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New Operational Techniques of Implantation of Biomaterials and Titanium Implants in the Jaw with the Atrophy of the Bone and Soft Tissues

D. B. Nikityuk[1], A. L. Urakov[1, a)], A. P. Reshetnikov[1, b)], M. V. Kopylov[1], D. Yu. Baimurzin[1]

[1]*Izhevsk State Medical Academy, Russian Ministry of Health, Department of General and Clinical Pharmacology, Izhevsk.*

[a)]Corresponding author e-mail: urakoval@live.ru
[b)]areshetnikov@list.ru

Abstract. The research into dynamics of quality of clinical use in 2003 – 2012 of autologous and xenogeneic biomaterials at dental transplantation and implantation among 1,100 of adult patients was made. The analysis results show that at autologous bone transplantation implant survival is observed only in 72% of cases, and the "necessary" result of bone repair occurred only in 6 – 9 months. Transplantation of biomaterials of OsteoBiol® (materials "mp3", "Genos" and "Evolution") provided engraftment and bone regeneration in 100 % of cases and allowed the use of dental implantation immediately after transplantation even in case of reduction in the patient's alveolar crest down to 2.0 mm. Replace Select implants of Nobel Biocare® were used at plantation. In order to exclude Schneiderian membrane's perforation lighting of Highmore's sinus with the cold blue-violet light from inside at sinus elevation is recommended as well as deepening of dental instruments into the bone only until the blue-violet light appears under them. To exclude deficiency of soft tissue under the cervical part of the ceramic crown application of special anti-fissure technology involving biomaterial flap dissection and its laying around the implant is suggested.

INTRODUCTION

Due to high surgical technologies of dental and soft tissue restoration by plantation of titanium implants and biomaterial, it acquired the status of the most fashionable and promising technology in dentistry [1-4]. A special role in the success achieved has been played by xenogeneic collagen containing biomaterials produced by OsteoBiol® [5]. The results of a long-term clinical use of these materials prove their high compatibility with the human tissues. Clinical outcomes show that the assortment of the specified biomaterial is broad enough and rather diverse. In general, it meets the clinical needs. However, the arsenal of operative technologies involving their application is not wide. In particular, operative technologies of dental implantation on patients with severe atrophy of dental and soft tissues of the jaw are insufficiently advanced yet [6-8].

OBJECT OF RESEARCH. MATERIALS AND METHODS

In this relation, the objective of our work is improvement of the existing operative technologies in order to improve efficiency of biomaterial and titanium implants plantation in conditions of jaw bone and soft tissues atrophy. The research is based on results of surgical operations which were performed in 2003 – 2012 in dental clinic "ReSto" in Izhevsk. Provided that in 2003 – 2007 transplantations were made using the autogeneic grafts obtained from patient's donor areas (chin, external scroll line area, ramus of the lower jaw, maxillary tuberosity, iliac crest, shin bone, and venous blood) as well as various xenogeneic biomaterials of several different manufacturers other than OsteoBiol®. In the period of 2008 – 2012 osteoplastic xenogeneic biomaterials of

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OsteoBiol® were used for transplantation. Herewith for bone volume gain material “mp3” (heterologous cortical spongeous prewet collagen containing mixture with granule size of 600 – 1000 μm), preparation “Genos” (cortical spongeous bone mixture with granule size 250 – 1000 μm) and preparation “Evolution” (heterologous pericardia) [5]. Replace Select implants of Nobel Biocare® of relevant (“appropriate”) sizes were used at dental implantation for all patients. The implants were installed on upper jaws using standard technologies [3].

Radiographic analysis and roentgenoscopy were made using “Planmeca Prolane EC” orthopantomograph with “Dimax 3” system and “Planmeca Infra” visiograph connecting using the fiber optic cable to the display of a personal computer, the screen of which was placed above the dental chair at the patient’s head. Infrared diagnostics was made using infrared scanner TH91XX (NEC, USA) within the range of 26 - 37°C in the room of the dental clinic at air temperature 24-25°C [9-11]. The data obtained at infrared thermography were processed using software Thermography Explorer and Image Processor. Herewith, subjects of evaluation included location of the missing tooth, defect of dental and/ or soft tissues, deformation ratio of alveolar crest, and local hyperthermia degree. The period of patient’s health observation lasted for 2 years after implantation.

At results analysis all patients were divided into several groups. The first group composed of 250 patients with operations made in 2003 - 2007 without application of materials of OsteoBiol®. Of which amount 90 patients had an operation made on the lower jaw and 105 of them had an operation on the upper jaw and 55 patients had operations on both jaws. The second group consisted of 850 patients who were operated in 2008 - 2012 with transplantation of biomaterials made by OsteoBiol®. Of which amount 323 patients has an operation of dental transplantation and implantation in the lower jaw area, 357 had an operation in the upper jaw area and 170 patients had operations on both jaws.

Herewith, 307 patients had grinding teeth absent in the upper jaw with atrophy of bone tissue resulted in reduction in the distance from the alveolar crest to the bottom of Highmore's sinus to less than 5 mm. Before implantations these patients had an osteoplastic operation of lateral sinus elevation for lifting of sinus floor elevation in the area of absent tooth for the “appropriate” height. The total amount of sinus elevation amounted to 379. In 287 patients the access to the Highmore's sinus was formed through the window in the anterolateral wall of the bone of the upper jaw according to the existing technology, and in 20 patients – according to the unconventional technology of our invention [12, 13].

In case the patient has the grinding teeth absent in the lower jaw and in the presence of severe atrophy of bone and soft tissues, transplantation was made by plastic repair with overlapping fixation of transplant material and/ or with material fixation into the bone. Out of these patients we divided a group of people consisting of 25 people who had 1 tooth absent on both sides of lower jaw. Simultaneously, they had significant symmetrical atrophy of bone and soft tissues of the jaw. In 4 months after bilateral dental transplantation and single-stage implantations the implants were opened, the quality of the surgical implantation was revised and tooth crowns were installed on implants with application of a common technology. Herewith, on one side of the jaw transplantation of biomaterial according to the inventive technology was used around the open transplant involving preparation of a transplant-transformer in the form of a disk with a hole in the middle and then this transplant was put as a skirt on the implant.

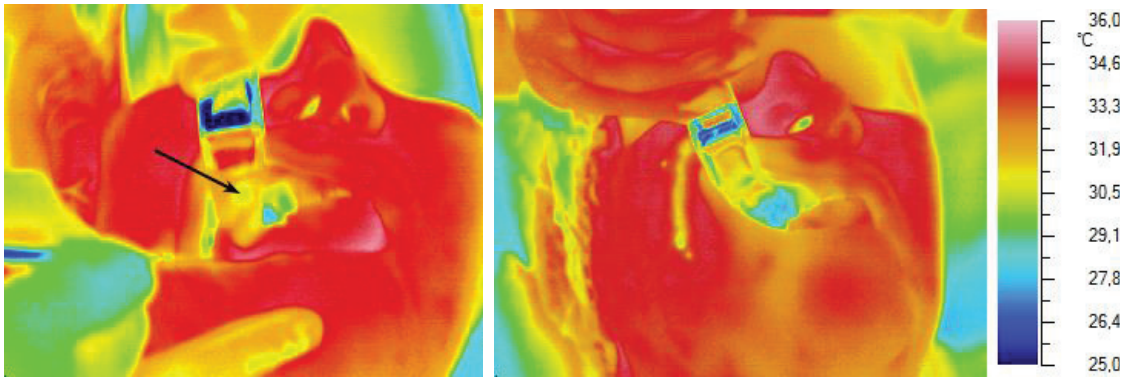
In 2002 – 2007 for elimination of insufficiency of soft tissues isolated bone blocks were used in 175 patients, and xenogeneic transplant materials in 75 patients. Sinus elevation with tissue transplantation for subsequent installation of implants into side sections of upper jaw was used in 160 patients. Herewith the total amount of sinus elevation operations composed 180. In 32 patients the height of alveolar crest composed less than 5 mm, so these patient had an operation of sinus elevation with biomaterial transplantation first. In those years the sinus elevation operation lasted for 2.33 ± 0.12 hours on average ($P \leq 0.05$, $n = 180$). In 6 – 9 months after transplantation the surgical assistance in the form of dental implantation was provided only to 23 patients (72 % of patients), as in 9 patients (28% of patients) the quality of osteanagenesis after transplantation was considered as insufficient. That is why these 9 patients had the second sinus elevation operation with transplantation of autogenous biomaterial, which lasted for 1.46 ± 0.08 hours on average ($P \leq 0.05$, $n = 32$).

In 2008 – 2012 operations of dental transplantation with implantation were made with transplantation of osteoplastic xenogeneic biomaterials produced by OsteoBiol® in 850 patients. In particular, for sinus elevation, bone volume increase and increase in height of alveolar part of upper jaw bone the materials “mp3” and “Genos” were used, and for covering of exposed Schneiderian membrane in the bone “window” of the upper jaw “Evolution” material was applied. Herewith the sinus elevation operation with biomaterial transplantation was made on 247 patients, with the total amount of 344 sinus elevation operations made on these patients. Herewith, the duration of sinus elevation operation was about 1.27 ± 0.06 hours on average ($P \leq 0.05$, $n = 344$). The results of radiographic analysis show that the transplantation performed using the osteoplastic xenogeneic biomaterials of OsteoBiol®

provided osteanagenesis within the expected time period in all 247 patients. Provided, that all 3 types of biomaterials of OsteoBiol® ensured beginning of osteanagenesis immediately after their transplantation.

According to the obtained results the decision on application of single-stage dental implantation in patients with the decreased height of the alveolar crest of the upper jaw down to 2 mm was taken. The sinus-elevation operation with transplantation of xenogeneic biomaterials of OsteoBiol® in combination with the single-stage dental implantation was performed in 25 of such patients. The results of the performed surgical operations showed that transplantation of biomaterials mp3, Genos and Evolution produced by OsteoBiol®, supplemented with single-stage implantation of Replace Select implants produced by Nobel Biocare® provided graft retention, osteanagenesis and implant survival in all 25 patients. The results show that out of 344 standard sinus elevation operations performed in 87 operations (in 25%) Schneiderian membrane's perforation took place. Besides that after installation of the ceramic crowns on implants, 689 patients out of 850 operated patients showed severe deficiency of soft tissue. This soft tissue deficiency resulted in formation of a fissure between soft tissue of the jaw and the cervical part of ceramic crown after its installation on the implant.

The analysis of the existing technologies of sinus elevation operations shows that in the process of all sinus elevation operations using commonly accepted technologies cooling of soft and dental tissues on the area of surgical wound took place. It is shown that the local hypothermia is caused by injections of cool solutions of medical products and the cool air in the room (Fig. 1).



(a) (b)

FIGURE 1. Thermophotogram of the face (a) of patient P. 15 sec. after injection into the gum of 1.7 ml of Septanest at temperature of 24°C (the arrow shows the place of injection), (b) of patient K. immediately upon completion of the window in the bone of the upper jaw and exposure of Schneiderian membrane during the sinus elevation operation

For the purpose of new technology development it was decided to investigate the possibility of additional lighting of the Schneiderian membrane from inside (from the side of Highmore's sinus). Herewith, we preferred the nasopharyngoscope for additional lighting of the Schneiderian membrane. The experience of its application in 10 patients with absent grinding teeth and in the presence of moderate atrophy of upper jaw bone showed that insert of the nasopharyngoscope into the nose cavity and placement of the light source in front of the natural hole into the Highmore's sinus in the nose allowed lighting Highmore's sinus and shine through the exposed Schneiderian membrane.

During sinus elevation operations we conducted the study of trans-illumination degree of the bone and the Schneiderian membrane when using the light source of different brightness and the wave length of the light emitted. The obtained results and conducted theoretical calculations showed the trans-illumination prospect of dental and soft tissues of the upper jaw during the sinus elevation using the cold blue-violet light. Herewith, we managed to find the method of complications prevention and develop a new method of sinus elevation.

For prevention of Schneiderian membrane's perforation we developed the Sinus Elevation Method at Dental Implantation (Application for Invention RUS No 2014132778) [13]. The essence of this method implies that preliminary the appropriate Highmore's sinus is lit with cold blue-violet light from inside and formation of the annular groove using the borer and subsequent stripping of the Schneiderian membrane from the bone using the dental elevator is made under continuous visual control of the tissue illumination under the tool points. Provided, that they are deepened into the bone only until the blue-violet light appears under them.

The specified method was applied in 10 patients, with absent grinding teeth and moderate atrophy of upper jaw bone. To light the Highmore's sinus from inside we inserted a flexible modified nasopharyngoscope “Atmos” with 3.2 mm in diameter, which was equipped with the source of blue-violet light. The light source was placed at location of natural hole to the Highmore's sinus, directing the light beam into it through this hole evenly illuminating its external wall with it. After that with continuous visual control of the illumination degree of tissues under instrument points we formed the annular groove in the upper jaw bone using the borer and stripped the Schneiderian membrane from the cut segment of the bone and other bone sections using the dental elevator, deepening the instruments into the bone only until the blue-violet light appears under their points.

The results show that application of the suggested method in patients of this group allowed avoiding perforation of the Schneiderian membrane at sinus elevation in all 10 people.

Consequently, the suggested method allows preventing perforation of Schneiderian membrane both at groove formation using the borer and at membrane stripping from the bone using the dental elevator. The matter is that additional lighting of Schneiderian membrane using cold light from inside provides the doctor with additional information on thickens of its wall as the bone of the upper jaw is non-transparent but the Schneiderian membrane is transparent and almost colorless. That is why formation of the groove in the bone using dental instruments and stripping of the membrane from it in the transmitted light is the method to control the bone thickness and membrane preservation. Appearance of transparent blue-violet membrane under surgical instruments is the symptom of optimum deepening into the tissue. Timely termination of deepening secures safety of the Schneiderian membrane and prevents its perforation.

Simultaneously with this, we analyzed the existing dental transplantation and implantation technologies in order to prevent defects of soft tissues under the cervical part of the ceramic crown after placing a crown on an installed implant. The research results showed that the said disadvantage of existing dental transplantation and implantation may be related to the absence of efficient anti-fissure measures in the procedure thereof. In particular, there are no instructions in respect of the use of special “patterns” to prepare transplants for transplantation. In addition, there are no technologies of making “skirt transplants” and transplantation thereof around installed implants. That is why, in case of severe soft tissue atrophy, existing dental transplantation technologies do not ensure the “necessary” increase of the soft tissue volume around installed implants. In this regard, after placing crowns on installed implants, fissures can exist between the crowns and the tissue surface.

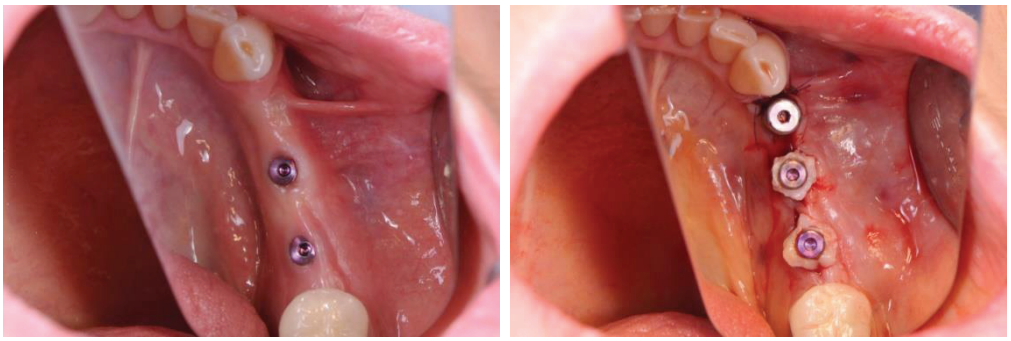
In some time, each of these fissures turns into a kind of a “landfill site” and “infection incubator” in a patient’s mouth, as it gets filled with food remnants while masticating. Food remnants are decaying in a fissure under the influence of microorganisms and creating an aggressive environment, which early destroys the installed dental structure and damages soft and bony tissues. This leads to bad breath, parodontitis and inflammation of other soft and hard mouth cavity tissues.

Due to the fact that the cause of fissures under the cervical part of a crown is a significant deficiency of soft jaw tissues, we decided to find a solution by giving a biomaterial being transplanted a special anti-fissure shape, and by the development of the best possible technology of its transplantation around an implant. In order to increase the soft tissue volume around an implant, with dominating increase of the soft tissue height of the jaw ridge, we developed a special biomaterial shape, special “pattern” for its cutting out by a special “mold”, subject to the installed implant dimensions, and a special original technology of one-time transplantation around an installed implant.

In this case, we proceed on the basis that, in order to eliminate a significant soft tissue deficiency around an installed implant, a transplant is required, which has a special (specific) shape. In particular, in order to increase efficiently the soft tissue volume around an implant, a transplant shall be of a flattened shape, with an increase of its width in the middle, in the form of a roll, whose central part shall have a cross cut with the opportunity to transform this cut into an opening to be put on an implant. That is why the opening shall have dimensions enabling its transformation into an opening having a diameter corresponding to the diameter of an installed implant. A ready transplant having such shape is placed around an implant in the way similar to putting a skirt on it.

The technology of giving a special shape to a used biomaterial and dental transplantation, developed by us, was applied upon placing crowns on installed implants of 14 patients not having grinder teeth and having significant atrophy of lower jaw soft tissues. In this case, upon the patients’ examination performed within scheduled terms after carried out dental implantation, a standard list of controlled quality parameters of given treatment was added by the appraisal of the width of regenerated soft tissues over the implant cover. All patients from this group had soft tissues of less than 1 mm over the cover. In order to prevent fissures between a crown and soft tissues, connective-tissue bioptate was put as a “skirt” on healing abutment of each installed implant, which was excised from the patient's upper jaw tubercle, and this bioptate was preliminary specially shaped.

A connective-tissue bioptate was cut out from the patient's upper jaw tubercle as a band with the width of 2 to 3 mm and length exceeding the implant radius value by 3 mm. Then the cut out piece was transformed by surgical instruments into a triangle with two equal sides, which base was 3 to 4 mm, and which height was so that it exceeds the implant radius by 2 to 3 mm. An end-to-end cross section was made in the ready bioptate triangle in the direction from the base to the top of the triangle in the line of its height with the length exceeding the implant radius by 1 mm. And then the bioptate was cut in parallel to its plane in the middle of its width. The section was performed from the top to the base of the triangle, and the section was finished 1 to 2 mm before the base and the formed triangle plane leaves were opened until they formed a rhombus with a thickening fringe in the middle. After that, around a selected installed implant, a surgical excavation was formed, the implant cover was replaced by a healing abutment with a diameter equal to the implant diameter, the bioptate was placed so that its section center was over the top healing abutment center, upon placing the biomaterial so that its roll is up and the roll longitudinal axis is in the line of the jaw longitudinal axis. Then the transplant was stretched by its rolls' corners, thus extending the opening up to its sizes' compliance with the healing abutment sizes, the transplant was put by its opening on the healing abutment, positioning it tightly in its seat, straightening and placing it in the straightened shape inside the surgical excavation in the soft tissues, after which the wound was made down (Fig. 2).



(a) (b)

FIGURE 2. A part of the lower jaw of patient Sh. in 2.5 months after the performed installation of three implants instead of missing teeth 34, 35 and 36 before (a) and immediately after putting the transplant skirts on 2 healing abutments of implants, which were "naked" due to soft tissues deficiency (b)

The results of preventive measures of the dental implantation deficiency have been assessed during 2 years after the performed surgery. It is determined that the application of the elaborated anti-fissure dental transplantation led to the prevention of fissure between crowns and soft tissues of each of the 14 patients. In this regard, all patients fully restored their masticatory function; their mouth cavity mucous tunic was pink and having the same normal local temperature. All these patients did not have bad breath, inflammations of soft and hard mouth cavity tissues, and other evidence of microbial aggression in the area of installed dental structures.

Therefore, in case of excessive atrophy of jaw soft tissues, the transfer of biomaterial performed according to the inventive technology developed by us before installing tooth crowns on implanted transplants shall guarantee no fissures under crowns.

The mentioned technology was the basis of the invention "Method for elimination of insufficiency of soft tissues in dental implantation" [13]. The concept of the new operative technology is reduced to production of a transformer graft from biomaterial having original form with a thickening roll and a center hole to be put on healing abutment of the integrated implant as a skirt, and the free edges of such transplant-skirt would be covered with preliminary lifted flips of jaw soft tissues.

RESULTS

Thus, we developed inventive methods of biomaterials transplantation in case of excessive atrophy of soft and hard tissues of jaw, which significantly improve the accuracy, efficiency and safety of sinus augmentation with simultaneous dental implantation, crowning of the implanted transplants, and extend the use of osteoplastic xenogeneic biomaterials by OsteoBiol®.

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