Application of titanium and titanium alloys in dental implantology

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Lamellar and spiral titanium implants have been used for about 30 years world-wide, ten years ago there appeared home systems of dental implants designed by Suvorov O.N. and produced by All-Russian Research Institute of Medical Engineering and implants designed by Massarsky A.S. and produced by “Contrast” company (St. Petersburg). Despite wide application, these systems did not fully meet consumers’ requirements. It was connected with some structural deficiencies, accuracy of machining, the quality of the used titanium.

Based on the home and foreign experience, a new system of titanium implants “Konmet” has been developed in 1996 that includes 12 types of spiral and lamellar implants, 28 types of suprastructures and prosthesis devices, 32 types of the instrument. (See Fig. 1).

Commercially pure titanium of Grade 4 according to ASTM F 67-89 standard, USA is used for implants manufacture. The selection of this material was done due to the fact that it combines the properties which meet the requirements placed to implants to the best advantage: specific corrosion resistance, nontoxicity and bioinertia, suitable mechanical properties (strength, plasticity, abrasive resistance, homogeneity). The so-called prospective implant materials such as sapphire, boiceramics, zirconium alloys as well as alloys of titanium nickelide do not have such a combination of properties.

In order to increase the degree of osteointegration with the osseous tissue, intraosseous parts of an implant are sprayed with titanium powder using plasma spraying unit. A porous structure with 40-50 µm in thickness with the specific pore size 10-15 µm is formed. (See Fig. 2).
A correctly installed implant can serve from 5 to 7 years in the conditions of alternating load and corrosive effect of physiological fluid of the living body.

In dental implantology strict requirements are placed to the junction of the denture support element (suprastructure) and an implant. (See Fig. 3). A tiny suprastructure shall transfer masticatory load on an implant throughout the whole service life without any intermobility. We tried to ensure such requirements by precision treatment of conjugated surfaces of implant's head and suprastructure. Limit deviations on dimensions are $0.02\pm0.03$ mm. Since suprastructure has no direct contact with tissue, it allowed to use titanium alloy Ti-6Al-4V ELI to ASTM F 136-92 which is less bioinert but has greater strength than Grade 4 titanium. Support heads manufactured from this alloy are safely locked on Morse taper in implant's head without tears and biting, this helps to perform direct selection of the head standard size.
When the necessity arises to use the third load-bearing element of the supporting structure - a screw to secure angular heads to an implant or metal frame to a suprastructure, this element is manufactured from the stronger alloy VT16. Thus, the combination of the commercially pure titanium Gr4 with Ti-6Al-4V ELI and VT16 alloys allowed to develop the implant structure that is simple enough for clinical use, has sufficient bioinertness, strength as well as production effectiveness. In order to eliminate the possibility of implants' surface contamination with particles of other metals, it is advisable to use titanium instrument during the operation. "Konmet" company mastered the production of the cutting instrument from high-strength titanium alloy VT16 used for preparation of osseous bed for implants. (See Fig. 4).

The process cycle for the manufacture of such an instrument includes quenching, machining and ageing of the finished parts in vacuum furnace. The final product is a cutting instrument that preserves its cutting properties throughout hundreds of operations having the absolute stability to presterilizational cleaning and sterilization. A number of titanium instruments has been developed that exfoliate periosteous tissue - raspatories as well as titanium hook-spreaders. (See Fig. 5).

Currently, we are performing the research work aimed at the increase of liability and durability of our implant system. The effectiveness of operation and the service-life of an implant is primarily determined by the stressed-and-strained state of the surrounding osseous
tissue during the process of masticatory load transfer. If we take into account the fact that elastic modulus of a solid titanium implant is by an order greater than the same parameter of a bone and also that a system implant-bone lacks damping layer in the form of periodontal tissue, then the task to develop the effective supporting structure is turned out to be a very complicated one.

We suppose, that one of the possible ways of partial settlement of this problem is the use of porous titanium and bicomposite elements in implant’s structure, which would impart damping properties to an implant and simultaneously help to its integration with the osseous tissue.