among patients of senile and old age.

The bioactive interlayer on the surface of dental implant is necessary for the increase of biocompatibility to be made in form of synthetic covering being similar in its constitution and structure to bone tissue which will allow the decrease organism's reaction to the alien structure and the affinity to surrounding tissues.

It is also necessary to understand that the alienness is determined by the chemical element composition. Chemical composition of bone tissue is represented by such microelements as calcium and phosphorus that represent themselves the basis and also by other chemical elements such as microelements and ultra-microelements.

The scientific basis of analysis of biological role of chemical elements was established by the academic V. I. Vernadsky. The further study of biological role of chemical elements was contintued by A.P. Vinogradov, V.V. Kovalsky and other scientists [2, 3, 4, 6, 7, 10].

GOAL

To increase the affinity of the surface of dental implant's surface with bone tissue by the by the modification of its structure and by the way of synthetic complex application supplemented with important biogenic elements.

MATERIALS AND METHODS

The preparation of synthetic complex, supplemented by biogenic elements takes place by the following way in the beforehand prepared solution of certified chemical compounds in molar ratio:

Ca - 1.67, P – 1, Mg - $1.2x10^{-2}$, F - $1.1x10^{-5}$.

Acid-alkalic environment of the solution is sustained in the range of pH numbers 7,2-7,4, which matches physiological values.

Then evaporation of the solution in the porcellaneous cup takes place at a temperature of 35 – 55 ^{0}C with the avoiding of severe differentials.

The connective component (plastificator) is included in the obtained product such as carboxymethyl cellulose, for example, or polyvinyl spirit or hydromethyl cellulose or glycerin or methylcellulose. The content of connective component is 5-25% by mass above 100%. The mixtures is being tempered at the 650-900 ^{0}C temperature. The temperature above 1200 ^{0}C leads to the melting of calcium phosphate. The obtained product is grinded in orbicular mill to the formation of micro- and nano- particles. Particles obtained after the grinding process represent themselves incorrect spherical forms or crystalloid forms that will be afterwards used to provide the maximum affinity to the bone tissue structure.

The fluorine microelement is included into the prepared pulverulent macro elemental complex by the way of interfusion in the orbicular mill to the formation of homogenous mass.

By this way the synthetic complex is prepared with molar ration of elements being: Ca - 1.67, P – 1, Mg - $1.2x10^{-2}$, F - $1.1x10^{-5}$.

$Ca_{10}(PO_4)_6(OH)_2$, $CaCO_3$ were taken as a calcium in the preparation of synthetic complex. Magnum was used in the form of magnesium carbonate $MgCO_3$ or $Mg(OH)_2$ or $Mg_3(PO_4)_2$. CaF_2 was used for the fluorine usage. Carboxymethyl cellulose or polyvinyl spirit or hydromethyl cellulose or glycerin or methylcellulose could be used as the intermedium.

The mineral composition of bone tissue area has been researched with the usage of spectral analysis. Bone tissue was obtained from the femur's capitulum during the treatment of two patients with the diagnosis of deforming hip joint arthrosis of 3rd degree by the method of total endoprosthetics. Such method of bone tissue sampling is performed with the patient's agreement and it is legally competent.

Figure 1. Photo. Quorum Q150 ES Vacuum Post and Process Preparation of a procedure for spraying a conductive layer with a piece of bone tissue to form a conductive layer and further study in an IR spectrometer.

The spectral analyses was performed in scientific-research laboratory of Earth Cryosphere Institute, Tyumen Scientific Centre SB RAS due to the fact that the spectral analysis itself can be performed only in the presence at this object of metallic substrate, which is necessary for the reflection.

The research of every type of covering on the titanium implants is possible. But the conduction of bone tissue area analysis can't be performed without the preliminary preparation. The preparation of wet bone material by the method of drying and spraying of golden dust on its surface is required. That will allow the necessary moment of reflection and will give the possibility to conduct the required spectral analysis of the bone material.

The turbomolecular pumped coater – Quorum Q150 ES is used during the conduction of dehydration and production of biological wet preparations for the analysis on spectrometer. The work of the coater is presented by the deletion (displacement) of H_2O and water vapor with the application of carbon dioxide whereupon the drying by carbon dioxide takes place.

This procedure is performed in the condition of high vacuum and, being sparing, ensures the preservation of fragile samples, preparing them to the spraying of conductive layer. At the moment of drying process completion the researched object is set in the facility for the conductive layer spraying.

After that the spectral analysis of prepared bone tissue's sample was conducted with the usage of the IK Fourier HITACHI TM 3000 spectrometer.

Figure 2. The result of the deposition of a conductive layer on the surface of the bone tissue

During the spectral analysis evaluation of two samples of bone tissue thr conclusion can be made that there is nothing standardized. Every man is individual and consequently, as it was mentioned above, the bone tissue is the depot for microelements and their quantity is different in cases of different patients. But in spite of this the composition of determined biogenic elements is identical and their quantity is just about the same. Macroelements of calcium, phosphorus and magnum have been detected. Such method allows the determination of the presence of chemical elements more than 10^{-5}. But the presence of fluorine has been revealed by the routine method.

Figure 3. Stage of installation of the stage with an experimental titanium implant with the Bioactive Covering on the Basis of Synthetic Complex with Biogenic Elements

Further we used more widespread and economically profitable electrochemical method in our work or, how it is more commonly known, method of microarc oxidation (MAO) in water electrolyte solutions. It has gotten wide spread lately as the method of application of bioactive calcium-phosphate coverings to the titanium surface. Titanium has been chosen not accidentally. It was recognized as the bioinert and accessible metal. The formation of covering is connected with the conduction of high-temperature processes in the area of local microarc discharges under the influence of external source of high voltage and it occurs due to the oxidation of the basic material and also due to the transfer into the covering of ultradispersed phase located in the electrolyte. Coverings received by this method possess good specter of physical and chemical features such as high corrosive durability, wear resistance, strength and chemical sustainability in aggressive environment [5, 8, 11].

In our work we have conducted the elaboration of the application method to titanium implants that begins with the application of covering to the titanium substrate [18]. The convenience of experimental titanium substrate sizes used for application, analysis of structure and durability of covering's adhesion to the implant's surface, is very important in the experiment's conduction.

RESULTS AND DISCUSSION

The presence of the most important macroelements such as calcium, fluorine and magnum in bone composition was confirmed by the results of performed microscopy and spectral microanalysis.

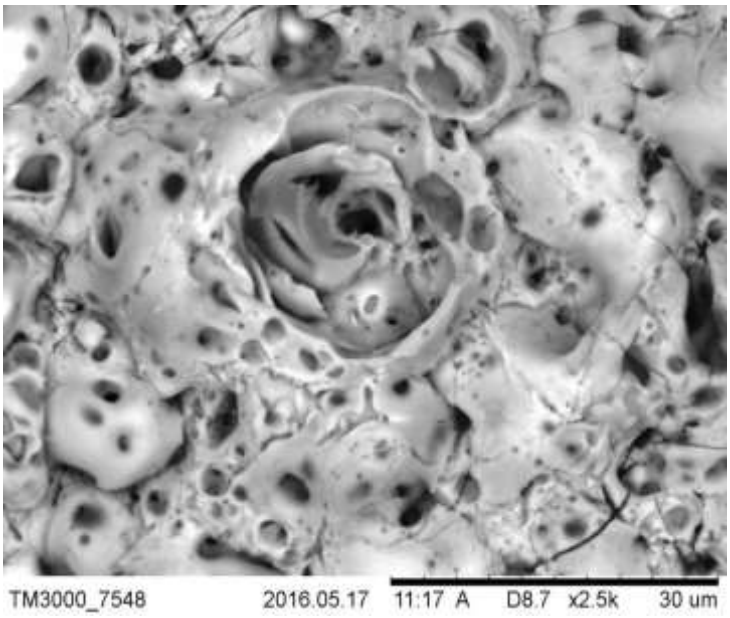

Figure 4. Microscopic picture of the structure of the bioactive coating on an experimental titanium implant (magnification of 30 microns).

Analogically the elemental composition of synthetic covering on the experimental dental implants was analyzed. As a result of performed spectral analysis analogical correlation of elements in the bone tissue composition was detected as well as on the experimental dental implants coverings.

The important moment is the necessity of reflection of vibrations in stoichiometric correlation of calcium to phosphorus with the meaning of 1,67 in the synthetic complex on the basis of calcium and phosphorus and supplemented by the biogenic elements. But after the application of such complex to titanium implants these meanings begin from 0,5 and reach 1,33. Everything depends on parameters and settings of electro chemical facility during the application to implants.

After the performed analysis and elaboration of electro chemical way of application of bioactive covering to the surface of titanium implants, the author's methodic was standardized by us that corresponds to modern requirements and allows the control of necessary thickness, elemental composition and covering's structure which features can be used in different goals and pathology. The methodic of electric chemical method of application of porous covering to titanium implants was elaborated and standardized by us. It is the basic demand during the establishing of small batch manufacture. Applied synthetic covering of the titanium bars of experimental dental implants has next parameters: thickness of it is 55-65 mkm., and its porousness is 10-30 mkm.

During the process of research and developments results were systematized and that found its continuation in the creation of the computer program: "The Program of Biogenic Elements and Constructive Features Selection during the Titanium Implant Development" (Biolement-Implantat Pro). The program is intended for the selection of biogenic chemical elements combinations that can be used in the appliance of bioactive covering and systematization of constructive features of developed titanium implants. This program allows the effectuation of elemental composition systematization of bioactive coverage and constructive features of developed implants [17].

The chemical basis of applied covering, the selection of biogenic elements positively influencing the reparative regeneration of bone tissue, the covering structure, the variety of titanium implant, its form and screw-thread are

all taken into account in this program. The covering possessing high affinity to the surface of dental implants with surrounding bone tissue by its elemental structure and composition is one of the most important features of our experimental dental implant. As a result of our work necessary biogenic elements were determined namely magnum and fluorine.

These elements actively participate in biochemical reactions of difficult process of reparative regeneration of bone tissue after mechanical trauma in the moment of dental implantation process. After all the violation of bone structure integrity takes place during the implantation process and consequently it triggers the cascade of destructive processes. It is necessary to increase the affinity between implant and bone, interaction between which can be described as "own-alien" in the "implant-bone" contact, to the limit for the decrease of the destruction rate. Consequentially the similarity in the elemental composition and structure will allow the decrease of experimental dental implants aliennsess and increase the affinity of dental implants with surrounding bone tissue that can be realized with the usage of synthetic complex on the basis of calcium and phosphorus supplemented with biogenic elements and applied to implants in the form of bioactive covering by the electric chemical way.

CONCLUSION

After the completion of research and developments we elaborated and developed models of dental implants with bioactive covering on the basis of synthetic complex supplemented by biogenic elements approximate as much as possible to the composition and structure to the bone tissue what will influence in positive way the reparative regeneration of bone tissue around the implanted endoprosthetics and the formation of durable bone-metallic unit in the "implant-bone" contact, and consequently it has to provide the stability of set implants in the post-operational period.

REFERENCES

1. Bert M., Missika P., Giovagnoli G.L. "The Elimination of Implantological treatment complications // Stomatology's Alphabet – 2007. – 355 p.
2. Vernadsky, V.I. The Chemical Structure of the Earth Biosphere and Its Environment: Monograph. – M.: Science, 1965. – 374 p.
3. Vernadsky, V.I. Problems of the Biogeochemistry (Tr. Biogeochem. Lab., 16 Vol.). M.: Science, 1980. 320 p.
4. Vinogradov A.P. Chemical Elemental Composition of Sea Organisms / Ch. Ed. E.M. Galimov; [comp. By L.D. Vinogradove]. M: Science, 2001. 620 p.
5. Karlov A.V. The Clinical Practice of Usage of Titanium Implants with Bioinert and Bioactive Coverings in Conjunction with Quasi-Telescopic Systems of Exterior Fixation during the Treatment of Long Tubular Bones // The Man and His Health. Traumatology, Orthopedics, Prosthetics, Biomechanics, Rehabilitation of Disabled: Mater. Of Russian National Congress. – SPb., 1998. – 28 p.
6. Kovalsky V.V. Geochemical Environment and Life. M.: Science, 1982, 76 p.
7. Colomiitsev M.G., Gabovich R.D. Microelements in Medicine. – M.: Medicine, 1970.
8. Petrovskaya T.S., Shakhov V.P., Vereshagin V.I., Ignatov V.P. Biomaterials and Implants for Traumatology and Orthopedics. – Tomsk: Publishing House TPU, 2011. – 307 p.
9. Robustova T.G. The Teeth Implantation (Surgical Aspects) // M.: "Medicine", 2003. 560 p.
10. Skalniy A.V. Microelemtosis of Men. – M.L Publishing House KMS, 1999.
11. Skalniy A.V. Chemical Elements in the Physiology and Ecology of Men. – M.: Publishing House ONIX 21st Century-World, 2004
12. Tyan A.R. Sidorov A.V. Causes of Failures in Stomatological Implantology // News of Stomatology: Spec. Edition. – 1993. - #3. – 26-28 pp.
13. Aro H.T., Markel M.D., Chao E.Y.S. Cortical bone reactions at the interface of external fixation half – pins under different loading condition // J. Trauma. -1993. - Vol. 35, N 5. - P. 776-785.
14. Baimagambetov S.A., Balgazarov A.S., Ramazanov Z.K., Markov A.A., Ponomarev A.A., Turgumbayeva R.K. Abdikarimov M.N. Modern models of endoprostheses and periprosthetic infection. Biomedical Research (India). 2018; 29: Iss.11.
15. Branemark P-I, Zarb GA, Albrektsson T. Tissue-Integrated Prostheses (Osseointegration in Clinical Dentistry). Quintessence Publishing Co., Inc.: Chicago, 1985.-350 p.
16. Markov A. Problems of the surgical treatment of patients with fractures of the proximal femur on the basis of osteoporosis. Sys. Rev. Pharm. 2019; 10(1): 143-145.
17. Markov A.A., Skalny V.V., Antonenko A.I., Svetkin S.A. Program of selection of biogenic elements and constructive features in the development of titanium implants" (bioelement-implantat pro). Certificate of registration of a computer program RU 2019662321, 09/20/2019. Application No. 2019661066 dated 09.09.2019.
18. Markov A.A., Sokolyuk A.A. The Method of application of synthetic bioactive calcium-phosphate mineral complex on implants of medical purpose: pat. 2606366 C1 RF. - №201513 9102; decl. 14.09.2015; publ.10.01.2017, bul. 1.
19. Saithna A. The influence of hydroxyapatite coating of external fixator pins on pin loosening and pin track infection: A systematic review // Int. J. Care Injured. – 2010. – № 41. – P. 128-132.
20. Xu S., Long J.,Sim L., Diong C.H., Ostrikov K.R. Fplasmasputte ring deposition of hydroxyapatite bioceramics: synthesis, performance, and biocompatibility // Plasma Proc. Polym. – 2005. – V. 2. – P. 373–390.
21. Das, B. and KJ, M., 2017. Disability In Schizophrenia and Bipolar Affective Disorder. International Journal of Psychosocial Rehabilitation, 21(2).
22. Elsass, P., Rønnestad, M.H., Jensen, C.G. and Orlinsky, D., 2017. Warmth and Challenge as Common Factors among Eastern and Western Counselors? Buddhist Lamas' Responses to Western Questionnaires. International Journal of Psychosocial Rehabilitation, 21(2).
23. Weston, S.M., Martin, E.D., Shippen, M.E., Kraska, M.F. and Curtis, R.S., 2017. Parents with Serious Mental Illness Served by Peer Support

Specialists. International Journal of Psychosocial Rehabilitation, 21(2).

24. Griffiths, C.A., 2017. Determinates of mental illness severity. International Journal of Psychosocial Rehabilitation, 21(2).
25. Lau, H.Y., 2017. Family Therapy and Cognitive Behavioral Therapy for a Case with Co-morbidity of Depression and General Anxiety Disorder in Hong Kong–A Single Case Study. International Journal of Psychosocial Rehabilitation. Vol 21 (2) 21, 30.