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Maxillary Sinus Floor Augmentation: A Literature Review

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Abstract: ***Aim: The aim is to study the development of the maxillary sinus floor augmentation (MSFA) procedure. Materials and methods: Articles related to the subject were searched in Google Scholar, PubMed, Scopus and ScienceDirect databases, using keywords in various combinations. Results: Articles, included in this review described clinical, experimental studies and few reviews of the literature. The articles considered anatomy of the maxillary sinus, MSFA techniques, preoperative diagnosis and complications in MSFA, tissue repair materials used in a maxillary sinus floor augmentation procedure. Conclusion: In the past, MSFA was used only with the aim to repair defects resulting from traumatic injuries or resective oncological surgeries, today it is a predictable technique for bone augmentation in cases of subantral bone deficiency. In modern implantological practice, the procedure is aimed to obtain the quality and volume of the newly formed bone, suitable for placement of osteointegratable implants. With the development of technology, CBCT has established itself as the gold standard in preoperative preparation, and the trend towards performing MSFA is aimed at reducing the invasiveness of the procedure through various techniques, one of which is the endoscopically guided MSFA.***

Keywords: maxillary sinus floor augmentation, lateral approach, bone substitute materials, barrier membranes, CBCT

1. Introduction

In modern dentistry, dental implantology occupies an important place and is increasingly widely advocated, being the optimal option for restoring the masticatory apparatus in case of partial and total edentulism and the only option for permanent prosthetics in case of distally unlimited defects of the dental rows. At present, the main type of implants used in dental implantology are intraosseous osteointegratable implants, which require the presence of a sufficient volume of bone in the areas of implantation.

Immediately after the guided bone regeneration, there follows the method of augmentation of the floor of the maxillary sinus as an augmentation procedure to increase the available volume of bone in the distal region of the upper jaw to achieve optimal rehabilitation with dental implants.

Maxillary sinus floor augmentation is a procedure for augmentation of the subantral bone in the direction of the maxillary sinus cavity (2).

AIM: To study the development of the maxillary sinus floor augmentation procedure

2. Materials and Methods

Articles related to the subject were searched in Google Scholar, PubMed, Scopus and ScienceDirect databases, using keywords in various combinations. “sinus lift”, “maxillary sinus floor augmentation”, “lateral approach”, “maxillary sinus anatomy”, “bone substitute materials”, “barrier membranes”, “CBCT”. Articles in English and Bulgarian published in the period between 1994 and 2024 were included.

3. Results

1) Anatomy of the maxillary sinus.

The maxillary sinus (MS) was discovered by the English anatomist Nathaniel Highmore in 1651 and bears his name - Highmore's antrum - antrum Highmori. It is a cavity located in the body of the upper jaw in the form of a pyramid, which has six walls - anterior (corresponding to the contour of the fossa canina), posterior (appearing as a tubercle of the upper jaw), superior (floor of the orbit), mesial (lateral wall of the nasal cavity), vestibular (the lateral surface of the upper jaw) and lower (floor of the sinus), the thickness of which depends on the pneumatization of the sinus and is usually located 1 cm below the floor of the nasal cavity. The borders of the MS floor are usually marked anteriorly by the first premolar and posteriorly by a small depression behind the root of the third molar. This means that MS can vary tremendously in size, with its pneumatization increasing steadily with age and after tooth loss. The inner walls of the MS are lined with a membrane (Schneiderian membrane according to the author). It is made up of pseudostratified ciliated epithelium. Normally, its thickness varies from 0.13 to 0.5 mm. Thickening of the membrane is considered sinus disease, and the sinus mucosa is considered thickened when it is more than 2 mm. Blood supply to the MS is carried out by three branches of a. maxillaris – a. infraorbitalis, a. alveolaris superior posterior and a. nasalis lateralis posterior. Between the first two vessels, anastomoses are very often formed (most often two) - one extraosseous and one intraosseous (often designated as a. a. a - alveolar antral artery - lat. arteria alveolaris antralis) (13, 75, 49, 54, 56, 63, 74, 77, 80, 81).

2) Maxillary sinus floor augmentation techniques.

MSFA is a procedure to permanently create the necessary level of subantral bone to place dental implants in the distal areas of the upper jaw.

In 1960, Boyne first reported a case of bone grafting in the area of MS for prosthetic indications. The need for the procedure is to create conditions for the subsequent reduction of the distal part of the upper jaw in the area of the maxillary tuber/osity with the aim of normalizing the intermaxillary relations and subsequent treatment with removable conventional prosthetic structures. Normal intermaxillary relations were lost due to afunctional atrophy followed by pneumatization of the maxillary sinus. In the past, MSFA was only used to repair defects resulting from traumatic injuries or resective oncological surgeries. Very few cases have been reported in the past century where bone repair materials have been placed for the purpose of MSFA with subsequent prosthetic treatment (60, 65).

Sunitha V. Raja reviews and reports that to date there have been two main types of methods used to augment the maxillary sinus floor—closed methods (osteotomy technique) and open methods (maxillary sinus floor augmentation technique) (78).

The osteotomy technique for MS floor augmentation was first introduced by Summers in 1994. The concept of this technique is based on the pursuit of maximum preservation of bone tissue by compressing the trabecular canals and increasing their density. Its implementation requires the use of specific tools called osteotomes, with the help of which the trabecular canals are compressed in the lateral and vertical direction. The technique is called osteotomic because the bone reparative material needed to augment the floor of the MS is introduced through a pre - prepared osteotome opening for placement of an intraosseous implant. The osteotomy technique requires simultaneous placement of an implant, as a mandatory condition is the achievement of its primary stability (79, 96, 97, 112).

A requirement for the application of this technique is a sufficient volume of available bone in the vestibulo - oral direction in the distal part of the alveolar crest, a height of the available subantral bone height (SBH) of at least 6 mm, and the absence of septa at the bottom of the MS (53, 108).

The osteotomy technique can provide 2 - 3 mm SBH although there are sources that report much higher values as well. A relatively common complication when performing this technique is perforation of the Schneiderian membrane, occurring in 10 - 26% of the cases (38, 76).

As an advantage of the osteotome technique compared to open techniques, less pain and swelling in the post - operative period can be noted (14, 35, 53, 56, 69, 70).

In open techniques, after the mucoperiosteal flap prep, the corresponding wall of the MS is reached, which will subsequently be used to access it (18, 20, 112).

Many different open access methods for MSFA have been tried over the years (4, 40, 42, 93, 98). An example of this is after Caldwell - Luc, in which the osteotomy opening is localized in front of the crista zygomaticoalveolaris in the area of the fossa canina. Another modification uses access, through an osteotomy located at the level of the existing alveolar ridge (32). Over time, the most appropriate method has become the one in which access to the MS is performed through an osteotome opening in the lateral (side) wall of the MS. This technique is referred to as sinus floor augmentation with lateral access (MSFALA).

It has been described in the literature as reliable and well predictable (26, 52). In this technique, after prep of a mucoperiosteal flap, the lateral wall of the MS is exposed and an osteotome opening is formed in it for access. The operator's approach during the osteotomy can vary widely. In some cases, it can thin and completely remove the lateral cortical plate, and in others, after contouring the osteotomy hole, the cortical plate is prepared from the sinus membrane and stored in saline so that it can be returned to its original position at the end of the manipulation. closing the access window. There is a possibility that after the formation of the access window, the lateral cortical plate be elevated in a vertical direction together with the Schneiderian membrane, thus becoming a new floor of the maxillary sinus (4, 11).

Each of these principles is closely dependent on the anatomical features of MS. The securing of the bony access opening is followed by elevation of the Schneiderian membrane. This is done by first carefully preparing it from the bony walls of the MS using specific elevators, then lifting it in a vertical direction as needed as the case may be. In this way, the necessary space is prepared for the subsequent bone augmentation of the subantral bone (20).

The lateral approach maxillary sinus floor augmentation procedure can be performed with MSFA with immediate implant placement or MSFA with delayed implant placement (1, 12)

3) Preoperative diagnosis and complications in maxillary sinus floor augmentation.

Before proceeding with MSFA, a thorough diagnosis of both the specific MS anatomy of the given patient and the underlying pathology should be performed. For the purposes of this diagnosis, a three - dimensional image obtained by means of the cone - beam computed tomography (CBCT) is used. It provides very precise information about the specific morphology of the alveolar process in the area where the implant is planned to be placed, as well as about anatomical sites in the vicinity (27, 31, 36, 47, 107). In alveolar bone augmentation, the three - dimensional image obtained by CBCT enables examination of the recipient site and an accurate assessment of the volume of bone regeneration that we need (8, 9, 16, 41).

In a systematic review of the literature, Weiss et al. (109) confirmed that CBCT is a valuable imaging technique in dental implantology, oral and maxillofacial surgery and orthodontics, offering the advantages of three - dimensional and multiplanar views with minimal distraction at low radiation dose, for more accurate diagnosis and treatment overcoming the limitations of 2D rendering, such as warping, zooming, and overlaying.

In a systematic review of the literature, Greenstein et al. (46) concluded that CBCT images offer highly accurate and valuable diagnostic information to facilitate treatment planning for implantology, oral and maxillofacial surgery

and orthodontic cases, providing valuable diagnostic information at reasonable risk of radiation dose for treatment planning, which is both 14% more accurate than periapical images and 23% more accurate than panoramic images compared to 1.8% for CBCT images.

In MSFLA, the intraosseous anastomosis may be affected and cause intraoperative complications—hemorrhage and impaired visibility during operation. Using CBCT, the intraosseous anastomosis can be localized in advance (88, 102, 105).

Before proceeding to MSFA, with the help of CBCT, the thickness of the Schneiderian membrane should be determined, as in the case of its thickening more than 3 - 4 mm. consultation with an ENT (ear - nose - throat) specialist is mandatory, as this is considered a sign of chronic inflammation, which in turn would lead to perforation of the membrane during the surgical procedure and subsequent compromise of graft integration (43, 61, 100).

The most common complications associated with MSFA are divided into two groups based on the time of occurrence: post - operative and intraoperative (17, 29, 67, 87, 100).

Post - operative, in turn, are divided into acute and chronic. Acute ones include postoperative infection and benign paroxysmal positional vertigo. Postoperative infection as a complication can develop within 24 hours to several weeks after the operation, accompanied by the following symptoms - unpleasant odor, migraine - type headache, discomfort in the middle of the face, pressure with the position of the head, sensitivity and nasal congestion. Benign paroxysmal positional vertigo occurred in a patient who underwent MSFA with an osteotome technique. The complication is due to detachment of the otoliths in the utricular macula, as a result of compression during the osteotomy technique, and their movement when the patient changes position, causing vertigo. The complication usually occurs in patients over 50 years of age, and the incidence increases with age. Chronic sinusitis belongs to the group of chronic postoperative complications. It can be avoided by careful and systematic preoperative diagnosis of the sinuses. Thickening of the sinus membrane is thought to predispose to postoperative chronic sinusitis. (27, 29, 67, 100).

Schneiderian membrane perforation is the most common intraoperative complication with an incidence of 6% - 42% in MSFA. There are various factors that influence the possibilities of perforation of the Schneiderian membrane. These factors can be eliminated with a properly conducted preoperative diagnostics. Perforation of the membrane can occur at any stage of MSFA. The prognosis for treatment usually depends on the size of the perforation. The observed survival of implants with perforation of the membrane less than 5 mm. is about 97.14% while in 5 to 10 mm perforation there is 91.89% survival of implants and when it is 10 mm or more, the survival rate is about 74.14% (19, 67, 100).

The next most common intraoperative complication after Schneiderian membrane perforation is involvement of the intraosseous anastomosis in MSFLA. This complication causes hemorrhage and impaired visibility during work. It can be avoided with properly performed preoperative diagnostics (19, 29, 67, 100).

Moreno - Vazquez et al. (68) performed a retrospective analysis of 127 patients who underwent MSFA, aiming to evaluate early and late complications after the procedure. Based on 202 MSFAs performed and a total of 364 implants placed, they found that the most common intraoperative complication was Schneiderian membrane damage (25.7%), which showed no association with postoperative complications, and 14.9% of patients developed postoperative complications. In conclusion, they define MSFA as a proven and reliable method of bone regeneration in cases of subantral bone deficiency due to the observed low rate of postoperative complications and the success rate of implants placed in the regenerated area.

Al - Dajani (7) performed a meta - analysis of a systematic review of the literature aiming to determine the incidence of Schneiderian membrane perforation occurring during a maxillary sinus floor augmentation procedure, also to investigate possible risk factors and associated complications. Based on 12 reported studies with a total of 1652 MSFA procedures reviewed in them, they reported a mean rate of Schneiderian membrane perforation of 23.5%, ranging from 3.6% to 41.8%. Reduced membrane thickness and sinus septa increase the risk of perforation.

Schwarz et al. conducted a clinical retrospective study on 300 patients with MSFALA performed on a total of 407 sinuses. They found that the presence of sinus septa and a residual SBH below 3.5 mm were the main risk factors increasing the incidence of Schneiderian membrane perforation. They observed a higher prevalence of the postoperative complication - sinusitis in cases of membrane perforation - 31.4%, despite its intraoperative removal (85).

4) Tissue repair materials used in a lateral access maxillary sinus floor augmentation procedure

Tissue repair materials are tissue, biomaterial, or a combination thereof, placed in a receiving site to support tissue regeneration in order to preserve or restore their volume and qualities (3).

a) Application of barrier membranes in maxillary sinus floor augmentation with lateral approach

The barrier membrane is used in guided bone/tissue regeneration, aiming to prevent proliferation of fibroblasts and epithelial cells in the regenerative cavity. MSFALA, as part of the group of bone - augmentation procedures, is also based on the principle of regeneration, in which a barrier membrane is used, with the aim of eliminating the possibility of growth of a certain type of tissue and allowing the regeneration of slower growing ones (3).

Barrier membranes can be non - resorbable or resorbable. Representatives of non - absorbable membranes are polytetrafluoroethylene (PTFE), titanium - reinforced membranes and titanium foils. They are considered the gold standard in regenerative procedures, as they allow optimal course of regeneration processes and little loss of volume due to the performance of their barrier function over a long period of time. In practice, they have been superseded by

resorbable membranes, due to their main disadvantages, which are the need to reopen the operative field in order to remove them, as well as the need to fix them to the bone in the first surgical stage, as well as the frequent fenestrations and dehiscences during their application.

Resorbable membranes are synthetic and collagen. Representatives of synthetic resorbable membranes are polylactide, polyglactin and polyethylene glycol. The first two representatives demonstrate in their clinical application the need for fixation to the bone and a high frequency of exposure, therefore they are not used in practice. Resorbable collagen membranes can be of different origin, pericardial, dermal, peritoneal, tendon, as well as with various duration of performance of barrier function - from 1 to 6 months. This type of membrane is widely used because of its easy clinical manipulation, its rapid integration in the recipient tissues and the lack of need for fixation in the bone, as well as the lack of a second surgical stage for removal. The limited time in which they perform their barrier function, can be defined as a partial drawback, which necessitates the application of the so - called "bulk" technique, in which bone substitute material (BSM) is placed in a volume exceeding the planned one for restoration. The application of barrier membranes in MSFA has two directions. The first direction is covering the access window to prevent fibrous encapsulation of BSM by fibrous connective tissue originating from the oral mucoperiosteum (37, 58, 64, 66, 72, 75, 82, 89, 90, 103, 107).

The membrane should cover the window at least 3 - 5 mm. Placing the membrane below the incision line should be avoided to prevent membrane exposure (108).

The second direction is to isolate the elevated sinus mucoperiosteum from the newly created cavity, for subsequent augmentation, with a view to preventing fibrous encapsulation of BSM with fibrous connective tissue originating from the sinus mucoperiosteum, as well as to reduce the frequency of complications associated with small, undiagnosed perforations (2).

b) Bone substitute materials in maxillary sinus floor augmentation with lateral approach.

BSMs are tissue, biomaterial, or their combination, placed in the receiving site with an application aimed at preserving or restoring bone quality and/or volume (3, 110).

BSM integration results from a complex series of interactions between the BSM and the recipient specific to each type of BSM. BSM can be of autogenous, allogeneic, and xenogeneic origin, as well as alloplastic materials (95).

The various manifestation of the properties of BSM determine the differences in the terms of the osteogenesis that occurs when they are used (50, 62, 73, 92).

The main functions of the BSM placed in the newly created cavity after the sinus mucoperiosteum is elevated in MSFALA are: to preserve the volume under the elevated membrane until the newly formed cavity is filled with newly created bone, in other words it must be mechanically stable and it must be resorbed slowly; should help the movement of osteogenic cells; particulate BSM colonize faster than osteoblasts, and the higher rate and extent of colonization will contribute to faster and easier repair of the initial bone defect; the material must be porous to ensure rapid angiogenesis. BSM should promote bone formation at a certain distance from the bone walls. There is a directly proportional relationship between the number of bone defect walls involved in the process and the number of osteogenic cells present. The quantity and quality of the newly formed bone formation depend on the osteogenic potential of the traumatized walls of the bone defect and on the vascularization and presence of osteogenic cells. BSM should allow remodeling of the newly formed bone to take place. There is a direct relationship between the rate of BSM resorption and the rate of its replacement by newly formed bone tissue. Resorption of the material cannot occur before it has fulfilled its osteoconductive function, because this would lead to the collapse of the pre - planned required volume intended for augmentation (21, 22, 44, 47, 51, 55, 84, 92, 101, 113).

El Balka et al. (31) concluded that autogenous bone remains the “gold standard” just like BSM in augmentation procedures. The statement is based on a meta - analysis of data obtained on the amount of newly formed bone through histomorphometric analyzes described in the scientific literature for the period 2000 - 2017, based on cases with MSFALA performed and the use of BSM of different origin - autogenous, allogeneic, xenogeneic and alloplastic BSMs.

Starch - Jensen et al. (91), through a meta - analysis after a systematic review of the literature up to 2020, aiming to establish the lack of difference in the histomorphometric results obtained for the amount of newly formed bone in cases with MSFALA performed using BSM of autogenous origin compared to those of allogeneic, xenogeneic origin and alloplastic BSM, concluded that autogenous BSM gives better histomorphometric results compared to other augmentation materials.

Acocella et al. in a clinical study on 15 patients with performed MSFA, in which BSM of allogeneic origin from human fresh - frozen bone was used, established, using histological and histomorphometric analysis an active remodeling process and absence of inflammatory reaction in all biopsies taken at the third month. They concluded that allogeneic BSM is biocompatible and can be successfully used in MSFA (6).

Calasans - Maia et al. (24) in a clinical study on 20 patients with performed MSFA, in which BSM of xenogeneic bovine origin was used, established by histomorphometric analysis for the amount of newly formed bone in all biopsies taken at the third month, an active process of osteoconduction. They conclude that xenogeneic BSM of bovine origin is biocompatible and can be successfully used in MSFA with subsequent implantological treatment.

Xavier et al. (111) found that bovine origin xenogeneic BSM produced better histological results compared to fresh - frozen allogeneic BSM in MSFA, with both materials resulting in a high percentage of newly formed bone, allowing the subsequent placement of implants with a high

rate of their osteointegration success with a follow - up period of 6 months. The claim is based on a clinical study of 30 patients who underwent MSFA. Patients were divided into two groups of 15. Fresh frozen allogeneic BSM was used in one group, and xenogenous bovine origin BSM in the second. After 6 months, biopsies were taken from both groups for histological examination, from which data analysis revealed a statistically significant difference in the volume of newly formed bone in favor of xenogeneic bovine origin BSM. Histological examination of biopsies from patients in which fresh - frozen allogeneic BSM was used showed osteoblastic cells in close contact with the osteoid matrix, connected by bridges between the particles of fresh - frozen allogeneic BSM and the newly formed bone, and in those with used xenogeneic bovine BSM showed particles of the xenogeneic BSM in close contact with the new bone, with visible osteoid matrix bridges and osteoblastic cells surrounding it.

Kim et al. (57) in a clinical study of 37 patients with performed MSFA of a total of 51 sinuses using xenogeneic bovine origin BSM and allogeneic BSM found that the mean height of newly formed bone was similar between the two types of BSM after performed histomorphometric analysis of biopsies taken after a 6 - month recovery period.

Starch - Jensen et al. (94) through a meta - analysis of a systematic review of the literature, aiming to establish the lack of difference in the histomorphometric results obtained for the amount of newly formed bone in a case of performed MSFALA with used alloplastic BSMs compared to those of autogenous, allogeneic, xenogeneic origin, concluded that there were no differences in the outcome of implant treatment after MSFALA with alloplastic BSM used compared to the other types of BSM.

Velasco - Ortega et al. (106) claimed that MSFALA is a predictable technique for bone regeneration in cases of subantral bone deficiency. The augmentation procedure is aimed at obtaining the quality and volume of the newly formed bone, suitable for placing osseointegratable implants. The success of the procedure is largely due to the skill of the surgeon, but does not depend on the biomaterial used.

MSFALA is one of the most reliable options for increasing bone volume in the vertical direction. However, graft consolidation requires adequate angiogenesis and migration of cells involved in osteogenesis and bone remodeling. Avila et al. (10) suggest that these biological events are largely determined by the dimensions of the MS cavity. They conducted a clinical study, the aim of which was to evaluate the influence of the distance between the lateral surface of the upper jaw and the mesial wall of the nasal cavity in the vestibulo - lateral direction of MS based on the results of histomorphometric analysis of the amount of newly formed bone after a performed augmentation procedure according to MSFALA. The clinical trial included 25 patients needing MSFA. They underwent a preoperative CBCT examination based on which they were made a personalized surgical guide. The distance between the lateral surface of the upper jaw and the mesial wall of the nasal cavity in the vestibulo - lateral direction of the maxillary sinus corresponding to 8, 10 and 12 mm of the alveolar ridge is measured. MSFALA was conducted. Patients were followed - up for a 6 - month period, with one of the patients developing an infection after MSFA. After 6 months, bone biopsies were taken at implant placement from a total of 24 patients. Histomorphometric analysis of bone biopsies corresponding to 8, 10 and 12 mm of the alveolar ridge was performed. An inverse relationship was established between the percentage of newly formed bone after MSFALA and its width, taking into account the distance between the medial and lateral walls of the MS in the vestibulo - lateral direction at 8, 10 and 12 mm from the alveolar crest, respectively.

4. Discussion

MSFA is the most commonly used procedure to permanently create the necessary level of subantral bone for placement of conventional 8 mm length dental implants in the distal maxilla regions. The procedure has been used for almost 40 years in implant surgery, and has a high predictability of implant treatment success (94, 102).

The factors that favor the success rate of MSFA are still debated (41).

In recent years, attention has been paid to the morphology of MS. Attempts have been made to develop a classification of MS in order to assist in the preoperative planning of the augmentation procedure in the direction of choosing an approach suitable for BSM. (25, 99)

Several publications have reported an inverse relationship between the percentage of newly formed bone after performed MSFA and its width, taking into account the distance between the medial and lateral walls of the MS in the vestibulo - lateral direction of the alveolar ridge. (10, 59, 83, 86)

Bertl et al. (23) claimed that MS width appears to be a relevant factor for graft consolidation in MSFA. They investigated the possibility of compiling an accessible and clinically relevant classification of MS, based on its width in the vestibulo - palatal direction, taking into account the distance between the medial and lateral walls of the MS, but due to the large variation of the width of the MS, the authors concluded that it is not possible to create an accessible and meaningful classification. They found that the MS width in the vestibulo - palatal direction is related to SBH and SB width.

Today, there are reports in the literature aimed at implantology using endoscopically navigated MSFA using endoscopes with 0°, 30°, 45°, 70°, 90°, and 120° angulated visual axis offset from the instrument axis. The authors indicate endoscopically guided MSFA, as a minimally invasive technique, with good visual control of the operative field, allowing the detection of intraoperative perforations of the Schneiderian membrane during manipulation, as well as control of the positioning of the barrier membrane and BSM during the augmentation procedure, also reduces the chances of undetected migration of BSM particles into the antrum and thus reduces the risks of postoperative infection. (5, 15, 31, 34, 36, 39, 48, 71, 109)

Today, elevation of the sinus floor with crestal access has been replaced in clinical practice by the application of reduced - length implants, for which there is already sufficient evidence that it is a more reliable and minimally invasive approach, with the same indications of SBH – 6 – 8 mm. (1)

In 2015 Peev offers a general classification of bone deficiency from the point of view of dental implantology, as well as a clinically oriented protocol for choosing a method for applying dental implants in conditions of reduced SB volume, according to which MSFALA is indicated in the presence of SBH of less than 6 mm. According to the former, in SBH from 2 to 5 mm, MSFALA is undertaken with immediate implant placement, and in case of SBH below 2 mm, MSFALA is undertaken with delayed implant placement. (1)

In the literature today, a trend is noticed that SBH, in which the method for the application of implants in conditions of subantral deficiency maxillary sinus floor augmentation with lateral approach with immediate implant placement is undertaken, acquires a wider range. This is due to the lower reported minimum value of SBH at which maxillary sinus floor augmentation with lateral approach with immediate implant placement is undertaken – 1 - 2 mm, but only in cases where primary stability of the implants can be achieved. (28, 31, 30, 104)

5. Conclusion

In the past, MSFA was used only with the aim to repair defects resulting from traumatic injuries or resective oncological surgeries, and today it is a predictable technique for bone augmentation in cases of subantral bone deficiency. In modern implantological practice, the augmentation procedure is aimed at obtaining the quality and volume of the newly formed bone, suitable for placement of osteointegratable implants. With the development of technology, CBCT has established itself as the gold standard in preoperative preparation, and the trend towards performing MSFA is aimed at reducing the invasiveness of the procedure through various techniques, one of which is the endoscopically guided MSFA.

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