REVIEW ARTICLE

CONTENTS

Retrospective analysis of the effectiveness of modern bone plastic methods in dental implantation (literature review)

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ABSTRACT

Aim: The aim of our study is a retrospective analysis of modern methods of osteoplasty in dental implantation using various combinations of autogenous and allogeneic grafts**.**

Materials and Methods: The selection of publications related to the research topic was carried out in the scientific databases Scopus, PubMed, BVS and Scielo using the following keywords: dental implantation, bone grafting, alveolar bone remodeling, dentin graft, autotransplantation. When searching for publications relevant to the research topic using, it was possible to identify 187 relevant articles. The search depth parameter was 7 years in order to ensure the analysis of the most relevant data related to the research goal. The review included original scientific articles, research results and official recommendations of medical associations, only articles with positive results in the study group. The collected materials were analyzed according to the principles of content analysis with further systematization and classification of data in CADIMA software.

Conclusions: In reconstructive surgery, autogenous bone is still considered the cornerstone in solving the most important tasks in bone grafting. Autografts from the lower jaw are successfully used, in particular, in cases of significant atrophy of bone structures, as they have predictable and reproducible results. Three-dimensional plastic surgery, which consists in transplanting thin cortical blocks in the form of overlays, provides a long-lasting clinical result and is more effective than the use of thick bone blocks.

KEY WORDS: dental implantation, bone grafting, alveolar bone remodeling, dentin graft, autotransplantation

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INTRODUCTION

Partial or complete absence of teeth is always accompanied by atrophy of the jaw bone tissue, which, when planning dental implantation, in at least 30% of cases necessitates the elimination of the alveolar bone volume deficit [1-4]. Augmentation using autogenous block graft is one of the most common and effective methods of bone tissue regeneration. In addition to its reliable fixation and optimization of the surface structure, a differentiated approach to the selection of material depending on the clinical situation also allows reducing the risk of graft "settling" [2]. Taking into account the availability of various methods of osteoplasty of defects of the alveolar processes of the jaws and a wide range of osteoplastic materials, there is currently no unambiguous solution to the problem of atrophy. Planning a specific osteoplasty technique and the selection of a graft depend on an accurate assessment of the degree of bone resorption, as well as the nature and size of the defect [3,4]. An important diagnostic value in this process is computed tomography of the jaws, which, in addition to determining anatomical features, allows you to establish the type of bone tissue, choose the optimal surgical protocol and predict the timing of osseointegration [3-6].

Prosthetics on dental implants is considered the most modern method of restoring the dentition in case of edentia. At the same time, the main problem that specialists increasingly face at the stage of planning implantation is the insufficient volume and poor quality of bone tissue in the area of the intended implantation [5]. To solve this problem, numerous methods have been proposed at different times: installation of implants bypassing the maxillary sinus [6], the use of subperiosteal implants, implantation with perforation of the floor of the maxillary sinus and others [7–9].

According to many authors, the most effective way to restore the volume of alveolar bone in the vertical and horizontal directions after tooth loss is to use the patient's own bone tissue [10]. Autotransplantation is considered the "gold standard" for restoring organs and

tissues due to structural compliance, lack of immune response, and presence of progenitor cells in the transplants [7,8,10]. The success of such manipulation largely depends on the choice of technique and type of osteoplastic material [10]. An important factor when planning autotransplantation is the morphospecificity of tissues, i.e. the fact that at the cellular level the same tissue in different organs differs in structure, cellular composition, physiological activity, and reactivity [11,12].

AIM

To conduct a retrospective analysis of modern osteoplasty methods in dental implantation using various combinations of autogenous and allogeneic grafts.

MATERIALS AND METHODS

The selection of publications related to the research topic was carried out in the scientific databases Scopus, PubMed, BVS and Scielo using the following keywords: dental implantation, bone grafting, alveolar bone remodeling, dentin graft, autotransplantation. When searching for publications relevant to the research topic using, it was possible to identify 187 relevant articles. The search depth parameter was 7 years in order to ensure the analysis of the most relevant data related to the research goal. The review included original scientific articles, research results and official recommendations of medical associations, only articles with positive results in the study group. The collected materials were analyzed according to the principles of content analysis with further systematization and classification of data in CADIMA software.

REVIEW AND DISCUSSION

The lack of functional load in the area of lost or missing teeth leads to atrophy of the jaw bone tissue. Healing of the post-extraction socket, which occurs under a blood clot, is also accompanied by natural atrophy of the alveolar bone tissue both in width and height and reaches 16-30% of the initial size with the formation of a saddle-shaped ridge [10,12]. This complicates the further implementation of dental implantation surgery and, as a result, subsequent prosthetics.

Healing of the socket of an extracted tooth is accompanied by significant spatial changes in the alveolar bone in the form of its resorption and deformation, which creates unfavorable conditions for future dental implantation and prosthetic rehabilitation. The results of the analysis of a number of literature publications indicate that autologous dentin graft, due to its morphological similarity to the cortical membranous matrix, biocompatibility, bioactivity, excellent osteoconductive and osteoinductive properties, ability to ankylose and slow resorption, is an extremely promising material for bone-plastic substitution in the practice of surgical dentistry and maxillofacial surgery [11,12].

According to researchers, bone tissue deficiency is observed in more than half of the cases [8,10]. Alveolar bone loss can occur even before tooth extraction and complicate the course of reparative regeneration at the implantation stage. In the process of preparation for dental implantation, the structure of the bone is of decisive importance, therefore it is extremely important to determine the morphological quality of bone tissue, its architectonics and density. In the clinical practice of a dental surgeon, there are various methods of increasing the volume of bone tissue, including autogenous bone block plastic, localized barrier technique, use of autogenous bone chips, and others. To eliminate horizontal and vertical atrophy and reconstruct bone tissue, the method of expanding a narrow alveolar ridge using a bone spreader, alveolar ridge splitting technique are used [10,13]. However, even with complete well-being in the postoperative period and a favorable clinical prognosis, there is a possibility of lack of complete integration in the area of the installed implants. Autogenous block plastic is a classic of bone tissue restoration, as it combines osteoinductive and osteoconductive properties. At the same time, the basis of any regeneration is timely vascularization of the graft, which should also be given great attention. Therefore, the issue of restoring the required volume of bone tissue is one of the most important and key in dental implantology [6,9,13].

Today, there are various osteoplasty techniques that solve the problem of atrophy. Some authors [14,15] describe successful implantation based on the adaptation of the intraosseous parts of the implants to real anatomical conditions by using short screw, subperiosteal implants, basal and zygomatic implant systems [7, 8,15]. Other researchers recommend performing reconstructive osteoplastic operations to create the necessary anatomical conditions [9–15]. However, with large volumes of bone grafting, it is not always possible to obtain the proper volume of bone graft without additional surgical interventions, and in some cases there is a lack of intraoral sources of cortical bone tissue to perform such an operation. The use of extraoral bone sources (tibial tuberosity, skull, iliac crest) is not always justified and involves significant invasion, after which patients temporarily lose their ability to work and are forced to be hospitalized [8,10,13,16].

The use of alternative sources of bone biomaterials could contribute to the implementation of a less invasive osteoplasty protocol. As some authors note, the most optimal biomaterial in terms of the combination of osteoinductive and osteoconductive properties after autogenous bone grafts are allogeneic biomaterials [11-16].

Intraosseous implantation occupies an important place in the comprehensive rehabilitation of patients with dentition defects [15,17]. It is well known that dental implantation is a multi-stage approach that includes bone grafting, dental implantation and possible soft tissue grafting, which, in turn, can cause a number of additional complications for the patient:

• the undesirability of using removable temporary orthopedic structures throughout the entire stage of surgical treatment, which can deepen atrophic changes and additionally overload the functional center;

• frequent use of antibacterial drugs at the stage of maintenance conservative therapy, which can lead to the development of antibiotic resistance;

• the need for repeated traumatic interventions in the surgical field, which increases the risk of intra- and postoperative complications.

In the process of preparing for dental implantation, the structure of the jaw bone is of decisive importance, therefore it is necessary to assess the morphological quality of bone tissue, its architectonics and density, as well as to identify the degree of resorption. At the stage of planning and choosing the method of surgical intervention, one of the most frequent limitations for dental implantation is insufficient thickness and height of the alveolar process [17,18]. According to a number of authors, more than 50% of patients require additional bone-plastic operations - both previously and directly at the stage of dental implantation [18]. The presence of atrophy of the jaw bone tissue significantly complicates the traditional stages of implantation, and in most cases makes it impossible without prior surgical preparation of the alveolar ridge [13,17].

In recent years, there has been a tendency to increase the number of patients with bone pathology. Among the most common etiological factors of jaw atrophy, it is necessary to single out pathology of the endocrine system, in particular diseases of the thyroid and parathyroid glands, as well as pathology of the bone tissue itself. Loss of alveolar bone can occur even before tooth extraction - as a result of unsuccessful endodontic treatment, periapical pathology or progressive periodontitis, as well as as a natural physiological process associated with periodontal rupture [4,5,11].

Damage to the periodontal ligament during tooth extraction directly triggers bone tissue atrophy due to disruption of the functional and anatomical connections between the periodontium and the walls of the alveolus, which worsens the vascularization of the area [19]. According to a number of studies, during the first 12 months after tooth extraction, the width of the alveolar ridge decreases by 50%, with two-thirds of this bone loss occurring in the first 3 months [18].

Faced with such problems, the professional community has developed a number of alternative treatment methods that involve simultaneous dental implantation and bone grafting [18,19]. However, the results of bone grafting are not always predictable. There are several key factors that determine a positive result: the absence of an infectious agent, the condition of the soft tissue segment, the reliability and stability of the fixation of the bone augmentation, adequate blood supply to the intervention area, as well as the presence of cellular growth factors and morphogenetic proteins of the graft, which initiate osteogenesis [20]. According to the literature, bone grafting is indicated in 30–80% of cases [6,12,15,17,20]. Various techniques are used to eliminate bone tissue deficiency, including the use of xenogeneic materials, homogeneous bone tissue and allografts.

METHODS OF INCREASING THE VOLUME OF ALVEOLAR BONE

To increase the thickness of the alveolar ridge, the technique of directed bone regeneration or "fencing" proposed by Professor Mauro Merli can be used. The essence of the technique is to create a space for the formation of bone tissue using a resorbed plate for osteosynthesis, previously prepared on a stereolithographic model. Prof. M. Merli used deproteinized xenogeneic bone material and autogenous bone chips in his technique. The fencing of the bone material was carried out with a bioresorbable membrane. Thus, the technique of three-dimensional augmentation allows you to create a promising form of the future alveolar ridge, restored with mixed bone material, covered with a collagen membrane that forms a protective barrier. According to the results of this study, the volume of newly formed bone tissue after 6 months was 3.39 cm^3 [15,20].

Also Prof. M. Merli and A. Mazzoni popularized the localized barrier technique, which consists in the reconstruction of small three-dimensional bone defects in two stages. In the first stage, based on computed tomography data using a stereolithograph, a titanium plate is manufactured. It is installed at a planned distance from the native bone, forming a physical barrier that holds the biomaterial necessary for regeneration, providing vertical and horizontal augmentation. The

incision is made along the lingual surface of the crest with a vestibular slope, which allows for exposure of the crest with minimal elevation of the lingual flap. Then, the titanium plate is fixed and the defect is filled with demineralized bone material (DBM) in a reverse phase medium (RPM) in a ratio of 1:1 with autogenous shavings obtained from the external oblique line of the mandible [20].

As is known, demineralized bone material in a reverse phase medium stimulates the natural processes of bone formation, in which mesenchymal cells differentiate into osteoblasts. Since the RPM medium becomes more viscous at warm temperatures, this allows the material to be plastic at room temperature and harden already in the operating field [15]. Today, the following bone grafting methods are most popular for eliminating horizontal and vertical atrophy and reconstructing bone tissue: autogenous bone block grafting, narrow alveolar ridge expansion technique using a bone spreader, alveolar ridge splitting technique, etc. [15, 16,18,20]. However, even with a successful postoperative period and a favorable clinical prognosis, there is still a possibility of complete or partial bone integration in the area of the installed implants.

AUTOGENOUS BONE BLOCK RECONSTRUCTION

Autografting is considered the "gold standard" of bone tissue restoration. Autografting allows for the restoration of bone tissue both vertically and horizontally, combining osteoinductive and osteoconductive properties. Early vascularization of the graft is extremely important to ensure a positive clinical outcome. The mechanism of bone tissue remodeling goes through three consecutive phases. Osteocytes of the cancellous bone of the graft remain viable, producing osteoid plates for 3–4 weeks, feeding diffusely from the surrounding vascular system. However, after 2 weeks, only osteocytes located within a radius of up to 300 μm from blood vessels survive, which determines the first phase of neoosteogenesis. The second phase begins approximately 6 weeks after transplantation and lasts up to 6 months; it is characterized by the destruction of graft cells and the release of growth factors and inductive proteins, which trigger remodeling of the graft by newly formed bone tissue cells. The third phase is osteoconductive, when the inorganic hydroxyapatite skeleton of the graft acts as a passive matrix for remodeling of new bone tissue with subsequent resorption of the graft. In addition, the cortical plate of the graft acts as a barrier that prevents the infiltration of connective and epithelial tissue into the recipient area [7, 12,21,22].

The indisputable advantage of the autotransplantation method is complete biocompatibility, lack of immunogenicity, and the formation of organotypic bone tissue. Autografts can be harvested from both intraoral and extraoral donor sites. However, in order to avoid additional trauma, it is more expedient to use intraoral sources - the chin of the lower jaw and the projection of the external oblique line. Cortical blocks are obtained from the external oblique area, and cortical-cancellous blocks are obtained from the submental area. The difference between them is the presence of a cancellous layer, rich in cells, which promotes faster revascularization and neoosteogenesis. As already noted, adequate vascularization of the graft is a prerequisite for successful osteogenesis [23, 24].

METHODS OF BONE AUTOGRAFT HARVESTING

Methods of graft harvesting from the submental area. The first stage is to provide adequate anesthetic support. This intervention is performed under local anesthesia in the area of the right and left submental foramina. Next, a vestibular incision is made apical to the mucogingival junction, placing the blade at a right angle. The flap is peeled to the lower edge of the chin, which creates conditions for wider wound edges and better mobilization of the mucogingival flap [18,20,24]. Then, two horizontal cuts are made with a microsaw, which are connected by vertical ones, determining the shape and size of the future autograft. A safe zone of 3–5 mm from the apices of the tooth roots should be taken into account. As a rule, the diamond disc used to perform the cuts completely dissects the vestibular cortical plate. Additional holes are made along the line of the cuts. The graft thus selected is separated with a thin chisel. Then, a scraper or chisel can be used to remove the volume of spongy tissue up to the lingual cortical plate [23-25]. To facilitate the graft collection, its fragmentation in the middle part is allowed. Closing the defect of the donor site is advisable to be carried out using a collagen membrane, which acts as an inner lining for bone chips, bone-plastic material and a non-resorbable membrane (for example, titanium foil or a membrane with a titanium reinforcement), since the main task is to preserve the contour of the chin and stabilize the material. After that, layer-by-layer suturing of soft tissues without tension is performed. Among the possible complications when using this technique (in the presence of anterior teeth) is damage to sensitive nerve fibers and blood vessels that innervate and vascularize the anterior group of teeth of the lower jaw. Transplantation of a graft from the chin area is par-

ticularly relevant in the reconstruction of the anterior part of the mandible, as it reduces the duration of the operation and provides a single access to the donor and recipient areas [23,25-27].

Method of graft harvesting from the external oblique line. This method does not require local anesthesia, as the doctor can focus on the patient's subjective feelings regarding the approach to the mandibular nerve. Infiltration anesthesia is performed from the vestibular and lingual sides. Then a trapezoidal incision is made and the mucoperiosteal flap is peeled off. The size of the graft depends on the length of the external oblique line and the volume of bone tissue [8,13,19,24,27]. Two vertical and one upper-horizontal cuts are made with a microsaw, using a milling cutter. An important task is to avoid damage to the mandibular nerve. Its exposure is possible with a weakly expressed external oblique line, during preparation below the level of the nerve or when performing a vertical cut on the ascending branch of the jaw. Point holes up to 3 mm deep are drilled between the vertical cuts. The block is separated by hammer blows on a thin chisel. The resulting graft consists of a thick cortical layer and a thin spongy layer [18,20,27,28]. Closure of the donor site defect is usually performed with a collagen sponge, which stabilizes the blood clot and accelerates healing. It is also possible to use bone-plastic materials. In this case, the collagen membrane is laid tightly to prevent migration of the material, which can irritate and damage the nerve, and only then is bone material added. The soft tissues are sutured in layers with knotted sutures [28,29]. The literature also describes a "veneer" technique of autoplasty, which is characterized by the presence of osteoperforations in the area of the receptive bed. Also important is the maximum correspondence of the graft configuration to the recipient bed. The inner surface of the graft is carefully polished, which is necessary for tight contact with the bone tissue of the recipient, as well as to avoid the smallest cavities that prevent graft engraftment. Graft fixation is performed with compression mini-screws, which provide conditions for healing and reconstruction of the autograft [29]. Adaptation of the obtained autograft is performed at some distance from the receiving area with titanium screws followed by filling with bone chips. There are methods of using platelet mass with an increased fibrin content (FRP), obtained by centrifugation, as membranes. In this case, after installing the implants in the bone bed and laying the osteoplastic material, FRP (Fibrine Riche en Plaquette) is used. According to the results of the study, a lower rate of hematomas and severity of soft tissue edema is noted in the postoperative stage compared to the control group [26,29].

The use of piezo instruments in bone surgery is a proven method [27]. Implant bed preparation by splitting and expanding the bone is relevant even with a small thickness of the alveolar crest. One of the important advantages of this method is the preservation of the available volume of bone tissue. Since the end of the last century, researchers have used the technique of extension plastic surgery, which consists of osteotomy along the middle of the alveolar crest in the distal-medial direction and filling the defect formed with hydroxyapatite or autogenous bone tissue [30]. During this surgical intervention, the crest is split along its apex along the length of the defect with a thin bur or microsaw with displacement of the vestibular wall. The state of blood supply and the activity of remodeling of the displaced vestibular cortical wall are of great importance. In case of violation of the listed processes, resorption of the vestibular cortical plate is noted. When the bone is expanded, the implant bed is prepared with drills and osteotomes of increasing diameter. A bed is gradually formed that corresponds to the shape of the implant.

Due to the layer-by-layer exfoliation of the vestibular mucoperiosteal angle, the vestibular plate displaced by the chisel is held by the periosteum, which ensures its vascularization and prevents chipping. With sufficient primary stability, a single-stage installation of dental implants is performed, and the free space is filled with autogenous bone chips with subsequent suturing of the soft tissue flap. [27,30,31]. The protocol for the operation of splitting the alveolar ridge with a single-stage installation of dental implants includes an incision of the mucous membrane in the area of the dentition defect along the center of the alveolar ridge. Then, using microsaws and Lindemann burs, a vertical osteotomy is performed along the middle of the ridge within the defect and to the depth of the planned implant placement. In the area of the distal and medial borders of the defect, vertical osteotomy lines are performed in the vestibulo-oral direction to the middle of the ridge. At the base of the potential bone flap within the borders of the defect, a compact osteotomy is performed with a spherical bur or Lindemann bur. Next, a microscrew is installed in the base of the bone bed of the implant to the depth of the bone flap, taking into account immersion in the fixed part of the defect area.

Then, the space between the installed implants is filled with deproteinized osteoplastic material with a membrane overlap and differentiated, hermetic wound suturing [32-34]. In cases of small alveolar ridge volume, optimal mobilization of the flap during the bone plastic stage is difficult. Prof. Marius Steigmann, Maurice Salama proposed the method of subperiosteal envelope flap. The technique consists in forming a mucous flap on the vestibular surface without violating the integrity of the periosteum. Then the periosteum is peeled off in the apical direction to the depth of the planned dental implants with the formation of a pocket into which the bone material is hermetically placed (Tutodent, Bio-Oss).

Then a resorbable collagen membrane is sutured to the periosteum with absorbable suture material, ensuring the tightness of the subperiosteal space and preventing the germination of soft tissue structures deep into the surgical intervention. The edge of the membrane is placed under the thickness of the lingual flap, thereby preventing the migration of bone material. Then a full-layer suturing of the soft tissues is performed. According to the results of the study, an increase in the thickness of the alveolar crest is noted after 6 months, on average by 6.71 mm [32,33,35].

CONCLUSIONS

Thus, our content analysis of scientific publications indicates that in case of bone deficiency, it is possible to use various methods of restoring the volume of lost bone tissue. The combination of bone-plastic materials, in particular autologous dentin graft, with platelet-enriched fibrin, may be a promising therapeutic option for replacing defects after tooth extraction due to acute or chronic periodontal pathology. The composition of autologous dentin graft with platelet-enriched fibrin proves its effectiveness in replacing periodontally compromised teeth, periapical granulomas, and radicular cysts.

In reconstructive surgery, autogenous bone is still considered the cornerstone in solving the most important tasks in bone plastic surgery. Autografts from the lower jaw are successfully used, in particular, in case of significant atrophy of bone structures, since they have predictable and reproducible results. Three-dimensional plastic surgery, which consists of transplanting thin cortical blocks in the form of overlays, provides a long-lasting clinical result and is more effective than the use of thick bone blocks.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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