Results of fibrous matrix application with the aim of bone crest augmentation in the direct bone regeneration process

Pantus AV, Rozhko MM, Kogut VL, Grekulyak VV and Yatsiv TZ

Abstract

Introduction: The study of the GBER effectiveness with aim of existing bone deficiency correction with the use of different bone grafts and their analogues remains the actual issue of practical dentistry.

Objective: Evaluate the effectiveness of using a fibrous matrix for the purpose of bone crest augmentation during the implementation of the guided bone regeneration procedure in order to optimize the conditions for the intraosseous titanium dental implants placement.

Materials and Methods: In the study group bone augmentation was performed with a mixture of autogenous bone material and developed by the authors polymeric matrix from the Resorb X foam of the KLS Martin Resorb X foam; in the control group, as a bone replacement material, was used a mixture of autogenous bone tissue and allogeneic graft Cerabone.

Research Results: Six months after the implementation of the guided bone regeneration procedure, it was found that the average increase in the vertical and horizontal parameters of the bone crest in the area of intervention among the patients of study group were 3,19±0.59 mm and 3.08±0.79 mm, respectively.

Conclusions: The absence of a statistically substantiated, clinically pronounced or tomographically-registered difference in the studied indices indicates the possibility of an effective and predicted use of polyactic acid foams in the protocol of the implementation for guided bone regeneration of the residual jaw crest at the Adentia region in order to optimize the conditions for the intraosseous titanium dental implants placement.

Keywords: Fiber matrix, bone, polymeric membrane

1. Introduction

The loss of a unit of a tooth row, regardless of etiology, leads not only to the development of associated functional and occlusive changes in the structure of the tooth-jaw apparatus, but also to the progression of localized atrophy in the adentity region, provoked by the lack of necessary load on the residual crest region. The results of previous researches indicate that the severity of the deficiency of the vertical and horizontal parameters of the bone in the area of odic adentity is a derivative of the duration of the existence of the defect in the dentition, and therefore their early replacement helps to minimize the need for additional surgical interventions in the implementation of complex rehabilitation protocols in the future. However, in the presence of pronounced atrophic changes, the conditions for performing odic implantation procedure in the area of the existing defect are limited, and the implementation of this type of intervention is possible only with the preliminary reconstruction of the bone crest in order to compensate for the existing shortage of bone offer.

The issue of the differences in survival and success rates of dental implants established in the region of augmentation is immediate or postponed, remains the subject of discussions, although in a number of researches, a statistically significant difference between these parameters could not be registered. Meanwhile, the protocol of delayed implantation in the area of pre-augmentation is characterized by its significant advantages and higher predictability, which is ensured by the possibility of monitoring the changes in the state of bone tissue using various methods of visualization (sight roentgenography, orthopantomography, cone-ray computer tomography) as in the course of the formation of a new bone bed, and just before the stage of the establishment of intraosseous titanium supports. Possibilities of reconstruction of the residual crest in order to achieve an increase in its vertical and horizontal parameters include options for the implementation of classical bone
transplantation procedures for the application of various substitutes or their mixtures, different variants of osteotomy followed by the completion of the formed augmentation bed, or directed bone regeneration (DBR) procedures using barrier membranes [9, 10]. The study of the effectiveness of NKR algorithms with correction of existing bone deficiency deficit by different bone grafts and their analogues remains the actual issue of practical dentistry, which justifies the need for appropriate clinical and experimental research.

**The aim of the research**

Evaluate the effectiveness of using a fibrous matrix for the purpose of augmentation of the bony crest of the jaws during the implementation of the directed bone regeneration procedure in order to optimize the conditions for the establishment of intraosseous titanium dental implants.

**Materials and methods of research**

The formation of the patient sample was performed by selecting them from the general population of Ivano-Frankovsk dental clinics for use as criteria for the inclusion of the following parameters: 1) age of patients from 18 to 50 years; 2) the presence of an Odic tooth area in the area of molars or premolars; 3) written consent of the patient to conduct a complex of diagnostic and surgical manipulations in order to provide rehabilitation through single implantation in the admission and auxiliary procedure for bone augmentation; 4) confirmation from the data of a cone-ray computer tomography of the deficiency of the width and height of the bone crest necessary for the establishment of the dental implant. Exclusion of patients from a pre-existing research complex was performed using the following criteria: 1) the age indicator is outside the range of 18-50 years; 2) the registration of available hemopathology, limiting the possibilities for conducting and predicting successful results of procedures for bone augmentation and / or dental implantation, adversely affect the regenerative potential of bone tissue; 3) the presence of a tobacco smoking habit in a patient; 4) the state of pregnancy or breastfeeding; 5) the presence of a significant bone defect in the area of a single Adentiya with a deficiency of the required height parameters or the width of the residual crest of more than 4 mm; 6) lack of opportunity and motivation of the patient to correct the low level of oral hygiene. In the process of forming the final volume of the sample of dental patients under study using inclusion and exclusion criteria, 33 patients (18 women and 15 men) were randomly assigned to be randomized into two groups - the research group and the comparison group. The process of uncontrolled distribution of patients in the group was carried out using a package of adapted software, which allows to ensure an even independent distribution of subjects to the initial parameters of each individual clinical situation. Thus, the research group was presented by 16 patients (8 women and 8 men), and the comparison group was 17 patients (10 women and 7 men).

The first stage of surgical treatment of patients in both groups involved a bone augmentation procedure in the area of bone deficiency. The intervention was carried out under local anesthesia with the formation of the trapezoidal incision, the separation of the mucous membrane, the filling of the defect site with a mixture of bone-substitute materials, which were further blocked by a polymeric membrane, and the subsequent sewing of the intervention area. Removal of stitches performed in 10-12 days after surgical manipulation, taking into account the clinical condition of the tissues in the area of intervention.

The difference in the first stage of treatment between patients in the research group and the comparison group was that in research group the bone augmentation, was carried out by mixture of autogenous bone material (collected from the area of the upper jaw boom) and developed by the authors of the polymer matrix of foam polyactic acid formulation of the Resorb X foam of the KLS Martin Resorb X foam (foams were made by the phase separation of the polymer with subsequent gamma sterilization, the final thickness of the used fibrous matrix was on average 30 mm, and the diameter of the individual fibers - from 4 microns to 10 microns); in the control group, as a bone replacement material, a mixture of autogenous bone tissue and allogeneic graft Cerabone (Botiss) was used, which was further covered with a polymeric membrane. As a membrane for blocking the area of iatrogenic intervention, the membrane KLS Martin was used, which was individually modified according to the defect configuration by the method of thermo active pressing (Patent for the invention of Ukraine No. 114143).

Six months after the procedure of augmentation of patients, a repeated cone-ray computer tomography was performed to record changes in the parameters of bone tissue in the area of intervention and to further plan the stage of dental implantation. An estimation of changes in the dimensional parameters of the residual crest in the area of bone reconstruction was carried out with the help of the tool "Line" in the used Viever for the use of reference co-ordinates for measuring the levels of the enamel-cement border of the teeth surrounding the defect of the tooth row. The installation of dental implants was carried out in accordance with the classical protocols of the procedure described in the literature, similar to that of the research group and the comparison group.

As representative indicators, the average values of the initial and final dimensional parameters of the bone residual crest in the implantation area were used, and the survival rates and success rates of the implanted implants were recorded after 12 months of their functioning.

Statistical analysis of numerical data was performed in Microsoft Excel 2019 software (Microsoft Office 2019 (Microsoft)).

**Results of the research and their Discussion**

In the analysis of the data of the medical history of patients in the research group and control group, it was found that the average duration of single Adentiya duration was 5.5 ± 1.6 and 7.1 ± 0.4 years, respectively. After conducting the primary cone-ray computer diagnostics, the average parameters of the deficit of the vertical parameters of the bone crest in the area of the dental defect, which reached 2.94 ± 1.57 mm and 3.04 ± 1.62 mm in the research group and the control group, were determined. The average deficit index of horizontal bone parameters was at the time of the initial examination of 2.12 ± 1.15 mm and 2.71 ± 0.89 mm. Thus, there was no statistically difference between the initial indicator of the bone deficit in the vertical and horizontal directions among the patients in the research group and the comparison group (p> 0.05).

Six months after the implementation of the directed bone regeneration procedure, it was found that the average increase in the vertical and horizontal parameters of the bone crest in the area of intervention was among the patients in the research group 3.19 ± 0.59 mm and 3.08 ± 0.79 mm, respectively, that
in percentage representation relative to the initial situation corresponded to an increase of 108.5 ± 19.25 % and 145.28 ± 15.16 % in the vertical and horizontal directions, respectively.

Among the patients in the comparison group, the augmentation of the area of bone tissue deficiency, which was performed using a mixture of autogenic bone tissue and allogeneic transplant, the absolute mean increase of the vertical crest parameters was 3.55 ± 0.77 mm, while the horizontal ones were 3.33 ± 0.19 mm. At the same time, the average % growth of the bone in the vertical direction relative to the initial situation was 116.77 ± 12.19 %, and in the horizontal direction was -122.87 ± 21.05 %. The analysis of the obtained results found that in both groups of research the average increase in the horizontal parameters of the bone crest in the area of intervention was dominated by the average increase in vertical parameters, although the difference between these parameters was not statistically confirmed (p≥0.05). Similarly, it was not statistically confirmed by the difference between the resultant mean bone growth rates in both the horizontal and vertical directions in both groups (p≥0.05), which indirectly suggests that the effectiveness of two protocols of directed bone regeneration among the patient sample was similar.

### Table 1: Comparison of the researched parameters among patients in the research group and the comparison group

<table>
<thead>
<tr>
<th>Researched parameters</th>
<th>Research group</th>
<th>Comparison group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average index of deficit of vertical crest parameters</td>
<td>2,94±1,57 мм</td>
<td>3,04±1,62 мм</td>
</tr>
<tr>
<td>Average index of deficit of horizontal crest parameters</td>
<td>2,12±1,15 мм</td>
<td>2,71±0,89 мм</td>
</tr>
<tr>
<td>The average increase in the vertical crest parameters</td>
<td>3,19±0,59 мм</td>
<td>3,55±0,77 мм</td>
</tr>
<tr>
<td>The average increase in the horizontal crest parameters</td>
<td>3,08±0,79 мм</td>
<td>3,33±0,19 мм</td>
</tr>
<tr>
<td>Average% increase in vertical crest parameters</td>
<td>108,5±19,25%</td>
<td>116,77±12,19%</td>
</tr>
<tr>
<td>Average% increase in horizontal crest parameters</td>
<td>145,28±15,16%</td>
<td>122,87±21,05%</td>
</tr>
</tbody>
</table>

The survival rate of implants, registered in 12 months after their establishment in the field of augmentation, in the research group and in the comparison group was 100 %, however, the success rate of implantation in the research group was 87.5 %, while in the comparison group - 94.11 %. Reducing the success rate of implantation in the research group may be justified by the failure of two patients to recommend maintaining an adequate oral hygiene level and reducing it to a critical negative.

In a systematic research which was conducted by Donos N. and colleagues (2008), the authors found that the clinical results of implant placement in intact and augmented bone crest were not statistically different, regardless of the implementation of the bone reconstruction protocol (use of barrier membranes, bone substitutes or split osteotomy). At the same time, the average survival rate of implants in the sites of augmentation was 91.7-100 %, and in the control sites, without any intervention on the bone crest, 93.2-100 % [11]. Similar results were later described in the research of Jense S. and Terheyden H. which they emphasized that combinations of some types of bone substitutes were more closely researched than others, which, however, did not diminish the potential role of the latter, but argued the need for additional clinical experiments [12].

The results of a research which was conducted by Schneider D. and colleagues (2013) point that the use of modified Polylactide mullion in the structure of directed bone regeneration does not differ from the protocols for the reconstruction of the residual crest using bone substitutes and membranes from tetra Polifito retile. Similar to our research, the authors failed to register any statistical difference in the clinical results obtained between the two groups. Moreover, the histological research conducted by the researchers also did not establish a difference in the structure of the formed tissues in the field of iatrogenic intervention [13].

Data of the retrospective analysis of the success of dental implants established in the area of augmentation by bone blocks of autogenic and allogenic origin, conducted by Rusin V.V. and colleagues (2018) indicate that, according to preliminary clinical observations, the indicators of intraosseous support found in allogeneic bone units are slightly higher at 95.5-96.0 % than those that were established in autogenously blocks [14]. However, the authors also noted that the indicators of the success of implants installed in the areas of reconstruction of the bony crest of the jaws depend not only on the used type of bone substitute material, but also on the impact of a number of other weighty factors, in particular on the load period, the establishment of intra-axial titanium supports with respect to the time of reconstruction of the residual crest, the topography of the area of surgical intervention, the observation time, the criteria that were selected for the evaluation of the success rates [14]. The results of our monitoring of the success of implants placed in bone tissue areas were augmented by two protocols (using a polymer matrix or Allogen analogue in combination with an autologous graft) correlating with the data obtained in previous researches and confirming the biological ability the use of a polymer matrix to achieve effective results of directed bone regeneration.

The argumentation of the use of Polylactide mullion in combination with other types of bone transplant was widely described in Lanao and colleagues. The authors noted that a significant advantage of such a type of bone substitute is that, it can be manufactured in full compliance with the individualized three-dimensional structure of the defect of bone tissue. At the same time, researchers also singled out some of the disadvantages of skeofolds from polylactic acid, in particular: low osteoconductivity, the possibility of disadvantages can be leveled due to the use of a mixture of a polymer matrix or analogue in combination with an autologous graft) correlating with the data obtained in previous researches and confirming the biological ability the use of a polymer matrix to achieve effective results of directed bone regeneration.

The argumentation of the use of Polylactide mullion in combination with other types of bone transplant was widely described in Lanao and colleagues. The authors noted that a significant advantage of such a type of bone substitute is that, it can be manufactured in full compliance with the individualized three-dimensional structure of the defect of bone tissue. At the same time, researchers also singled out some of the disadvantages of skeofolds from polylactic acid, in particular: low osteoconductivity, the possibility of developing an inflammatory response taking into account the acid structure of the medication, insufficient initial mechanical characteristics [15]. However, some or all of these disadvantages can be leveled due to the use of a mixture of polylactic mullion with other types of bone transplant to achieve the most predictive effect during the implementation of surgical iatrogenic interventions in order to optimize the conditions for the establishment of dental implants.

### Conclusion

The results obtained in the course of the research show the effectiveness of using a fiber matrix from lactic acid foams as part of a mixture of bone substitute materials for the purpose of implementing a directed bone regeneration procedure, which according to the registered indicators was similar to the level of allogenic bone graft efficiency. The statistical
difference between the values of the mean increase in the vertical and horizontal parameters of the bone crest among the patients in the research group, the augmentation of the adentia region in which was carried out using a mixture of autogenic bone material and the developed polymer matrix from foam polyactic acid Resorb X of KLS Martin firm, and among the patients in the comparison group, the reconstruction the deficit of the bone offer in which was carried out by a mixture of autogenic and allogeneic bone substitutes, failed to register (p≥0.05). The absence of a statistically substantiated, clinically pronounced or tomography-registered difference in the researched parameters indicates the possibility of an effective and predicted use of polyactic acid foams in the protocol of the implementation of directed bone regeneration of the residual jaw crest in the adentia region in order to optimize the conditions for the establishment of intraosseous titanium dental implants.

References


