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A systematic review of sinus floor augmentation complications. Does graft type influence the complications rate?

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ABSTRACT

Background. Sinus floor elevation is considered a safe procedure to properly augment the height of the edentulous crest. Often, complications may arise due to multiple causes and can lead to a poor outcome of the graft and implant's osseointegration. A careful surgical approach, a good knowledge of possible obstacles, and careful treatment planning can reduce the risks of complications, as well as their impact on the surgical outcome. This study aims to make a literature review of 40 articles, analyzing the incidence and type of complications related to maxillary sinus graft surgeries and graft materials.

Material and methods. A total of 40 articles published between 2015 and 2021 were selected for a systematic literature review on maxillary sinus floor complications. The studies were selected from 2 different internet databases: PubMed and Science Direct. The sinus lift complications were counted and their incidence was organized upon the surgical technique and the timing of occurrence (intraoperative, postoperative). It was also analyzed if the graft material influences the complication rate.

Results. In a group of 1757 sinus augmentation surgeries performed on 1605 patients, 363 complications were found. Sinus membrane perforation occurred in 242 cases, 29 procedures resulted in partial or total graft loss, there were 26 postoperative cases of sinusitis, 24 sinus infections, 16 wound dehiscence, 6 bleeding complications, 5 lost implants, and 2 oro-antral fistulas.

Conclusion. Sinus lift complications are sometimes inherent circumstances of the procedures, but they can also be prevented through an accurate technique and preoperative plan. The type of bone graft does not influence the incidence of surgical complications.

Keywords: maxillary sinus floor augmentation, complication, intraoperative bleeding, sinus infection, sinusitis, graft loss, schneiderian membrane perforation, wound dehiscence

INTRODUCTION

Sinus floor elevation surgeries represent a viable option for preimplant site augmentation in the posterior region of the maxilla [1]. Ideal treatment planning for edentulous sites combines prosthetic-driven implant insertion with fixed restoration [4]. However, the atrophic edentulous crest often impedes implant insertion without bone reconstruction of the bone defect [3-5]. Thus, grafting procedures often become an imperative stage before, or, simultaneous with implantation [2].

One of the most frequent bone grafting techniques of the maxillary crest is represented by sinus floor elevation [6]. Maxillary sinus graft provides the adequate bone volume for implants with proper

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height and diameter [7,8], to support the occlusal load specific for the posterior region. Various studies on sinus floor augmentation proved successful osseointegration of the implants and long-term success of the restorations [6].

The incidence of complications related to maxillary sinus graft has increased accordingly to the more increased number of surgeries and doctors performing them [9]. There is a large spectrum of risk factors, respectively: specific anatomic features of the patient, lack of experience of the surgeon, or, poor surgical technique and planning [12]. Depending on the moment when they occur, there are intraoperative, immediate postoperative, and delayed complications of sinus floor augmentations [10,11].

The resolution of a medical complication is directly related to the practitioner's experience in applying adequate treatment at the right moment [13]. A correct therapeutic protocol of the surgical complication may still result in a successful outcome of the augmentation. During grafting procedures is crucial for the operator to master each step of the surgery. The surgeon should be able to predict the evolution of the procedure and the healing pattern of the patient along with possible complications [12].

Many studies are indicating good results by using graft materials, such as autogenous bone, allogenic bone, alloplastic components. Autogenous bone is the gold standard for sinus floor elevation due to its best bone regenerating potential [12,13]. Autografts showed the highest percentage of newly formatted bone [41,74].

This review aims to present the complications of maxillary sinus floor augmentation procedures, for the practitioner to implement the proper treatment and prevail possible obstacles. This report should also guide the surgeon in choosing the best graft material adapted for each clinical case.

MATERIALS AND METHODS

Screening process

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Figure 1) [14].

Relevant studies, written in English and published between 2015 and 2021 were selected from ScienceDirect and Pubmed databases. The main topic of the articles was the maxillary sinus augmentation performed on human subjects, taking into con-

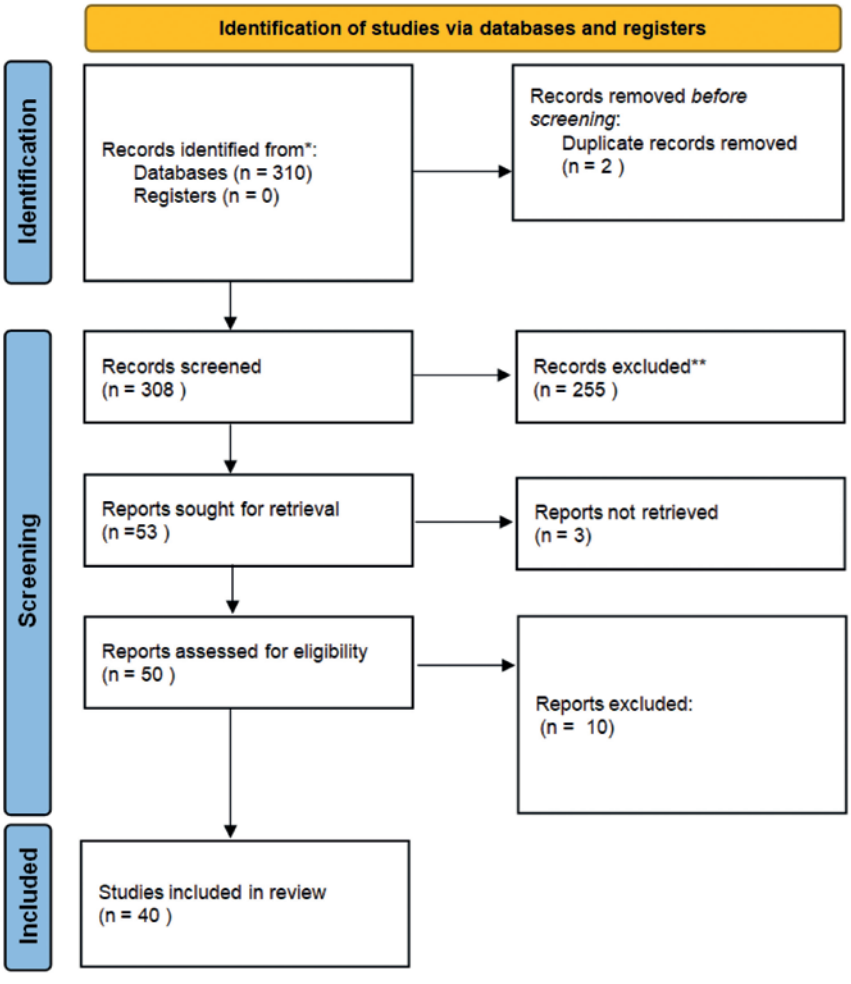

FIGURE 1. Study selection

sideration the graft materials and complications mentioned within the outcomes of the studies. The keywords used for our findings were: "sinus floor elevation" AND "complications".

The initial research identified 310 reports, 2 duplicates were excluded. After screening the articles based on their abstracts and titles, 53 reports were assessed for eligibility. Only 40 articles were selected for data collection.

The review protocol included a full analysis of each article, performed by a single investigator who classified the complications according to the crestal and lateral approach, but also into intraoperative, postoperative. The investigator also noted each graft material down, analyzing if the graft type influences the complication rate. Eligible articles for this review presented studies performed on a minimum of 8 sinus floor surgeries. Inclusion and exclusion criteria are listed in Table 1.

TABLE 1. Inclusion and exclusion criteria of the articles

Inclusion criteria	Exclusion criteria
articles written in English language	articles written in other languages
articles published between 2015-2021	articles published earlier than 2015
randomized controlled trials	case reports
clinical trials	meta-analyses
sinus floor augmentation procedures: intraoperative and postoperative evolution	systematic reviews
human subjects	animal studies

Data analyses

The following data were extracted from each article: first author, year of publishing, surgical technique (lateral/crestal), number of lift-sinuses, number of patients, gender classification, their average age, number of implants (if available), type of graft and number and type of complications (Table 2).

RESULTS

Forty articles were selected based on the inclusion and exclusion criteria. Altogether a group of 1643 patients having a mean age of 49,61 years was found in the latest studies on maxillary sinus floor augmentation. A total number of 1757 sinus augmentation procedures were analyzed by the complications they were related to. The surgeries were divided upon the surgical access towards the maxillary sinus into 1278 augmentation by lateral approach and 479 by crestal approach (Table 2). A total number of 363 complications were found, comprising intraoperative and postoperative unfavorable evolution.

The most frequent complications were the Schneiderian membrane perforations, respectively 242 cases, followed by 30 graft loss, 26 postoperative sinusitis, 24 sinus infections, 16 wound dehiscence, 6 hemorrhagic complications, 5 lost implants (insufficient implant stability), 2 oro-antral fistulas (Table 3).

When dividing the complications produced during crestal and lateral techniques, there were 340 complications for the lateral approach and 23 complications which occurred during osteotome sinus elevation technique.

A number of 1548 sinus floor augmentation surgeries were performed with different types of bone grafting materials (Table 4) and 209 procedures described new bone formation without bone substitutes (elevated Schneiderian membrane by implant apices and blood clot alone around the implants). Different types of graft materials were used in the studies: Polylactic acid and Polyglicolic acid, deproteinized bovine bone matrix, β-tricalcium phosphate, plateled rich plasma, carbonite apatite, autogenous bone from the mandible, hydroxyapatite, mix of hydroxyapatite and calcium carbonate, concentrated growth factor with deproteinized bovine bone matrix, β-tricalcium phosphate with plateled rich plasma, porcine xenograft. The complication rate does not depend on the presence or absence of the graft material. The type of bone graft does not influence on surgical complications rate.

In Table 5 are listed the conclusions of different studies on the outcome of the sinus floor augmentation with different bone substitute materials.

DISCUSSION

Maxillary sinus floor augmentation is a relatively simple and safe procedure with good results in creating a proper implant site for the posterior region of the upper jaw [53]. However, improper assessment of the cone-beam computed tomography, inadequate surgical planning, incorrect, or, aggressive use of surgical instruments can lead to many types of complications [15].

Upon the treatment applied by the surgeon, sinus graft complications may lead to fully healed surgical sites, with no consequences on the implant and graft osseointegration, or, difficult evolution of the clinical case. Some unfavorable events during surgery (e.g. sinus membrane perforation) are enchained with consecutive postoperative complications (infections, dislodgment of grafting materials, and implants into the sinus cavity)[54]. The maxillary sinus complications are classified into intraoperative incidents, immediate and late postoperative complications [10]. One of the most frequent intraoperative incidents is the Schneiderian membrane perforation [54–61]. Al-Dajani has related in a similar review an average incidence of 23,5% [62], while Nolan et al reported membrane perforation after

TABLE 2. The complication rate, type, the sinus grafting technique and material found in sample of 40 articles

First author (Year)	Sinus technique (crestal/ lateral)	No. of lift-sinuses (n)	No. of patients (n)	Mean age (years)	Women (n)	Men (n)	Type of graft material	No. of compli-cations	Type of complications
1. Stacchi C. (2017) (15)	lateral	20	25	58,2± 11,4	10	15	allo-plast	8	7 membrane perforations 1 intraoperative hemorrhage
2. Baldini N. (2016) (16)	lateral	32	16	57.56± 8.7	9	7	xeno-graft	9	7 membrane perforations 2 intraoperative hemorrhages
3. Bacevic M. (2021) (17)	lateral and crestal	22 11 lateral 11 crestal	22	51,9	14	8	xeno-graft	11	7 membrane perforations in 2 postoperative bleeding 1 implant 1 graft loss
4. Kiliç S. (2016)(18)	lateral	18	18	32,7	6	12	allo-plast	3	3 membrane perforations
5. Zhang (2016) (19)	crestal	38	56	38,95	24	32	No graft	1	1 membrane perforation
6. Stacchi (2015)(20)	lateral	72	72	55,4± 10,1	44	28	xeno-graft	4	4 membrane perforations
7. Kudoh (2018) (21)	lateral	8	8	58,1± 7,2	6	2	allo-plast	0	0
8. Dos Anjos (2016) (22)	lateral	20	10	48,3	4	6	xeno-graft	0	0
9. Nielsen H. (2021) (23)	lateral	23	40	52	23	17	auto-graft + allo-plast	6	1 intraoperative bleeding 3 membrane perforations 1 wound infection
10. Wang F. (2016) (24)	lateral	41	41	45,2	15	26	xeno-graft	5	5 membrane perforation
11. Taschieri S. (2017) (25)	lateral	25	25	51,05	14	11	xeno-graft	1	1 membrane perforation
12. Zheng (2021) (26)	crestal	63	45	49	18	27	xeno-graft + auto-graft	0	0
13. Pisoni (2016) (27)	lateral	41	41	53,2	14	27	auto-graft	13	6 membrane perforations 3 intraoperative hemorrhageS 3 wound dehiscence 1 graft loss
14. Boyacıgil (2020) (28)	crestal	44	25	48	14	11	xeno- graft	10	8 membrane perforation 2 postoperative sinusitis
15. Shiffler (2015) (29)	lateral	107	95	61	39	56	allo-plast	70	64 membrane perforations 6 postoperative sinusitis
16. Raynaud (2019) (30)	lateral	21	19	60,3	11	8	allo-plast	3	2 membrane perforation 1 wound infection
17. Bruschi (2019) (31)	crestal	71	52	59	29	24	no graft	0	0
18. Bassi (2015) (32)	lateral	20	17	-	-	-	no graft	0	0
19. Restoy (2015) (33)	lateral	12	11	47,3	5	6	auto-graft	3	3 membrane perforations
20. De Molon (2018) (34)	lateral	20	10	48.34 ± 12.83	6	4	xeno-graft	0	0
21. Adali (2020) (35)	lateral	20	10	57	8	2	auto-graft+ allo-graft vs allo-graft	2	2 membrane perforations
22. Lu (2018)(36)	lateral	51	49	53,8	30	19	xeno-graft	2	1 membrane perforation 1 wound dehiscence
23. Qian (2020) (37)	crestal	45	45	-	-		xeno-graft vs. no graft	3	3 membrane perforations
24. Sakkas (2016) (38)	lateral	105	99	43,1	10	89	auto-graft	15	11 membrane perforations 4 wound infection
25. Ritter (2019) (39)	lateral crestal	145 114 lateral 31 crestal	104	62	-	-	xeno-graft	51	32 membrane perforation 10 wound infection 4 postoperative bleeding 3 wound dehiscence 2 oroantral fistula

First author (Year)	Sinus technique (crestal/ lateral)	No. of lift-sinuses (n)	No. of patients (n)	Mean age (years)	Women (n)	Men (n)	Type of graft material	No. of compli-cations	Type of complications
26. Meloni (2017) (40)	lateral	32	32	48	-	-	xeno-graft vs. xeno-graft + auto-graft	1	1 membrane perforation
27. Gürler (2016) (41)	lateral	28	24	49,3	10	14	allo-graft	4	2 membrane perforation 2 postoperative sinusitis
28. Gatti (2018) (42)	crestal	49	35	55,7	18	17	auto-graft	0	0
29. Meloni (2015) (43)	lateral	20	16	46	7	9	xeno-graft vs. auto-graft	1	1 membrane perforation
30. Osman A. (2017) (44)	lateral	20	15	47	6	9	no graft	5	4 membrane perforations 1 intraoperative bleeding
31. Falah M. (2016) (45)	lateral	30	18	52	10	8	no graft	6	3 membrane perforations 3 implant loss (insufficient primary stability)
32. Starch-Jensen T. (2021) (8)	crestal	40	40	49,15 27 females 13 males	27	13	no graft vs. xeno-graft	1	1 membrane perforation
33. Alayan J. (2018) (46)	lateral	60	60	-			xeno-graft + auto-graft	17	8 membrane perforations 8 wound dehiscence 1 postoperative sinusitis
34. Fouad W. (2018) (44)	lateral	20	17	37,1 ± 11.1	8	9	no graft vs. xeno-graft	2	2 membrane perforations
35. Oba Y. (2020) (47)	crestal	23	23	58.1 ± 12.7	16	7	allo-plast	0	0
36. Tükel HC (2018) (48)	lateral	120	120	58,3	-	-	xeno-graft	66	22 membrane perforation 28 graft loss 1 wound dehiscence 15 postoperative sinusitis
37. Kozuma A. (2017) (49)	lateral	121	109	58,3	-	-	allo-plast + auto-graft	27	18 membrane perforation 8 wound infection 1 implant loss
38. Correia F. (2021) (50)	lateral	24	12	59.7 ± 8.7	-	2	xeno-graft vs. auto-graft	5	5 membrane perforation <2 mm
39. Younes F. (2019) (51)	lateral	22	22	59	15	7	xeno-graft	7	3 membrane perforations 4 intraoperative bleeding
40. Tallarico M. (2016) (52)	crestal	64	62	53,1	35	29	allo-plast	0	0

TABLE 3. Type and incidence of each complication produced intra- or postoperatively in the lateral and crestal augmentation technique

Type of complications	Number of complications lateral technique	Number of complications crestal technique
Intraoperative complications		
Membrane perforation	224	18
Hemorrhage	12	-
Postoperative complications		
Bleeding (hemorrhage)	5	1
Sinus infection	24	-
Wound dehiscence	16	-
Partial graft loss	1	-
Total graft loss	28	1
Sinusitis	24	2
Oroantral fistula	2	-
Implant failure	4	1
Total	**340**	**23**

TABLE 4. The total number of patients (and the mean age), the total number of sinus augmentation surgeries, and the complications rate for the lateral and crestal technique

Sinus technique (lateral/crestal)	Number of sinuses	Number of patients	Mean age (years)	Number and type of complications
Lateral approach	1278	1180	52,23	Intraoperative 236 Postoperative 104 Total 340
Crestal approach	479	425	46,99	Intraoperative 18 Postoperative 5 Total 23
Total	**1757**	**1605**	**49,61**	**363**

TABLE 5. Conclusions of different articles directly related to different types of bone substitutes used for sinus floor augmentation

Study (year)	Sinus-lift Surgeries (n)	Implants (n)	Type of bone graft	Type of evaluation	Survival rate	Conclusions
1. Kiliç S. (2016) (18)	18	-	Beta-tricalcium phosphate (β-TCP) versus (β-TCP) + plateled rich plasma (PRP)	Clinical and radiographical (OPG, CBCT)	-	(β-TCP) plus platelet-rich plasma (PRP) compared to β-TCP graft substitute alone: there was no significant more vertical bone gain or bone resorption
2. Kudoh (2018) (21)	8	9	Carbonate apatite with two granule sizes: S (300–600 μm) and M (600–1000 μm)	Clinical and radiographical (OPG)	100%	Low-crystalline carbonate apatite granules are providing a promising bone substitute
3. Dos Anjos (2016) (22)	20	25	Deproteinized bovine bone mineral particles of different sizes Bio-Oss Geistlich	Clinical and radiographical	100%	No statistically significant difference was found between small and large particles
4. Wang (2016) (24)	41	70	Deproteinized bovine bone mineral (DBBM)	Clinical, histological, histomorpho-metrical and radiographical	100%	DBBM demonstrated clinical, histomorphometric effectiveness. Later stages of osseointegration proved a higher amount of new bone formation (micro-CT at 8-11 months)
5. Pisoni (2016) (27)	41	-	Autogenous bone block placed under the sinus membrane vs. autogenous particulate bone below the sinus membrane	Clinical and radiographical	-	The mean bone gain for the group treated with a bone block was 12.55 mm, while the mean bone gain for the group with particulate bone graft was 10.63 mm
6. Raynaud (2019) (30)	21	-	Biomaterial made from 90% of synthetic biphasic bone substitute particles (60% hydroxy-apatite and 40% β-TCP) em-bedded within a 10% porcine type I or III collagen matrix	Clinical and radiographical	86,4%	Simple, safe, and repeatable technique with low complications rate (even in Schneiderian membrane perforations)
7. Adali (2020) (35)	20	20	Concentrated growth factor (CGF) with allografts vs. allografts alone	Clinical, histomorpho-metrical and radiographical	100%	No differences between the 2 groups regarding the amount of new bone formation
8. Qian (2020) (37)	45	45	Deproteinized bovine bone mineral vs. no graft material	Clinical and radiological		Periimplant bone height showed no significant difference between the two bone groups
9. Meloni (2017) (52)	32	46	Anorganic bovine bone (ABB) vs autologous bone mixed with 50% ABB	Clinical and radiographical	100%	No difference in survival rate, and complications of different bone substitute materials
10. Gürler (2016) (41)	24	24	Allogenous bone graft and L-PRF mixture with L-PRF membrane (leukocyte-platelet rich fibrin) vs. allogenous bone and resorbable collagen membrane	Clinical and radiographical	100%	The use of L-PRF combined with allogenous bone graft, covered with L-PRF membrane does not significantly improve the rate of postoperative complications
11. Alayan J. (2018) (46)	60	60	Anorganic bovine bone mineral (ABBM) + autogenous bone (AB)) vs. collagen-stabilized ABBM	Clinical and radiographical	96,6%	No difference in survival rate and complications of different bone grafting materials

sinus augmentation up to 40% [63]. In the literature, this accident is related to multiple causes and occurs during antrostomy, or, at the moment of its elevation from adjacent bony walls [55]. Cho et al. showed in their studies a higher risk of sinus membrane perforation during its reflection from the anterior, narrow region, where the medial and lateral wall create an angle less than 30° [1,64]. As incriminating risk factors there is the presence of sinus septa [65], thin, friable Schneiderian membrane, lack of experience of the surgeon [28], incautious, abusive use of the sinus curettes, use of traditional diamond disks with straight handpiece instead of piezosurgical units [62]. Sometimes, the surgeon performs an incision in the Schneiderian membrane to remove the maxillary sinus mucocele, which otherwise could hinder the membrane elevation [66]. Schneiderian membrane perforations can be treated with the aid of biological membranes (of autologous or xenogenic origins) and suturing techniques [5,56,67,68].

Tükel et al. concluded that Schneiderian membrane perforation, along with the presence of sinus septa and a reduced preoperative residual bone height (3-6mm) are considered statistically significant criteria for further postoperative complications and graft failure [48].

Important bleeding complications are related to injuries of the blood vessels from the anterior wall, which can occur during antrostomy and flap elevation [1]. Intraoperative bleeding represents the second most frequent type of complication for sinus floor augmentation surgeries [11,69]. The important arterial branch which can be injured during antrostomy is the alveolar antral artery, representing the intraosseous anastomosis between the infraorbital artery and the posterior superior alveolar artery [11,70]. The hemorrhage which may occur during flap elevation is caused by injuries of the extraosseous segment of the arterial anastomosis, or, of the lateral nasal artery [11].

Bleeding may hinder visibility when elevating the sinus membrane. It can lead to membrane perforations and displacement of the grafting material [11]. Arterial constriction is the correct management for intraoperative hemorrhage, performing pressure on the bleeding point, use of local vasoconstrictor agents, or bone-crushing around the intraosseous vessel [11]. Other options are electrocautery, ligation after the isolation, and chemocautery [70]. As a consequence, the local blood supply decreases, which can affect the vitality of the graft [11].

Vessel preservation can be carefully performed when using piezoelectric devices, accessing the sinus cavity with a double window technique, or, by palatal approaches [70,71].

Sinus graft infection was reported by other authors to have an incidence ranging from 1% to 15% [72,73]. This type of complication is associated with Schneiderian membrane perforations or wound dehiscence. Furthermore, there are predisposing factors as inadequate asepsis, contamination of the graft with saliva, or, preexisting chronic sinusitis [49,72]. Urgent treatment is required to avoid spreading the infection to the adjacent areas, resulting in orbital cellulite, infraorbital abscess, brain abscess [72]. Beyond systemic antibiotics, the management of this complication implies drainage, irrigation, and partial or total removal of the grafting material[72]. Left untreated, progressive infection and ostium obstruction can result in another postoperative complication, respectively the oroantral fistula [72,74].

The risk of sinus graft infection can be reduced, especially when large perforations of the sinus membrane occur, by using exclusive autologous materials [66]. Platelet-rich fibrin membranes are already known to be a viable alternative for xenografts and alloplastic material [66].

Acute maxillary sinusitis related to augmentation procedures is caused by ostium obliteration [72]. Various structures can impede proper mucociliary clearance, such as hematomas, seromas, particulate grafting material migrated through the membrane perforation, the edematous process due to inflammatory response, which results in mucosa thickening [72,75,76]. Another important aspect is the preservation of the maxillary sinus ostium (MSO), avoiding the overfilling with grafting material [72,75].

Sakuma et al. found a minimum distance of 25,2 mm of the MSO from the sinus floor and an average distance of 33,3mm [75]. Antibiotics, decongestants, and anti-inflammatory drugs administration are indicated to reduce the signs and symptoms of maxillary sinusitis [72].

Many types of the abovementioned intraoperative and postoperative complications are interconnected and can finally result in implant and graft loss. Besides osseointegration failure of the grafting material, implant loss can be caused by its displacement into the sinus cavity, improper primary stability [72].

The neurosensory disturbance is a rare complication of the maxillary sinus floor augmentation [69,72]. Aggressive flap elevation, pressure during flap retraction, or, mucoperiosteal flap dissection for tension-free closure can lead to injuries of the infraorbital nerve [69,72].

The bone grafting materials proved no difference regarding the incidence of complications. There is a minor difference between autogenous materials (PRFs, autografts) and xenoplastic or alloplastic transplants in relationship to infections rate [66].

For sinus floor augmentation procedures many studies showed good results with a variety of bone graft materials, like autografts, allografts, xenografts, alloplasts, or growth factors. Each material has a different indication thus, the technique should be adapted for each clinical case [1].

Autografts are considered the gold standard for augmentation procedures, due to their osteogenic properties [13,77,78]. The sources of autografts are represented by intraoral, or, extraoral donor sites. The harvesting process increases surgical morbidity. Other disadvantages are the high resorption rate and the limited availability [79,80] .

Regarding the size of the graft placed in the sinus cavity, studies showed a lower survival rate of implants placed in sinuses with block grafts than particulate grafts.

The allogenic bone substitute is obtained from donors of the same species. They have the purpose of a space-maintaining scaffold for bone regeneration, having good osteoconductive properties [81]. An increase of the osteoinductive capacity is possible when the mineralized portion is reduced and the amount of bone-specific proteins (especially bone morphogenic proteins) increases. When processing the grafting materials in order to eliminate the antigens and pathogens the concentration of growth factors decreases significantly.

Xenografts are bone substitute materials obtained from animal species and have the role of semipermanent osteoconductive biomaterials. Xenografts were used for sinus augmentation surgeries in many clinical trials [82]. They are good space maintainer and their high radioopacity facilitate the X-ray analysis for the clinician to recognize the material in the sinus cavity.

Alloplasts are synthetic biomaterials like calcium sulfates, hydroxyapatite, or polymers, or they can be from natural origins, like algae, or, coral-derived hydroxyapatite [83]. They are known for their osteoconductive properties, with no osteoinductive capacity. There are many studies showing their effectiveness in sinus floor augmentation procedures as sole materials, or, combined with other bone grafting substitutes [83].

Particulate bovine bone and alloplastic material are avascular structures, which need good local regenerative potential and efficient neoangiogenesis. Graft vascularisation is crucial in preventing necrosis, and thus a graft infection [66]. Platelet rich fibrin represent a viable source of leukocyte cytokines and red blood cells and growth factors, which is a major advantage for avascular, foreign materials like xenoplastic and alloplastic substitutes [66]. Therefore, PRFs are suitable to be incorporated in mixtures with other bone substitute materials [66]. Platelet concentrates (platelet rich plasma/platelet rich growths factors) with bone graft materials have promising results by enhancing the bone formation and vascularization process and reducing tissue inflammation. They might also reduce the risk of complication[13]

Sources of bias are represented by common complications, which can coexist in the healing period after all kinds of sinus floor augmentation procedures and different types of grafting surgeries in other regions of the oral cavity. The incidence and the severity of complications such as postoperative pain, swelling, hematoma, minor nose bleeding were not analyzed in this study.

CONCLUSIONS

Bone augmentation procedures are sometimes indispensable for proper implant placement. In the posterior part of the maxilla, sinus floor augmentation is one of the most frequent procedures, because of the simple, viable and predictable nature of the surgery. Complications resulting intra- or postoperatively can lead to unfavorable outcomes of the treatment plan. Sometimes the augmentation procedure needs to be repeated, which increases the costs and affects the patient's quality of life. A detailed CBCT examination and careful surgical planning can significantly reduce the incidence of possible complications.

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