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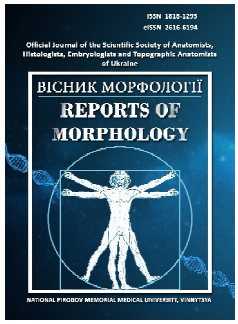

Histo-morphometric evaluation of post-augmentation bone tissue of the human mandible

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The clinical challenge of today is to restore the biological structure of atrophied bone tissue by combining methods of complex clinical rehabilitation, that is, intraosseous implantation and augmentation, in its interimplant sites. The aim of the study was to perform a histo-morphometric assessment of post-augmentation bone tissue using a combined technique of controlled autocellular transplantation with the use of bone allograft filler on edentulous distal segments of the human mandible with varying degrees and forms of atrophy. Trepanbiopsy specimens were used as the study material, after microtomy processing of which histological slides were prepared, followed by the accelerated May-Grunwald staining-fixation technique (Sigma-Aldrich, St. Louis, USA). For the histomorphometric study, stained histological specimens of post-augmentation bone tissue were imaged with an optical microscope camera (Leica DMLB, Germany). The analysis was performed using the Fiji information software, with the formation of reconstructed mosaic digital micrographs for further histomorphometry. The results of the evaluation of controlled bone tissue formation (post-augmentation), which are the key tasks, novelty, and justification of modern and effective methods of rehabilitation of patients with acquired forms of atrophy in the edentulous distal segments of the human mandible, are illustrated by microphotographs and presented in detail in this paper by the percentage of the quality of cross-linking of the cortical layer. The ratio of the newly formed cortical layer of bone tissue to the total area of the post-augmentation tissue study was 61.30 %, with a lateral form of atrophy (according to J. Cawood and R. Howell: class IV), in the post-augmentation period 4 months. The histo-morphometric assessment of the qualitatively formed cortical bone in the post-augmentation period of six months is 92.80 % of the total postoperative area. Therefore, it is biased to evaluate the quality of the formed bone in the mandible within the generally accepted average period of four months, although paraclinical densitometry shows positive values.

Keywords: *bone atrophy, morphometry, augmentation, mandible, human.*

Introduction

The edentulous mandible in human postnatal ontogeny is increasingly becoming an object of modern research. It acquires characteristics that depend on the strength and time of exposure to polyetiological factors, control of remodeling processes, and mineralization (maturation), that is, on the course of metabolic processes that lead to pathophysiological and morphological changes [18, 20, 22, 25].

An important indicator for assessing the controlled formation of bone (post-augmentation) tissue as a result of its directed regeneration [2, 26] is the quality of cross-linking of the cortical layer with the reproduction of histomorphological architectonics [14, 16, 31]. After all, the cortical layer is the hardest tissue of the mandible, which serves as a protective mechanical and permanent isolation barrier. The loss of its density in localized sites indicates the activity of remodeling processes, or the manifestation of pathological inflammatory-destructive or dystrophic processes as a result of metabolic disorders, etc [5, 12, 13]. Understanding these mechanisms and mastering the skills of densitometric assessment is a reliable basis for clinical diagnosis and planning of surgical operations. At the same time, the paraclinical differentiation between remodeling processes [4, 24] and inflammatory and destructive changes during radiographic densitometry is difficult. Therefore, most clinicians decide to postpone the

previously drawn up plan for the full rehabilitation of edentulous patients until the above manifestations "fade" or regress, which will result from the general functional state of the human body, acquiring new qualitative and quantitative characteristics of bone tissue [11, 15].

Another gap in research is the lack of accurate data describing the processes of bone tissue restoration, depending on the method of directed regeneration in a combination of bone replacement materials of biological and artificial origin with automeso concentrate or other biological and artificial activators [21, 27, 28].

The priority tasks in the study of post-augmentation bone tissue were aimed at studying: the acquired morphological, histological (overview) architectonics (general structure); activity (severity) of remodeling (physiologically replacement) processes of bone tissue; assessment of the qualitative characteristics of the newly formed cortical and trabecular layers of bone tissue over time.

That is why both the researcher and the clinician faced a twofold problem in choosing reliable diagnostic methods, or focusing on the results of the studies [6, 29, 32], as well as the data we have obtained below.

At first glance, bone grafting has long been used in maxillofacial surgery, demonstrating its priority on atrophied edentulous segments of the lower/upper jaws, affecting topographic changes in the canal(s) of the lower jaw [1, 7, 17], the position of the teeth of the upper jaws to their sinuses, and changes in bone density of even adjacent morphological structures.

The use of bone autografts or their substitutes faces certain difficulties in timely clinical support, due to the lack of a national "donor bone bank", which forces the use of existing fractional stocks in urgent cases, not always for their intended purpose. To achieve good integration of bone grafts and simplify the procedures for the formation and reproduction of the biological structure of bone, we have mastered the combined technique of controlled autocellular transplantation (Endoret - PRGF, Spain) with the development of our results, which are detailed in this paper.

The aim of the work was to perform a histo-morphometric assessment of post-augmentation bone tissue using a combined technique of controlled autocellular transplantation with the use of bone allograft filler on edentulous distal segments of the human mandible with varying degrees and forms of atrophy.

Materials and methods.

An equally important stage is the collection of newly formed bone tissue using standard rotating protocol trepanation osteotomes (BTIs) in the defined sites of the human mandible and for analytical comparison in two sites of the right and left upper jaws in the projection of the first and second large molar teeth (Table 1).

For proper fixation of the biopsy material, a buffered neutral 10 % formalin solution was used. It was prepared in the ratio: 9 parts of phosphate buffer with pH 7.2-7.4 and 1 part of formalin (formalin 10 ml, tap water 90 ml, NaH_2PO_4 0.4 g, Na_2HPO_4 0.65 g). In this way, a fixing effect was achieved and cross-links were formed between proteins and nucleic acids (NAs): protein-protein, protein-NAs, and NAs-NAs.

It is clear that at a high concentration gradient, diffusion processes will occur rapidly and can damage or deform the post-augmentation bone material under study. That is why, for dehydration, the samples were not placed directly in pure ethyl alcohol, but a set of alcohol solutions with a gradual increase in concentration was used: 70 °, 80 °, 90 °, and 96 °, each for 2 (two) hours.

The samples were then transferred to molten pure paraffin. To do this, paraffin wax in a porcelain cup was placed in a thermostat in advance (several days before pouring) at a temperature 2-3 °C higher than the melting point of paraffin wax (56 °C), poured into laboratory block molds, into which the samples were transferred. Double portions of paraffin wax were used to better rid them of organic solvent residues.

After microtomic processing and preparation of

Table 1. Histo-morphometric analysis of post-augmentation bone tissue of the lower (A, B, C, D, E, F) and upper (H, I) human jaws.

No. of marking	AS, μm²	Post-augmentation period, months	AF, μm²	AS/AF ratio, %
A	1560879649	4	956660353	61.30
B	3512170701	4	1505813540	42.90
C	3364192514	6	3123476138	92.80
D	3830031835	6	1881446888	49.10
E	2231635550	6	1173544.816	52.60
F	1693794773	10	1377650262	81.30
H	3071512894	8.0	1840123131	59.90
I	3027724997	8.0	1633063262	53.90

Notes: AS – the area of bone tissue under study; AF – the area of well-formed bone tissue.

histological specimens, we used the accelerated May-Grunwald staining-fixation technique (TU U 20.5-20650786-004:2012) to meet the outlined objectives.

Before staining, a working solution of the May-Grunwald stain-fixative was prepared by diluting it with neutral water in a ratio of 1:2 to 1:5. Neutral water was prepared according to the instructions as follows:

1) dissolve 9.50 g of anhydrous sodium phosphate in 900 mL of distilled water. Bring the water level to 1000 ml and mix well (solution A);

2) dissolve 9.07 g of potassium phosphoric acid monosubstituted in 900 mL of distilled water. Bring the water level to 1000 ml and mix well (solution B);

3) pour 63 mL of solution A and 37 mL of solution B into a 1000 mL volumetric cylinder and bring to 1000 mL with distilled water. The pH of the resulting neutral water was determined using a pH meter. The pH value was 7.0±0.2.

Undiluted May-Grunwald stain-fixative (Sigma-Aldrich, St. Louis, USA) was applied to unfixed sections to cover the entire section. After 3 minutes, the fixative dye was washed off with neutral water and then stained with a diluted working solution of the fixative dye for 10-15 minutes. Then they were washed with neutral water, air-dried, and examined under an optical microscope (Leica DMLB, Germany).

For histo-morphometric studies, stained histological specimens of post-augmentation bone tissue were photographed with an optical microscope camera (Leica DMLB, Germany). The analysis was carried out using the information software "Fiji", with the formation of reconstructive mosaic digital micrographs (Fig. 1) for further histo-, morphometry, the results of which are presented in Table 1.

Informed Consents provided and signed by patients regarding their participation in research in compliance with the main provisions of the GDPR (1996), the Council of Europe Convention on Human Rights and Biomedicine (04.04. 1997), the Declaration of Helsinki of the World Medical Association for the Ethical Principles of Scientific Medical Research Involving Human Subjects (1964-2013), Order of the Ministry of Health of Ukraine No. 690 of 23.09.2009, No. 616 of 03.08.2012 and approved by the decision of the Commission on Biomedical Ethics of Bukovinian State Medical University (Protocol No. 2 of 21.10.2021).

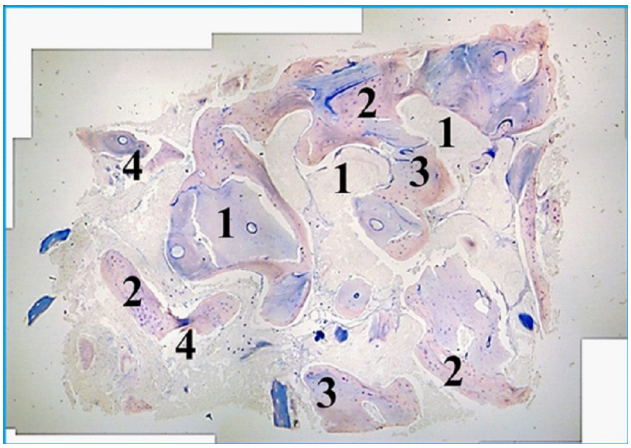

Fig. 1. Post-augmentation biopsy material of the distal edentulous segment of the mandible above the implant in the projection of the first large molar tooth of the mandible on the left side. 1 – sites of a well-formed cortical layer; 2 – sites of active bone remodeling; 3 – sites at the stage of completion of cortical formation; 4 – sites of cortical prolapse (flexion), and granulation replacement. Staining: according to May-Grunwald (Sigma-Aldrich, St. Louis, USA). Microphotograph by the method of programmatic (mosaic) reconstruction. Zoom: ×320.

The work is a fragment of the initiative research work of the Department of Histology, Cytology and Embryology of Bukovinian State Medical University "Structural and functional features of tissues and organs in ontogenesis, patterns of variant, constitutional, gender, age and comparative human morphology", state registration number 0121U110121.

Results

Our research aspiration was to evaluate the quality of the newly formed cortical layer of post-augmentation bone tissue, which was performed using the technique of controlled autocellular transplantation (Endoret PRGF, Spain) with the use of bone allograft (Human-Corticalis, Germany).

The most challenging task of today is to restore the biological structure of atrophied bone tissue by combining methods of complex clinical rehabilitation, that is, intraosseous implantation and augmentation, in its interimplant sites. The first iatrogenic obstacle is a significant loss of intraosseous trophic nutrition of the site. The second is blocking the main canal, which provides not only nutrition but also innervation and drainage function of this segment of bone tissue. Therefore, it is not an objective decision to assess the quality of the formed bone within the generally accepted average period of 4 months, although paraclinical densitometry determines positive values. Our clinical rationale for maintaining the density of post-augmentation bone tissue even at the stages of remodeling is based on the quality of allogeneic homograft and its dispersion (grinding, size, shape). The ratio of the newly formed cortical layer of bone tissue to the total area of the post-augmentation tissue study was 61.30 % (Fig. 2, see Table 1).

The deficit of cortical cross-linking over the implant, which is placed using the subcortical implantation technique, occurs due to a violation of histomorphological reconstruction at the stages of its osseointegration, which is limited by an artificial temporary block (plug). In this case, time only works to reverse the process cortical deproficit (Fig. 3). These conditions reduce the coefficient of the newly formed cortical bone layer from the total area of the post-augmentation tissue study to 42.90% (see Table 1).

Partial decortication and stability of the bone augmentation, in the lateral form of atrophy with adequate body height and cellular part of the mandible, even with insufficient bone width, contributes to a positive prognostic result (Fig. 4).

Taking into account the volume of surgical interventions performed and the increase in the planned width of the operative toothless distal segment of the mandible,

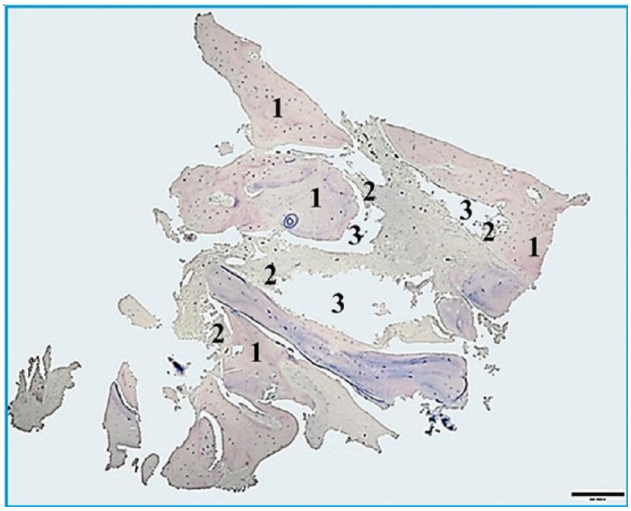

Fig. 2. A – post-augmentation biopsy material of the distal edentulous segment between the implants in the projection of the first and second large molar teeth of the lower jaw on the left, from the buccal side. Clinical diagnosis: Lateral atrophy (according to J. Cawood and R. Howell: class IV – the ridge of the mandible in the form of a knife blade, adequate height, and insufficient bone width). The post-augmentation period is 4 months. 1 – sites of a well-formed cortical layer; 2 – sites of active bone remodeling; 3 – sites of cortical prolapse (flexion), and granulation replacement. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

extending the post-augmentation period to six months, we achieved 92.80% of the well-formed cortical bone area (see Fig. 4, table 1).

The use of combined techniques in the treatment of a pronounced horizontal form of atrophy on edentulous distal segments, even after ensuring full stability of the augmentation, does not provide confidence in the restoration of the predicted volume of both the height and width of the body and the cellular part of the mandible. Accordingly, the expectations for the histological and morphological quality of the newly formed cortical layer, even if the clinical observation of the post-augmentation period is prolonged, are unjustified (Fig. 5).

The coefficient of the ratio of the newly formed cortical layer of bone tissue to the total area of the post-augmentation tissue study, after treatment of the horizontal form of atrophy class V flat ridge, was only 49.10 % (see Fig. 5, table 1).

The study of a similar form of atrophy in the same post-augmentation period as described above, over the implant in the projection of 3.6 tooth, showed better results, where the quality of cortical cross-linking was 52.60 % (Fig. 6, see Table 1).

This pattern is because the bone tissue under study was taken from the site on the border of the functioning dentition. Accordingly, the quality of trophic support is higher, which contributed to the formation of the cortical layer.

The study of bone tissue after the conservation of the post-extraction socket of the tooth without an implant,

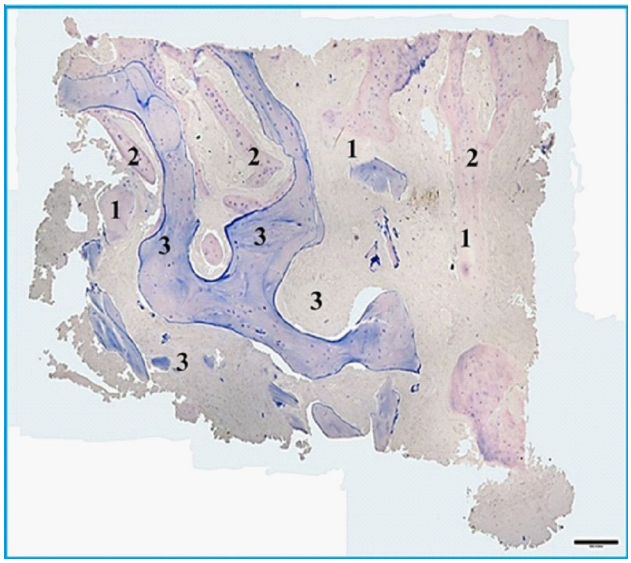

Fig. 3. B – post-augmentation biopsy material of the distal edentulous segment of the mandible above the implant in the projection of the first large molar tooth on the right side. Horizontal form of atrophy (according to J. Cawood and R. Howell: class VI – depression of the ridge, loss of bone tissue of the body of the mandible). The post-augmentation period is 4 months. 1 – sites of a well-formed cortical layer; 2 – sites of active bone remodeling; 3 – sites at the stage of completion of cortical formation. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

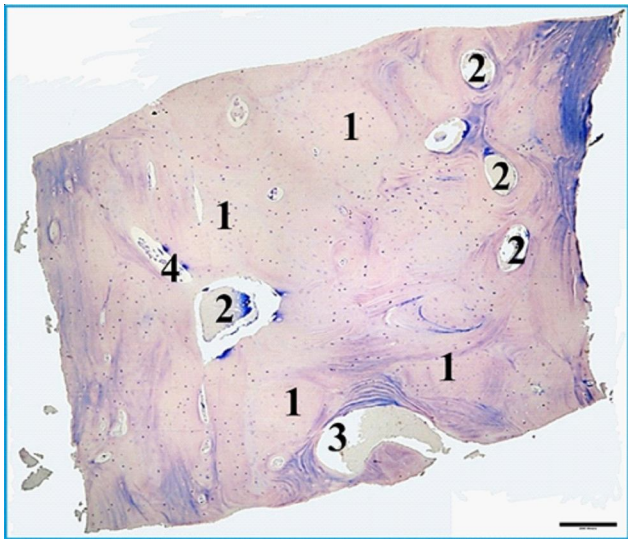

Fig. 4. C – post-augmentation biopsy material of the distal edentulous segment between the implants on the buccal side of the mandible of the first and second large molar teeth on the right side, with a lateral form of atrophy (according to J. Cawood and R. Howell: class IV – the ridge of the mandible in the form of a knife blade, adequate height, and insufficient bone width). The post-augmentation period is 6 months. 1 – sites at the stage of completion of cortical formation; 2 – sites of active apositional bone growth; 3 – site of cortical prolapse (flexion); 4 – site of active replacement (displacement) of granulation germination. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

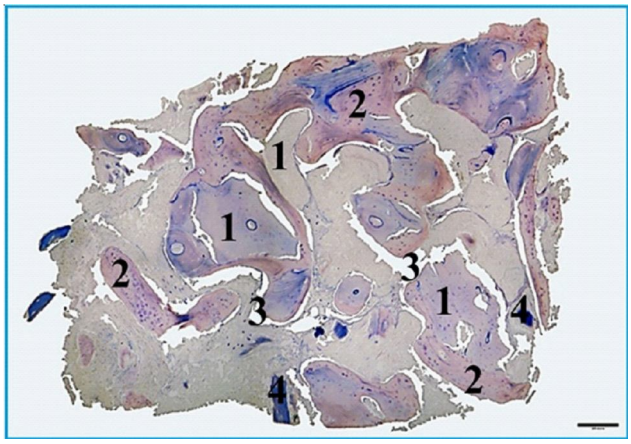

Fig. 5. D – post-augmentation biopsy material of the distal edentulous segment of the mandible above the implant in the projection of the second large molar tooth on the left side, with a horizontal form of atrophy (according to J. Cawood and R. Howell: class V – flat ridge of the mandible, insufficient height and width of the bone). The post-augmentation period is 6 months. 1 – sites of well-formed cortical layer; 2 – sites at the stage of completion of cortical formation; 3 – site of cortical prolapse (flexion); 4 – sites with oxidative inclusions from the implant cover. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

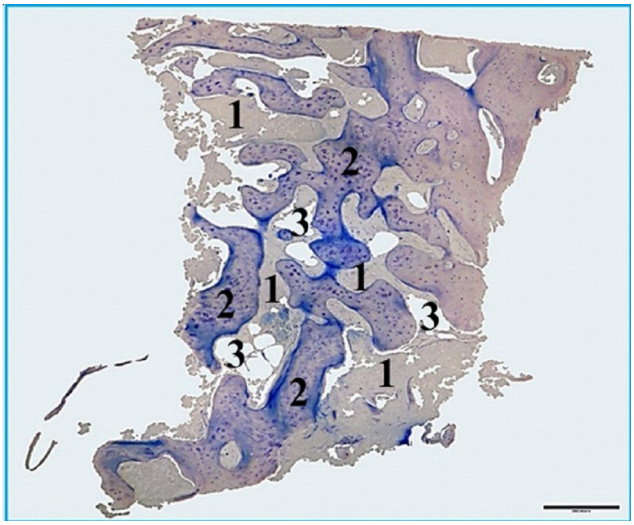

Fig. 6. E – post-augmentation biopsy material of the distal edentulous segment of the mandible above the implant in the projection of the first large molar tooth on the left side, with a horizontal form of atrophy (according to J. Cawood and R. Howell: class V – flat ridge of the mandible, insufficient height and width of the bone). The post-augmentation period is 6 months. 1 – sites of a well-formed cortical layer; 2 – sites of active bone remodeling; 3 – site of cortical prolapse (flexion). Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

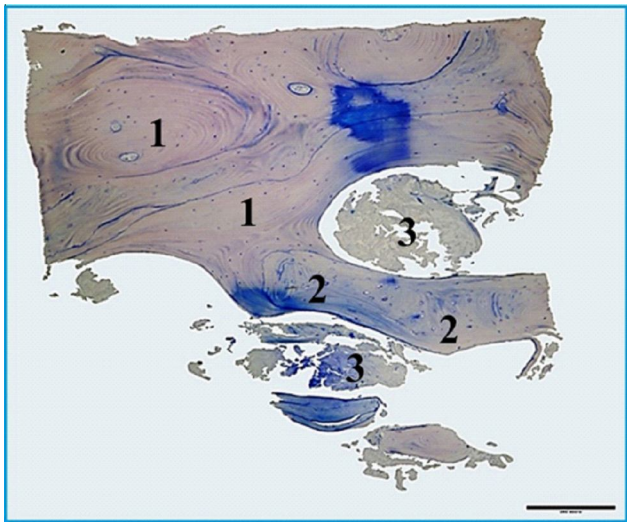

Fig. 7. F – biopsy material after the physiological process of bone tissue regeneration of the mandible, during the conservation of the socket of the first large molar on the right side using the Endoret PRGF technique (without bone replacement materials). The post-augmentation period is 10 months. 1 – sites of well-formed cortical layer; 2 – inter-root septum; 3 – site of active bone remodeling. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

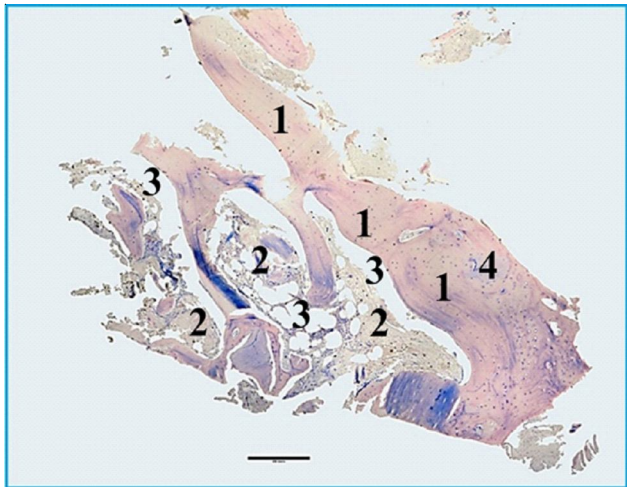

Fig. 8. H – post-augmentation biopsy material was taken from the distal edentulous segment of the upper jaw above the implant in the projection of the second large molar tooth of the upper jaw on the left side, with a mixed form of atrophy. The post-augmentation period is 8 months. 1 – sites of well-formed cortical layer; 2 – site of active bone remodeling; 3 – site of cortical prolapse (flexion); 4 – sites at the stage of completion of cortical formation. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

according to the Endoret - PRGF method, without the use of bone replacement fillers (Fig. 7), under the conditions of the physiological regeneration process, provided a high result of cortical cross-linking by 81.30 % (see Table. 1).

Preservation of the interdental septum and adequate early sealing of the socket using obturation blocks of automesoconcentrate make it impossible to prevent the early development of bone atrophy of the edentulous segment of the jaw.

To compare the results, we studied the post-augmentation biopsy material from the distal edentulous segments of the left (Fig. 8) and right (Fig. 9) sides of the

upper jaw above the implants placed using the subcortical implantation technique. The ratio of the area of cortical cross-linking of the newly formed bone tissue to the total area of the study was: in the projection of 1.7 tooth 53.90 % and the projection of 2.7 tooth 59.90 % in the post-augmentation period of 8 months (see Table. 1).

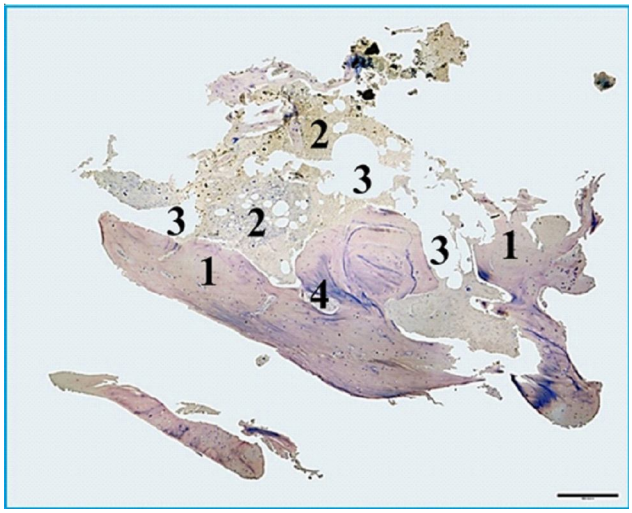

Fig. 9. I – post-augmentation biopsy material of the distal edentulous segment of the upper jaw above the implant in the projection of the first large molar tooth of the upper jaw on the right side, with a mixed form of atrophy. The post-augmentation period is 8 months. 1 – sites of well-formed cortical layer; 2 – site of active bone remodeling; 3 – site of cortical prolapse (flexion); 4 – sites of active apositional bone growth. Coloring: according to May-Grunwald-Gimza (MGG). Microphotograph. Zoom: ×320.

It is clear that the upper jaws, in particular the distal segments, are characterized by lower densitometric parameters and are easily subject to pathomorphological processes of fibrous replacement as a result of epithelial growth due to the loss of the membrane barrier caused by their excessive blood supply in general and in the postoperative period.

Discussion

Traditionally, the quality of bone and tissue repair is usually evaluated in the upper jaw within 4-6 months, and in the lower jaw within 3-4 months.

Scientists Kutsevliak V. F. and Liubchenko O. V. in their work [19] also conducted a layer-by-layer histomorphological assessment of directed bone tissue regeneration (DBTR). They determined the zonation of the regenerate structure on histotopograms with a division into surface and deep zones. The results of DBTR on day 42 are described: in the structure of the regenerate, 1 % of the hematoma remnants, 55 % cell-fiber tissue, 12 % osteoid, and 32 % newly formed bone trabeculae. Thus, the structure of the regenerate was dominated by cell-fiber tissue, well vascularized, with almost no leukocyte infiltration, and the osteogenesis zones occupied the deeper parts of the defect. On the 90th day, histotopograms showed that, according to morphometric data, cell-fiber tissue accounted for only 8 % of the regenerate structure, and a network of osteoid and newly formed bone trabeculae accounted for 92 %, with 9 % of them being large-looped. In the peripheral sites of the bone trabeculae network, the formation of neoplasms of the cortical layer was detected, which occupied 7 %. In other words, the area of cortical cross-linking (reparative osteogenesis) of the mandibular defects at the end of the third month was only 7 %.

Usually, both clinicians and researchers want to keep all tissue regeneration processes under close control to increase the effectiveness of osteotropic drugs on bone regeneration [3, 8, 9, 10, 30]. The researchers contributed to the study of the processes of regeneration of the cellular process of the jaws of experimental animals, on the processes of local resorption, under the influence of osteotropic drugs. A month after the experiment began, complete regeneration of bone plates was noted on almost all the damaged bone tissue, and only in some places narrow bands or islets of cartilage remained. The authors do not describe the quality of cortical layer formation, which makes it impossible to compare the results obtained, but it does open a proper discussion about the concentration and active ingredient of osteotropic drugs.

The results of the original study of ultrastructural changes in bone tissue and periosteum after gunshot and non-gunshot injury to the jaws in rats in the experiment [23] are available, which are presented only on day 7, with proper detail and conclusions, in particular, after gunshot injury, the periosteum shows signs of productive inflammation with connective tissue edema, with the accumulation of a large number of cells of histiogenic origin and with the localization of capillaries between them and the activation of osteoblasts. The bone is being actively restored.

Developing the discussion on the impact of autologous grafts, which are obvious and important for tissue engineering, on the quality of bone formation, the authors give an example of the use of autologous pulp progenitor cells derived from milk or permanent teeth [35], which is a promising source for engineering not only dental tissues. These cells are easy to isolate, easy to propagate in vitro, and ethically unobjectionable, making them an attractive model system for a variety of research applications. At the same time, the lack of universally recognized markers remains a serious problem in the isolation of such stem cells, and there is no standardized method for their isolation or purification. Such an interpretation limits clinical implementation, indicates low ergonomics of the technique, and does not provide confidence in the control of DBG, respectively, and in the final result.

We agree with the conclusions of the authors [34], who described the use of allogeneic bone implants saturated with mesenchymal stem cells (MSCs). Injections of allogeneic MSCs together with allograft immediately after bone injury, regardless of age, caused signs of slowed

bone formation and excessive connective tissue formation, so the combination of allogeneic MSCs with an allogeneic bone implant is inappropriate to use fresh.

We understand that autografts have better biological characteristics, but their scope and application are limited, primarily due to the somatic pathologies of the donor-recipient.

P. R. Verma et al. in their paper [33] provide projects for regional problem solving, which, in our opinion, is a favorable national solution. After all, the need for a skeleton arising from growing clinical demands is compensated by the use of different origin (auto-, allo-, xeno-) grafts and reduces the quality of the biological basis of the body's bone.

Thus, the objective, structured assessment according to clinical protocols presented in our study is a one-step combination of rehabilitation techniques for patients with bone tissue atrophy caused by the loss of the masticatory group of teeth and complicated by the topographic and anatomical features of the mandibular canal(s), which is a reliable and evidence-based clinical basis for the preparation of a treatment plan and a proper prognosis of preservation of the functional state, including the morphological characteristics of the newly formed bone tissue.

Conclusions

1. Complete bone and tissue repair of the cortical layer of the human mandible is not completed within the generally interpreted time frame of 3-4 months of the post-augmentation period.

2. Post-augmentation bone tissue formed by the technique of controlled autocellular transplantation using bone allograft filler on edentulous distal segments of the human mandible of various degrees and forms of their atrophy, according to histo-morphometric assessment, is 92.80 % of the qualitatively formed cortical bone area within the post-augmentation period of 6 months.

3. The process of regeneration of the bone tissue of the human mandible, under conditions of preservation of the post-extraction socket of the tooth, using the Endoret PRGF technique (without bone replacement materials), ensures the formation of the cortical layer in the postoperative period within 10 months by 81.30 %.

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ГІСТО-МОРФОМЕТРИЧНА ОЦІНКА ПОСТАУГМЕНТАЦІЙНОЇ КІСТКОВОЇ ТКАНИНИ НИЖНЬОЇ ЩЕЛЕПИ ЛЮДИНИ

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Клінічним викликом сьогодення є відновлення біологічної структури атрофованої кісткової тканини, під час поєднання методів комплексної клінічної реабілітації, тобто, внутрішньо-кісткової імплантації та аугментації, на її міжімплантаційних ділянках. Мета дослідження – гісто-морфометрична оцінка постаугментаційної кісткової тканини за комбінованою методикою керованої аутоклітинної трансплантації з використанням кісткового аллонаповнювача, на беззубих дистальних сегментах нижньої щелепи людини з різним ступенем та формами їх атрофії. Як матеріал дослідження в роботі використано трепанбіопсійні зразки, після мікротомічної обробки яких проведено підготовку гістологічних скелець, з подальшим застосуванням прискореної методики забарвлення-фіксації зрізів за Май-Грюнвальдом (Sigma-Aldrich, Сент-Луїс, США). Для гістоморфометричного дослідження забарвлені гістологічні препарати постаугментаційної кісткової тканини знімали камерою оптичного мікроскопа (Leica DMLB, Німеччина). Аналіз проведений за допомогою інформаційного програмного забезпечення «Fiji», з формуванням реконструкційних мозаїчних цифрових мікрофотографій для подальшої гістоморфометрії. Результати оцінки керованого формування кісткової (постаугментаційної) тканини, що є ключовими завданнями, новизною та обґрунтуванням сучасних й ефективних методик реабілітації пацієнтів із набутими формами атрофії на беззубих дистальних сегментах нижньої щелепи людини, ілюстровані мікрофотографіями та деталізовано подаються в даній роботі за відсотковим співвідношенням якості зшивання кортикального шару. Коефіцієнт співвідношення новоутвореного кортикального шару кісткової тканини до загальної площі дослідження постаугментаційної тканини склав 61,30 %, при латеральній формі атрофії (за J. Cawood та R. Howell: клас IV), у постаугментаційний період 4 місяці. Гісто-морфометрична оцінка якісно сформованої кортикальної кістки у терміни постаугментаційного періоду шість місяців складає 92,80 % від загальної постопераційної площі. Тому, проводити оцінку якості сформованої кістки на нижній щелепі, у загально прийнятому усередненому терміні чотирьох місяців, є необ`єктивним рішенням, хоч параклінічна денситометрія визначає позитивні значення.

Ключові слова: *атрофія кісткової тканини, морфометрія, аугментація, нижня щелепа, людина.*

Author's contribution

Oshurko A. P. – work concept and design, data collection and analysis, writing the article, critical review.
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