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Methods of socket preservation: literature review

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Abstract:
Aim. To analyze different methods of socket preservation. This procedure plays important role in the placement of implants, since due to this procedure, the bone that was left after the tooth extraction is going to be preserved. Also this procedure promote bone formation that is very significant for the reliable placement of implants.
Materials and methods. Was produced the study of the publications from PubMed, Cyberleninka , Google Scholar during the systematic review of the literature.Selected and included articles, the content of which concerns different methods of the socket preservation and their role on the bone tissue .
Results: 78 publications were reviewed. After analyzing the literature for inclusion criteria, the total number of publications has become 50.
Conclusions. According to the analyzed data, there are different methods of the socket preservation that lead to a successful result. However there are some methods that lead to a deterioration result for some patients. Therefore, at this moment investigating different methods of the socket preservation is not ended.

Keywords: methods of conservation, preservation, alveolar socket.

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Методы консервации лунки: обзор литературы

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Резюме:
Цель. Проанализировать различные методы сохранения объема лунки. Эта процедура играет важную роль при установке имплантатов, так как благодаря ей сохраняется кость, оставшаяся после удаления зуба. Также эта процедура способствует формированию костной ткани, что очень важно для стабильной установки имплантатов.
Материалы и методы. В ходе систематического обзора литературы были изучены публикации из PubMed, Cyberleninka, Google Scholar. Отобраны и включены статьи, содержание которых касается различных методов сохранения гнезда и их роли на костную ткань.
Результаты. Было проанализировано 78 публикаций. После анализа литературы на предмет критериев включения общее количество публикаций составило 50.
Выводы. согласно проанализированным данным, существуют различные методы сохранения гнезда, которые приводят к успешному результату. Однако есть и такие, которые приводят к ухудшению результата у некоторых пациентов. Поэтому на данный момент изучение различных методов сохранения гнезда не закончено.

Ключевые слова: методы сохранения, консервация, альвеолярная лунка.

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INTRODUCTION

Dental implantation is one of the methods for restoring dentition defects. However, this procedure is not always in demand due to cost. But along with the material component, the technical component also plays a significant role, namely bleeding, postoperative pain, unsuccessful integration of the implant, the likelihood of infection during surgery, as well as the biocompatibility of the implant .

However, there are certain indications before installing an implant:

1. Unilateral and bilateral end defects of the dentition;
2. Included defects of the dentition;
3. Complete absence of teeth in the upper and lower jaws;
4. Single defects (missing one tooth).

But there are also contraindications, which are divided into general and local. General contraindications are determined during anamnesis, and local ones – during a dental examination, using examination methods such as external examination, examination of the oral cavity, percussion, palpation, measurement, as well as the use of additional examination methods (cytology, radiography, thermometry, electroodontodiagnostics and others).

General contraindications:

1. Chronic diseases in the stage of decompensation;
2. Diseases of the endocrine system;
3. Systemic diseases of the bone and hematopoietic systems;
4. Allergic reactions to medications and dental materials;
5. Mental disorders;
6. Smoking;
7. Bruxism.

Local contraindications:

1. A pronounced degree of atrophy of the bone tissue of the alveolar crest, deep undercutting of the lower jaw, preventing the installation and reliable fixation of the implant;
2. Violation of the structure of bone tissue, neoplasms and inflammatory processes in the surgical area;
3. Pathological abrasion of hard dental tissues with a decrease in bite height;
4. Deformation of the jaws, including dentoalveolar lengthening with a decrease in the interalveolar distance of less than 5 mm;
5. Recurrent disease of oral mucosa;
6. Poor oral hygiene;
7. TMJ diseases .

As you can see from the above contraindications, problems with bone tissue significantly affect the installation of the implant. However, there is such a procedure as tooth socket preservation, which consists of preserving the bone after tooth extraction in order to preserve as much of the remaining bone as possible, which will serve as a support for placing an implant. This article describes several methods for preserving the tooth socket, which not only preserve the bone remaining after tooth extraction, but also promote osteogenesis.

AIM

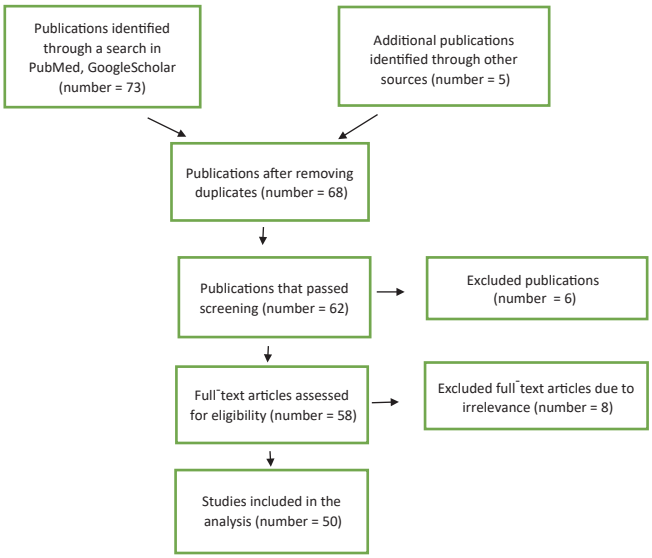
Analysis of articles on methods of preservation of tooth sockets, as well as identification of positive and negative side effects after this procedure.

MATERIALS AND METHODS

Publications in the electronic databases PubMed, Cyberleninka, Google Scholar were studied during a systematic review of the literature. Included are articles whose contents relate to data regarding various methods of tooth socket preservation and their effects on bone tissue.

Search terms included “methods of conservation”, “preservation”, “alveolar socket” (Tab. 1).

Table 1. **Article selection process [14].**



The eligibility of articles was assessed in several stages. At the first stage, an analysis was made of the title of the publication and the date of its publication in the publication (no later than 2008). Next, a summary and main topics covered in the article were discussed. At the last stage, the full-text versions of the selected articles were reviewed.

Publications were included based on the following inclusion criteria:

1. Articles dated and later.
2. Studying the relevance of data on tooth socket preservation methods.
3. Consideration of factors influencing the effectiveness of bone tissue preservation of various methods of tooth socket preservation.

We used data from the Cochrane Collaboration to assess the risk of bias [15,16], and tests were performed at each stage of selection, according to Higgins et al [16]. The levels of bias are as follows:

- low risk if all criteria are met;
- low risk when all criteria are met;
- moderate risk in the absence of only one criterion;
- high risk in the absence of two or more criteria;
- unclear risk, with few details available to enable a decision to be made regarding a specific risk assessment.

RESULTS

28 articles were reviewed, of which 26 were from the PubMed database, 1 from Google Scholar and 1 from Cyberleninka. Having made a selection according to exclusion criteria, the final number of papers was 11. In the selected articles, current data on methods of tooth socket preservation were analyzed.

DISCUSSION

Implantation failures can occur when there are general and local contraindications, such as:

- hormonal disorders;
- allergic reactions to dental materials;
- chronic diseases;
- problems with bone tissue.

Problems with bone tissue can occur after tooth extraction, since this operation is traumatic, because complications such as:

— Fracture of the crown or root of the tooth being removed.
— Damage to the crown, dislocation or removal of an adjacent tooth.
— Damage to the crown of the antagonist tooth.
— Pushing the tooth root into soft tissue.
— Fracture of a section of the alveolar process.
— Fracture of the tubercle of the upper jaw.
— Damage to the gums or soft tissues of the oral cavity.
— Dislocation of the lower jaw.
— Fracture of the lower jaw.
— Perforation of the floor of the maxillary sinus.
— Pushing the tooth root into the maxillary sinus.
— Damage to the inferior alveolar nerve.
— Pushing the root into the mandibular canal.
— Aspiration of a tooth or root.
— Bleeding.

Complications can also arise after removal:

1. Bleeding (primary, later and secondary).
2. Alveolitis.
3. Limited osteomyelitis of the socket.
4. 4.Sharp edges of the alveoli.
5. Exposure of the alveolar area.
6. Neuritis (neuropathy) of the inferior alveolar nerve .

However, to place an implant, it is necessary to have a bone support. In order to preserve the remaining bone after tooth extraction, which is necessary for further installation of an implant, there is a procedure called “tooth socket preservation.” Moreover, there is now evidence that this manipulation is effective before implantation, and also that not performing this procedure after tooth extraction will lead to the formation of connective tissue at the extraction site, which cannot replace bone tissue [18]. Therefore, carrying out preservation of the tooth socket is an important component during the period of removal and installation of the implant.

After analyzing scientific articles, we can conclude that there are many methods that not only preserve the bone remaining after tooth extraction, but also stimulate osteogenesis.

Comparison of the healing process of the tooth socket with the help of bisphosphonates and with the help of parathyroid hormones.

The article [4] describes an experiment in which the research material was rats (30 rats). They had their left and right second molars of the upper jaw removed, after which they were divided into three groups: the first group (parathyroid hormone was administered subcutaneously daily at a dose of 80 mcg/kg for 10 days); second group (bisphosphonate was administered subcutaneously every 2 days at 0.1 mg/kg per week for 10 days); control (saline solution was administered).

The highest bone mass was detected in the first and second groups. However, it is worth noting that the principle of action of bisphosphonates with the action of parathyroid hormones is different. Bisphosphonates inhibit bone resorption, which has a negative effect on both hard and soft tissues, since the synthesis of new tissues is also suppressed. And parathyroid hormones stimulate osteogenesis, which improved the condition of not only hard but also soft tissues.

Transplantation of bovine bone as a restorative material

The article [5] describes a case: a patient had a tooth removed, but bone resorption was discovered. In order to install an implant, the bone must be restored and the implant must be stable. For this purpose, bovine bone was taken mixed with saline solution. However, a collagen membrane was previously placed in order to protect the gum located around the defect. The implant was installed 6 months after the procedure. Thus, this method of alveolar socket regeneration is quite effective as it minimizes bone resorption, but this method has some technical difficulties due to the installation of a collagen membrane.

Preservation of the alveolar socket using autogenous bone material.

The article [19] describes a method for restoring the alveolar socket in patients after tooth extraction (one molar or premolar) using autogenous material. A total of thirteen patients were recruited. Ten patients were men and three were women, with a mean age of 54 years (range 44 to 66 years). Criteria were put forward that indicated what was necessary and what was prohibited in order for the patient to take part in this procedure.

Inclusion criteria were as follows:

1. Cases of removal of one premolar or molar
2. Bone destruction after tooth extraction
3. When the residual bone height is less than 4 mm to the sinus floor or inferior alveolar canal after tooth extraction
4. Patients who are generally healthy or have controlled systemic disease (ASA I or II)

The exclusion criteria were as follows:

1. Smoker
2. A patient who has had a bone graft placed at the site to be operated on
3. Patient who received radiation therapy
4. Patient with a history of sinus disease or symptoms
5. Patient with acute infection

A tooth that could not be restored was removed and used as a restorative material. The extracted tooth was kept in a sample bottle containing 75% alcohol and kept refrigerated or frozen. The dentist requested either a powder form of AutoBT (0.5 to 1 mm particle size) or a block form, depending on the purpose of the procedures. For AutoBT processing, the anatomical coronal part of the tooth was excised after removing the attached soft tissue. Remaining soft tissue and contaminants were removed with distilled water. The washed autograft was then dehydrated, defatted and lyophilized. It was then sterilized with ethylene oxide gas, packaged and sent to the hospital, which requested treatment. The block mold was made by the same method as the powder mold, without grinding, which allowed the original shape of the tooth root to be preserved. However, sometimes, because the defect was larger than the amount of material, the doctor used an allograft, but in the end, it did not worsen the results of the study.

After adding the material, it was necessary to monitor how long it would take to heal. Healing time ranged from 2 to 7 months. Next, an implant was installed, the healing period of which ranged from 2 to 5 months.

Thus, this technique is also quite effective in the matter of socket preservation.

The use of palatogingival flap and absorbable membrane in the procedure of alveolar socket preservation.

This article [6] states that patients who required implantation were divided into two groups in order to restore the alveolar socket. The first group had the socket restored using a palatogingival flap, and the second group – using absorbable collagen membranes. It is worth noting that

during the process of implant engraftment, complications were discovered (divergence, peri-implantitis), which were easily eliminated. It is worth noting that the use of absorbable collagen membranes was applied to the anterior group of teeth to maintain aesthetics. As a result, all installed implants were implanted. Thus, these techniques are suitable for alveolar socket preservation.

The use of super active platelet lysate as a stimulating substance for the healing of the alveolar socket

The article [7]: 36 rats were divided into two groups: the first group of mice (18) – after tooth extraction, they were injected with super active platelet lysate; the second group (18) – control group, after extraction, 2 ml of saline was injected. According to the MRI results, it was concluded that in the first group, bone tissue deposition was noticed 10 days after tooth extraction, but in the control group there was no such bone volume as in the first group. However, it is worth noting that superactive platelet lysate stimulates the inflammatory process in the early stages of tooth extraction, which accelerates the healing process of soft and hard tissues. But already in the later stages, there is no difference in the rate of bone formation between the two groups. Thus, super active platelet lysate can be used as a method of socket preservation, but it will only be effective for the first time after tooth extraction.

Application of the material "LitAr" on an alginate basis for the preservation of the tooth socket.

The article [1] describes two clinical cases:

First: a patient had teeth 1.3, 1.2, 1.1, 2.1, 2.2, 2.3 removed due to generalized periodontitis of the upper jaw teeth of the 3rd degree. the depth of the periodontal pockets of the teeth being removed ranged from 4 to 7 mm. After the teeth were removed, the LitAr material was placed into the alveolar sockets of these teeth. It has hemostatic properties, which prevented bleeding. Next, the wounds were sutured with suture material. After 6 months, a restored alveolar cortical plate could be seen on computed tomography. Thus, this clinical case proves that the LitAr material stimulates bone formation.

Second: the patient had tooth 3.8 removed due to horizontal tilt, as well as distal contact with tooth 3.7. It is worth noting that after tooth extraction, a simultaneous implantation was carried out using the LitAr material. After 7 days, an examination was carried out, during which it was noted that there was no inflammation, the edges of the wound were completely closed, and the patient also noted that the pain disappeared 48 hours after the operation.

Thus, this clinical case also confirms that the LitAr material can be used as one of the methods for preserving the alveolar process.

The influence of red and infrared lasers on the process of socket healing

The article [8] describes an experiment that examines the use of a laser as a stimulator of socket healing. 40 male rats were taken and divided into 4 groups: the first group was injected with saline; the second group received alendronate; the third group was administered alendronate and used red (wavelength 660 nm) radiation, and the fourth group was administered alendronate and used infrared (wavelength 830 nm) radiation. Alendronate is a drug that is an inhibitor of bone resorption (suppresses the activity of osteoclasts, stimulates osteogenesis). The lower first molars were removed 60 days after the start of drug administration. The radiation was carried out after tooth extraction (7 sessions, the interval between sessions was 48 hours). To evaluate the experiment, computed tomography was performed, as well as histometical analysis. If we compare the groups, the second group had more bone than the first, however, this bone was mostly necrotic. Alendronate does not affect the structure of the formed bone. However, in the third and fourth groups the number of vital bone formations was much greater than in the second group. Also in the fourth group the bone was denser.

Thus, we can conclude that red and infrared radiation helps restore the tooth socket.

The effects of bisphosphonate on socket healing in patients with radiological and hematological features

The article [9] describes an experiment aimed at identifying such a side effect of a bisphosphonate as osteonecrosis of the jaw. Two groups of patients taking bisphosphonate were identified. The first group had osteonecrosis of the jaw as a side effect; the second group was without osteonecrosis. Conduct laboratory tests: ESR, glucose, C-terminal telopeptide of type I collagen, parathyroid hormone, general blood test. There were also x-ray studies: a periapical x-ray and a panoramic x-ray were used.

It was found that in the first group there were often patients with anemia, leukocytosis, and smokers. And in the second group there were patients with problems with the gastrointestinal tract. The X-ray showed that in the first group the signs of osteolysis and bone sclerosis were much more common than in the second group. Laboratory tests showed that in the first group there was an increased level of alkaline phosphatase, which indicates a problem with the bones. However, the blood, calcium and phosphate tests were virtually the same. It is also important to mention that the bisphosphonate was administered to the first group intravenously, while the second group was administered orally. Thus, it is difficult to identify any one cause of osteonecrosis of the jaw as a side effect of taking a bisphosphonate, as the results show that this is a multifactorial problem.

The influence of pamidronate (second generation bisphosphonate) on maintaining the size of the alveoli after tooth extraction.

In the article [10], mini pigs (pigs) from which the premolars of the lower jaw were removed were taken for the experiment. Using a piezoresistor, the teeth were loosened and then removed. After extraction, two animals had their socket preserved using BEGO OSS (an osteoplastic material; BEGO OSS is a hydroxyapatite ceramic containing interpenetrating, communicating macro- and micropores, which is obtained from bovine cancellous bone tissue in a multi-hour process at high temperatures (T > 1200°C) and three animals with BEGO OSS + Pamithos (15 mg).

The result of this study was that in the second group, which was administered pamyphos along with BEGO OSS, it was observed that the bone was preserved better than in the first group. Thus, the combination BEGO OSS + Pamiphos can be used as a method of socket preservation.

Oxytocin as a stimulator of bone formation during the healing process of the tooth alveolus

The article [11] states that rats were taken and divided into 2 groups. The first group was injected with saline, and the second group was injected. 7 days after the administration of various injections, the maxillary incisor was removed. Then injections were also administered for 28 days.

RESULTS

Although the concentrations of calcium and phosphorus in the blood did not differ in the two groups, biochemical markers of bone formation were significantly higher in group number 2 (oxytocin was administered). In addition

to biochemical evidence, histomorphometric analyzes also confirmed that the rate of bone formation was much higher in the second group. Thus, it has been proven that oxytocin promotes bone formation.

The use of demineralized osteoplastic material in the preservation of sockets of extracted teeth.

The article [2] describes a clinical case in which, after tooth extraction, the tooth socket was preserved with a domestic preparation Xenograft Collagen. The peculiarity of this drug is that it is able to purify the osteoplastic matrix from various components, such as lipids, non-collagen proteins, fragments of cell membranes, which allows you to preserve bone tissue in its native state, as well as improve cell adhesion and improve vascularization. This material is also sterilized, which plays an important role in various invasive procedures. The final stage of treatment is decalcification of the bone matrix to expose growth factors.

The authors of the article operated on 11 patients who, after extraction surgery, used the Xenograft collagencollagen material to preserve the tooth socket. After 4 months from the moment of removal, a computed tomography was performed, in which a segmental mask was modeled, which made it possible to evaluate the resulting volume, the architectonics of the regenerate, and the average value of its density. The results of this study were as follows: the postoperative period passed without complications throughout its entire duration. It is worth noting that a bone block was previously taken from the regenerated area in order to further study the structure of the resulting bone. When comparing the obtained result with the original one, it was concluded that these drugs did not differ from each other. Also, histological examination showed the absence of inflammation, complete osteogenesis at the edges of the bone block. Newly formed blood vessels are seen. Thus, Xenograft collagen promotes the formation of a regenerate similar to natural bone.

Application of various methods of tooth socket preservation and their comparison

The article [3] describes an experiment conducted on dogs. They removed the distal roots of the third and fourth premolar of the mandible. Next, 4 groups were nominated: the first group – treatment was carried out using the Bio Os collagens material; second group – treatment was carried out using Bio Oss collagen material, and a soft tissue graft was also used; in the third group, no treatment was carried out: in the fourth group, a collagen membrane was installed on the buccal side of the tooth under study, and Bio Oss collagen material was also added. The results of this study showed that the first three groups showed a decrease in contour on the buccal side. In the fourth group, measurements were not possible. It is worth noting that in the third group, the reduction in buccal contour was significantly different from the first two groups. Thus, this study found that it is not always possible to achieve complete healing and preservation of the alveolar socket, since the Bio Oss collagen material prevents bone resorption, but shrinks.

Methods for preserving the tooth socket using directed (controlled) tooth regeneration and filling it.

The article [20] describes a study whose purpose is to analyze which of the methods: directed regeneration of the tooth socket (goal: to create a barrier over the bone defect, which will allow mesenchymal cells with fill the defect with osteogenic potential); filling the tooth hole. Patients who had a single-root tooth removed were randomly distributed into three different groups: the first group – guided tooth regeneration; second group – tooth socket was filled; the third group is the control group (without intervention). Bio-Oss material was used as a filling material in the first two groups.

4 months after the manipulations, a CBCT scan was performed. This study showed that in the first two groups the height of the alveolar process increased, while in the control group, on the contrary, the height decreased. However, it is worth noting that all patients were able to undergo implantation. The difference was the need use of additional bone material. Additional bone material was used in all three groups, the only difference being the number of patients requiring this procedure (there were more patients in need of this procedure in the third group). Thus, despite the fact that implantation was carried out in patients from all three groups, this procedure was more effective for patients in the first two groups, since the height of the alveolar process is of great importance for implantation. Therefore, filling the socket or targeted regeneration of the tooth socket promotes better bone preservation than in the control group, and also stimulates osteogenesis, which is important before installing an implant.

Evaluation of the use of platelet-rich fibrin as a material to promote the preservation of the alveolar socket of the tooth

Articles [17,21,28-33,45,47] describe studies aimed at determining the effectiveness of platelet-rich fibrin in the healing process and bone genesis.

Articles [21,30] analyzed articles on the topic of socket preservation using platelet-rich fibrin. The results of the tests showed that this technique is effective in socket preservation, as it helps preserve the remaining bone, stimulates the synthesis of new bone, and also accelerates the regeneration of soft tissues. However, the effectiveness in the synthesis of new bone is controversial, since not all studies have followed this dynamics. The article [28] describes the effectiveness of the regenerative ability of soft tissues by platelet-rich fibrin in smokers. Participants in this study had to meet the following criteria:

— They must be a current smoker (10 or more cigarettes per day);
— At least 21 years of age;
— They had their upper molar removed;
— The hole must have a four-wall configuration/

Study participants were randomly assigned to 4 groups:

Group 1 – platelet-rich fibrin was used;

Group 2 – adhesive bone with autologous fibrin glue was used in combination with lyophilized bone allograft, corticocancellous mixture and platelet-rich fibrin membrane;

Group 3 – used lyophilized bone allograft, corticocancellous mixture and collagen membrane; group 4 – a collagen plug was used.

As a result, faster regeneration of soft tissues was observed in the first group and in the second group the regenerative ability was faster. Moreover, in these groups there were fewer complications (swelling, pus), and participants in these groups complained less about postoperative pain.

Thus, despite the fact that all patients were smokers at the time of the study, nicotine has an adverse effect on the healing process of soft tissues, as well as on the tissue itself. Therefore, the use of platelet-rich fibrin improved and accelerated the healing process in this group of patients.

The article [29] describes a study that also tested the effect of platelet-rich fibrin. Two groups were distinguished: the first group, a fibrin membrane rich in platelets was installed after tooth extraction; group 2 (control) – no membrane was

installed after tooth extraction. There were 28 participants in total, 14 in each group.

The result of this study showed that in the first group, the rate of soft tissue regeneration was higher than in the control group, and histological examination indicated that the amount of bone mass increased in the experimental group, which suggests that platelet-rich fibrin stimulates osteogenesis.

The article [31] also reviewed the literature on the role of platelet-rich fibrin in the treatment of musculoskeletal injuries. The results are also ambiguous, since some sources indicate that this technique is effective in the healing process of injuries, while others do not. The author of the article suggests that the difference in results is explained by differences in the material, as well as the ratio of cellular components in it.

The article [32] describes a comparison of stimulation with platelet-rich plasma and modified osteoblast plasma. Since platelet-rich plasma is a fairly popular technique for stimulating healing, there are exceptions when the proper result is not observed, which is associated with the additional use of anticoagulants that inhibit wound healing. In this way, a modified plasma was created that did not contain additives and was also created at low centrifugation speeds. After conducting an experiment, which consisted of testing the rate of migration of osteoblasts, it was noticed that the rate of migration of osteoblasts with modified plasma was higher than with plasma that included additives. Thus, modified plasma can give more positive results after tooth extraction for the purpose of preserving the tooth socket, as well as regenerating soft tissues.

The article [33] describes an experiment in which platelet-rich plasma was used along with lyophilized bone allograft to evaluate the effectiveness of using a combination of the two substances. However, the results of this study did not show a significant difference between the use of platelet-rich plasma alone and plasma with lyophilized bone allograft. The only difference was that when using plasma with a bone allograft, it was possible to obtain more vital bone formations. Therefore, the use of platelet-rich plasma with lyophilized bone allograft is a good alternative method for tooth socket preservation.

The article [45] describes a method for using fibrin, rich in leukocytes and platelets, to preserve the tooth socket. After tooth extraction, the patient was given a membrane made of fibrin, rich in leukocytes and platelets. After 3 months, the implant was installed, and the material was taken for histomorphometric analysis. The result of this study confirmed the effectiveness of the plasma used as a material for preserving the tooth socket.

The article [47] describes the use of platelet-rich fibrin with bovine hydroxyapatite to improve the effectiveness of dental socket preservation. Study participants had two teeth removed according to indications. Conservation material was added to one of the wells, but not to the other. This study, like previous ones, confirmed the effectiveness of using a combination of bovine hydroxyapatite with platelet-rich fibrin.

The article [17] analyzed the literature on the topic: the use of autologous fibrin, rich in platelets, as one of the methods for preserving the tooth socket. The result of this review showed that this technique is not only effective in the matter of conservation, but also cheap.

The use of demineralized bovine bone as a method of preserving the tooth socket

Articles [22,36] describe methods of using bovine bone to preserve the tooth socket.

In the article [22], the authors set the task of comparing demineralized bovine bone with autologous bone (bone was taken from the branch of the lower jaw) . After tooth extraction, 2 groups were divided: in the first, demineralized bovine bone was used, and in the second, autologous bone was used. The results of this study are as follows: no significant differences in the effectiveness of these two methods were identified. However, it is worth understanding that harvesting autologous bone complicates the treatment process, as it requires additional intervention. Therefore, in this case it is impossible to give preference to a specific method, since both are effective, but there are also minor difficulties.

The article [36] describes a technique for socket preservation using mangosteen peel in combination with demineralized bovine bone. Namely, the process of stimulation of osteoblasts, type 1 collagen, and osteocalcin with these materials was considered. The result of this study showed that after using these materials, after 7 days, and after 30 days, an increase in the formation of osteocalcin, type 1 collagen, as well as osteoblasts was noticed, which indicates that the process of socket preservation intensified.

Application of Bio-Oss material for tooth socket preservation

The article [23] describes an experiment conducted on dogs. The teeth were removed. Next, the dogs were divided into 2 groups: the first group did not receive treatment (control group); the second group received Bio-Oss material after removal. Twelve weeks after tooth extraction, the resulting bone was analyzed. In the group treated with Bio-Oss material, there was a larger volume of bone formed. Thus, this study proved that Bio-Oss material can be used for preservation of the alveolar socket of the tooth.

Preservation of a tooth socket using dentin mixed with a xenograft

The article [24] describes a technique for preserving a tooth socket using dentin mixed with a xenograft (Bio-Oss material). The result of this study showed that this combination promotes greater bone formation than the use of Bio-Oss material alone.

Comparison of the use of polytetrafluoroethylene membranes with and without xenograft

In the article [25], an experiment was conducted in which 2 groups were distinguished: the first group after Tooth extractions were treated only with a polytetrafluoroethylene membrane, while the second group received not only a membrane, but also Lumina Bone Porous. The result of this study showed that in the second group there was less loss of bone tissue, and also better results in the height of the tooth socket.

Use of an autogenous graft for the preservation of the tooth socket

Articles [26,27,42] describe various experiments related to the study of the use of an autogenous graft for the preservation of the tooth socket.

The article [26] describes a technique for preserving a tooth socket using an autogenous graft (the patient's own teeth). Two groups were divided: in the first group, healthy teeth were used as a graft; in the second group – teeth that underwent endodontic treatment. The teeth were transformed using the TT Transformer medical device. The result of this study confirmed that autogenous material can be used to preserve the tooth socket, as it promotes healing without complications.

The article [27] conducted an experiment on dogs. The result of the experiment showed that autogenous material can be used as a material for preserving the tooth socket.

The article [42] compared two materials for tooth socket preservation, namely autogenous graft and beta-tricalcium phosphate alloplast. Histological analysis showed the best results for the autogenous transplant. In addition to histology, when determining the width and height of the alveolar process, the results of autogenous material also turned out to be the best. Thus, autogenous material is a good replacement for allogeneic material in the matter of preserving the tooth socket.

Preservation of the alveolar process of the tooth using an epigenetic modulation scaffold made of chitosan.

The article [34] describes a study conducted on rats. Biphasic chitosan calcium phosphate enriched with trichostatin A was proposed as a preservative material. Histomorphometric and histological analyzes showed bone growth in the area where this material was applied. Thus, this technique can be used for tooth socket preservation.

Using stem cells as one of the methods for tooth socket preservation

Articles [35,50] discuss the effectiveness of stem cells in a procedure such as tooth socket preservation.

In the article [50], an experiment was conducted, the essence of which was to evaluate the healing of the socket with the participation of stem cells and without them. The result of this study showed that the healing process of the socket was better with the participation of stem cells, as they contributed to the preservation of the width of the alveolar process after tooth extraction.

The article [35] analyzed articles on the role of stem cells in the process of socket healing. The result of this analysis is as follows: bone synthesis is observed histologically and radiologically after the use of stem cells. However, this topic is controversial and requires further research.

Use of combined collagen material for tooth socket preservation

The purpose of the study in the article [37] is to evaluate the use of combined collagen material for tooth socket preservation. Two groups were divided: the first group – after tooth extraction, treatment was carried out using a collagen cone and membrane; second group – no treatment was carried out. The results of this study indicate that in both groups there is a decrease in bone mass, but in the first group there is less resorption. Thus, the use of a collagen membrane and cone helps to reduce bone resorption after tooth extraction, but not the synthesis of new one.

Role of Moringa oleifera leaf extract in combination with demineralized freeze-dried bovine bone in tooth socket preservation

In the article [38], an experiment was conducted on Cavia cobaya guinea pigs. Four groups were divided: the first group, after tooth extraction, treated the socket with polyethylene glycol; the second group – demineralized lyophilized bovine bone xenograft; the third group – Moringa oleifera leaf extract, and the fourth – a combination of Moringa oleifera leaf extract with demineralized lyophilized bovine bone xenograft. The result of this study showed the best result, namely the effectiveness of the synthesis of osteocalcin and TGF-β1, in the fourth group. Therefore, the use of a combination of Moringa oleifera leaf extract with demineralized freeze-dried bovine bone xenograft can also be used as a method of tooth socket preservation.

Application of beta-tricalcium phosphate as a material for tooth socket preservation

The article [39] describes an experiment in which 40 patients took part. There were 2 groups of 20 people each: control group (no treatment was carried out after tooth extraction); experimental (beta-tricalcium phosphate was used). The result of this study showed that the height of the buccal and lingual plates changed in the experimental group. Thus, this technique, the use of beta-tricalcium phosphate, is involved in the preservation of the remaining bone and in osteogenesis.

Use of laser for socket preservation

The article [44] describes a method whose purpose is to analyze the effectiveness of laser in healing infected areas of the tooth socket. Histologically, it was revealed that the laser stimulated osteogenesis due to the expression of osteocalcin. In summary, this study demonstrated that the erbium-doped yttrium aluminum garnet laser, which was used in this experiment, can be used for tooth socket preservation.

The article [48] also studied the role of laser in socket healing after tooth extraction. Two groups were divided: control group – no treatment was expected; experimental – erbium and neodymium lasers were used. The result of this study showed that in the experimental group, there was no swelling, no bleeding, and no patients complained of pain throughout the study, while in the control group, both swelling and bleeding were observed. In addition to these data, histological data indicate that the experimental group had denser bone tissue. Thus, we can conclude that laser is one of the methods for preserving the tooth socket.

The article [12] talks about the effectiveness of using high-intensity laser therapy in combination with photobiomodulation as one of the methods for healing the tooth socket. This study was conducted on rats. Three groups were identified: the first group – after tooth extraction, a combination of photobiomodulation and diode laser was used; in the second group, photobiomodulation and carbon dioxide laser were used; the third group did not receive laser treatment (control group). The results were taken into account on the following days after tooth extraction: 3,5,7,10,21. On the 21st day after tooth extraction, it was revealed that the highest height of the alveolar ridge was observed in the first two groups. Thus, this study proved that the use of a combination of high-intensity laser and photobiomodulation can be used as one of the methods for preserving the tooth socket.

The article [13] reviewed articles on the relationship between the use of laser as a stimulator of osteoblast activity. The result of this analysis showed that laser is an effective method for socket preservation, however, in order for the effect to be positive, it is necessary to take into account the wavelength as well as the amount of use. So the best effect was observed when using a laser with a wavelength above 800 nm, and the number of applications should be more than three times. however, for the effect to be positive, the wavelength as well as the amount of use must be taken into account. So the best effect was observed when using a laser with a wavelength above 800 nm, and the number of applications should be more than three times. however, for the effect to be positive, the wavelength as well as the amount of use must be taken into account. So the best effect was observed when using a laser with a wavelength above 800 nm, and the number of applications should be more than three times.

Growth factors used as a material for tooth socket preservation

In the article [41], a study was conducted to evaluate the effectiveness of autologous concentrated growth factor as a material for tooth socket preservation. Two groups were divided: the first group was experimental, the participants in this group were treated after tooth extraction with preserved growth factor; the second group was control, after tooth extraction there was no treatment. In the first group, there is an increase in tissue density, as well as in the height and width of the alveolar process compared to the control group. Thus, the use of autologous growth factor is an effective method for preserving the tooth socket.

Comparison of inorganic bone with bone xenograft in the effectiveness of tooth socket preservation

The article [40] reviewed the difference between the use of inorganic bone and bone xenograft as a material for tooth socket preservation. However, the author of the article concluded that at the moment it is difficult to compare these methods, since the results differ, which requires further study of this topic.

Use of xenogeneic collagen matrix and bone allograft

The article [43] describes a study evaluating the use of xenogeneic collagen matrix in combination with bone allograft. During the study, a tooth extraction operation was performed, after which a socket preservation method was used using a xenogeneic collagen matrix and bone allograft. All patients came for preliminary examinations to minimize complications, if any, and also to monitor the healing process. The final examination was carried out 24 weeks after tooth extraction; an increase in the width of the bone was noted, and the resulting soft tissue had the same characteristics as in a healthy person. In addition, no complications were observed during the experiment. Thus, the use of a xenogeneic collagen matrix in combination with a bone allograft is an effective method for preserving the tooth socket.

The use of 3D printing as one of the methods for preserving the tooth socket.

Articles [46,49] discuss the use of 3D frames as an alternative to bone grafts.

Article [46] talks about the properties, materials from which 3D frames are made, and also describes a clinical case in which this design was used to evaluate the effectiveness of socket healing in rats and humans. As a result, this technique was more effective in rats than in humans. The author attributes this to the material from which the frame was made.

The article [49] describes a study whose purpose was to use 3D printed nanoporous hydroxyapatite for tooth socket preservation, and compare its effect with a nanocrystalline bone graft. Thus, two groups were identified: experimental, using 3D technologies, and control. The study involved 30 patients who had a tooth removed and also had their tooth socket preserved. 4 months later, after the tooth was removed, the result was analyzed, during which virtually no difference was found between the two groups. Thus, 3D technologies have good prospects for being widely used as a method of tooth socket preservation. However, at present, this method does not show absolute results, which means that this issue requires further study.

CONCLUSION

Thus, currently there are many methods for preserving tooth sockets, which allow not only to preserve the bone remaining after removal, but also stimulate osteogenesis. This is quite important for both the patient and the dentist, since only if the bone has not atrophied after removal and is able to withstand loads, will installation of an implant be possible. Of course, some of the methods are not fully developed ([41,46,49]) or have some difficulties in implementation (in article [5] installation of a collagen matrix). However, there are many other methods that can be successfully used in medical practice.

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AUTHOR'S CONTRIBUTION

Igor A. Voronov – has made a substantial contribution to the concept or design of the article; drafted the article or revised it critically for important intellectual content; approved the version to be published.
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