ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at: www.ijmacr.com

Volume – 3, Issue – 4, July - August - 2020, Page No. : 25 - 33

A brief review of complications of maxillary sinus augmentation – etiological factors and existing treatment options

[1]Dr. Mohsina Hussain, [2]Dr. Madhumaitri Patra, [3]Dr. Anik Sarkar, [1]Dr. Debabrata Gayen, [2]Dr. Subhajit Saha

[1]Post Graduate Trainee, Department of Oral and Maxillofacial Surgery, Dr. R Ahmed Dental College and Hospital, Kolkata, India

[2]Post Graduate Trainee, Department of Prosthodontics and Crown & Bridge, Haldia Institute of Dental Sciences and Research, Haldia, India

[3]Post Graduate Trainee, Department of Oral and Maxillofacial Surgery, Buddha Institute of Dental Sciences and Hospital, Bihar, India

Corresponding Author: Dr. Mohsina Hussain, Post Graduate Trainee, Department of Oral and Maxillofacial Surgery, Dr. R Ahmed Dental College and Hospital, Kolkata, India

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

Maxillary sinus augmentation (also known as sinus floor elevation) can be defined as a routine and predictable procedure for the prosthetic rehabilitation in the atrophic maxilla. Management of patients undergoing sinus augmentation procedure often requires a multidisciplinary approach involving various specialists in the preoperative phase to optimize surgical results and reduce intra-operative or post-operative complications. Certain complications arising intra-operatively may influence the outcome of therapy. Proper pre-operative planning and patient assessment will result in avoidance of or early detection of the complications. Early management of these complications will minimize the negative effects on therapy and can prolong the long-term success and survival of the implant prosthesis. In this brief review, we aimed to investigate the important complications associated with maxillary augmentation surgery and provide some insight to the etiological factors and the existing treatment options.

Keywords: Maxillary sinus augmentation, sinus lift, complications, membrane perforation, sinusitis.

Introduction

Maxillary sinus augmentation (also known as sinus floor elevation) can be defined as a routine and predictable procedure for the prosthetic rehabilitation in the atrophic maxilla.[1] Management of patients undergoing sinus augmentation procedure often requires a multidisciplinary approach involving various specialists in the preoperative phase to optimize surgical results and reduce intra-operative or post-operative complications.[2-4] Prolonged edentulism may have detrimental effects on the alveolar ridge as a result of severe resorption, leaving an inadequate site for implant placement. Surgery to augment these edentulous spaces may be often necessary for proper implant placement.These procedures have become increasingly popular prior to the placement of dental implants in posterior maxillae that have suffered from excessive bone loss due to sinus pneumatization, alveolar bone atrophy or trauma.[5] Dr. Hilt Tatum is credited for introduction of a modified Caldwell–Luc approach for maxillary sinus grafting in the 1970s which has been recognized as a reliable procedure with high predictability to date. He used the maxillary sinus cavity to increase the

thickness of the available bone using graft material, which allowed greater contact between the implant and bone after maturation of the graft.[6] However, as in all surgical procedures, in this procedure too, various intra-operative or post-operative complications may arise.[7] In the European Journal of Surgery, Veen et al. provides an elaborate definition of complication as 'every unwanted development in the illness of the patient or in the treatment of the patient's illness that occurs in the clinic'.[8] In this brief review, we aimed to investigate the important complications associated with maxillary augmentation surgery and provide some insight to the etiological factors and the existing treatment options.

Surgical Anatomy

Maxillary sinus is the first paranasal sinus to develop at 10th week of intrauterine life. Expansion occurs more rapidly until all the permanent teeth have erupted and reaches to maximum size around 18 years of age. This is the largest sinus and pyramidal in shape. Dimension of the sinus are as follows : height- 36 to 45 mm,Width- 25-35mm,Length-38-45mm. Average volume is about 15ml.[9] It is surrounded by six walls. The floor of the sinus lies below the nasal cavity and is formed by the alveolar and palatine processes of the maxilla. A thin layer of compact bone separates it from molar dentition. The floor of the sinus is in close relation with the root tips of maxillary posterior teeth, specially molars.[10,11] Opening from the sinus located high on the medial wall and opens into the semilunar hiatus of the middle nasal meatus on the lateral nasal cavity Situated in the superior aspect of the medial wall of the maxillary sinus. Accessory ostium can be present sometimes.[12] A thin respiratory ciliated epithelium lines the sinus internally known as Schneiderian membrane that continues with the epithelium of the nasal mucosa; however, the antral mucosa is approximately 1 mm thick and less vascular. The sinus epithelium possesses cilia that serve in the transportation of fluid secretions toward the ostium.[13] When insufficient bone height is present during dental implant installation in the posterior maxilla this membrane is elevated often. Barriers of cortical bone that arise from the floor or the walls of the sinus called as bony septa may divide the sinus into several recesses. septa can be further subdivided based on their origin. Primary septa which forms during maxillary development and tooth growth, or secondary septa which acquires during the pneumatization of the maxillary sinus after tooth loss.[14]

Approaches

The two most commonly used approaches for maxillary sinus augmentation are Internal sinus lifting (crestal approach) and External sinus lifting (lateral window technique). The lateral window technique, the still most widely used technique for sinus augmentation was originally described by Tatum[6] in 1977 and subsequently published by Boyne[15] in 1980. The crestal approach involves the elevation of both the Schneiderian membrane and bony floor of the sinus indirectly through the alveolar crest. With this technique, up to 5mm of the sinus floor elevation was demonstrated microscopically.[16] The lateral window technique involves the creation of a trapdoor osteotomy on the lateral wall of the maxillary sinus followed by elevation of the Schneiderian membrane to design a confined space for the placement of graft material and dental implant.

Complications

Complications associated with maxillary sinus augmentation are categorized into intraoperative complications, acute and chronic postoperative complications. In a study by Barone A et. al.[17], the most frequent complications of maxillary sinus graft were perforation or tear of the sinus membrane (60%), infection (21%), bleeding (9%),

migration, benign paroxysmal positional vertigo (BPPV) in descending order.

Intra-operative complications include tearing of the Schneiderian membrane, antral or nasal perforation, displacement of implant in the sinus cavity, excessive bleeding, insufficient primary stability, improper position or angulation of the fixture, damage or injury to the adjacent teeth or teeth roots, fracture of maxilla, fenestration, dehiscence or perforation of alveolar bone, obstruction of the oro-meatal complex and swallowing of instruments.[34]

Schneiderian membrane perforation

Schneiderian membrane is lined by pseudociliated stratified respiratory epithelium and plays a pivotal role in the protection and constitution of the maxillary sinus. Perforation of the Schneiderian membrane is frequently associated during elevation of the sinus because the procedure is performed blindly as it is impossible to visualize the sinus floor.[6,15] During sinus elevation, even a small tear in the membrane might result in direct communication between the grafted material and the contaminated sinus cavity. This can lead to infection and chronic sinusitis, which can further accentuate loss of the graft volume. Incidence of perforations in the external sinus lifting technique has ranged from 20% to 44% which is significantly greater than the crestal approach which has been reported between 0% and 25% but has shown minimal effect on long-term implant survival. Presence of septa is associated with an increased risk in sinus membrane perforation. In 1910, Underwood[18] examined 90 maxillary sinuses in 45 human skulls and found the prevalence of septa to be 33%. At present, septa in the maxillary sinus are often referred to as Underwood septa because of his pioneering work. Velasquez-Plata et al.[19] in their study of 312 sinuses found an overall prevalence of maxillary septa to be 32% for all patients and 24% for each maxillary sinus. Kim et al.[20] found a 26.5% prevalence of septa in 200 maxillary sinuses. A precise evaluation can be performed using latest imaging techniques like using computed tomography (CT) which may aid to determine the three-dimensional anatomy of the sinus to reduce the rate of perforation. When the presence of septa are pre-determined inside the maxillary sinus, lengthening of the window in the anteroposterior direction is advised so as to allow a lateral-to-medial elevation of the sinus membrane from either side of the septum. An alternative approach is the creation of two separate bony windows; taking into consideration that small sized windows may complicate the access and vision. Though clinical observation during surgery is the most common method for evaluation of perforated membranes, endoscopic evaluation is highly accurate and reliable. Use of piezoelectric surgery is considered to be a valuable adjunct to sinus augmentation surgery as it results in significant decreased rates of membrane perforation rates. Using diamond burs and elevating the membrane from lateral to medial, keeping the instrument in close contact with the bone throughout the surgical procedure also reduces the chances of perforation. The survival rate of implants has been reported to be 97.14% if the perforation of the maxillary sinus membrane is smaller than 5 mm, which is not significantly different from the normal survival rate of implants. However, since in cases of perforations with a size between 5 to 10 mm, survival rate is decreased to 91.89% and to 74.14% in cases of perforations larger than 10 mm, special care should be employed during surgery to avoid tearing the membrane.[20] When there is a perforation of the maxillary sinus membrane, simultaneous implant placement decreases the survival rate to 90.81%, hence there is a need to consider a two-staged approach.[21] Perforations most commonly have been repaired with the use of resorbable collagen

membranes interposed between the graft material and the Schneiderian membrane. During osteotome sinus augmentation, identification of the perforations are more difficult but may be repaired with a collagen plug placed into the site of osteotomy before insertion of the implant. Other means of repair of smaller perforations could include folding the membrane on itself, covering the perforation with collagen tape, use of resorbable membranes or freeze-dried human lamellar bone sheets. Larger perforations require careful suturing. As an alternative to suturing, use of fibrin adhesives or sealants for repair of perforations has also been advocated.[22-24]

Bleeding

Excessive bleeding is the second most common intraoperative complication of sinus augmentation procedure.[25] The anterior antral wall is densely populated with blood vessels; anastomosis occurs between the posterior superior alveolar artery and the infraorbital artery. Solar et al.[26] states that the average height from the alveolar ridge of these vessels is 18.9 to 19.6 mm which is in close proximity to the location of the created lateral window. Tearing of this vessel may complicate the surgical procedure by introduction of severe haemorrhage in the operative field. Most bleeding episodes are usually minor but, in some cases, profuse bleeding may occur which is difficult to control in a timely manner and induce additional complications such as impairment of blood supply, sinus membrane perforation and displacement of the graft material.[26] Hypertensive state of the patient may induce an abnormal increase in intraoperative bleeding which can be controlled with local anaesthesia injection or local application, verbal reassurance, and additional sedation for anxiolysis.[27] Firm digital pressure, direct ligation of the bleeding vessels, application of local haemostatic agents, burnishing the bleeding site with burs, use of piezo surgery for creation of the bony window and electrocautery have all been advocated for haemostasis.[28]Furthermore, upright posture of the patient can decrease bleeding by 38%, assisting in control of the bleeding.[29]

Inadequate primary stability

Implant stability initially relies on the host bone density and thickness the created osteotomy site, while future additional support is gained via integration of the grafted material with newly formed host bone. Optimal primary stabilization at the time of implant placement is an essential prerequisite for successful implant survival.[30] Lack of primary stabilization may result from inappropriate case selection in which patients have insufficient bone height or width, poor bone quality and density or due to iatrogenic causes like over preparation with the osteotomes. To avoid such complications, correct selection of patients, under-preparation of the implant bed followed by insertion of a substantially larger diameter implant, use of tapered implants instead of parallel-walled implants and use of rough surface implants has shown to increase the primary stability.[30]

Displacement of implant in the sinus cavity

Accidental dislodgement of dental implants into the sinus cavity can occur due to over preparation, when minimal crestal bone is engaged and excessive torque is applied for implant placement or due to poor primary stability of the implant. In this respect, taper-type implants with greater thread depths are advantageous over straight-type implants. At present, either the Caldwell Luc technique or the endoscopic technique is employed for removal of foreign objects from the sinus cavity. Although both procedures are effective, removal though endoscopy may induce minimal postoperative discomfort, swelling and oedema for the patient.[31]

Other complications

Improper surgical technique may lead to iatrogenic errors like tearing of the buccal flap in an attempt to achieve a tension-free closure. Hence, one must adhere to the basic surgical protocols of careful tissue handling and avoid redundant release of the buccal flap. Advancement flaps such as pedicled buccal mucosal flap may be considered in cases where sufficient tension-free closure is not achieved only by buccal flap release.

Communication between the sinus and oral cavity can occur intraoperatively or post-operatively following extractions of molars, loss of implants placed into the sinus, and improper wound healing after sinus augmentation procedures. If the communication between the two cavities remain patent, epithelialization occurs creating an oroantral fistula. Mobilization of a flap or free soft tissue grafts can be used to cover the oroantral fistula as recommended by numerous techniques in the literature.

Yet, another persistent and annoying complication related to poor surgical technique is the infraorbital nerve damage, resulting in short- or long-term paraesthesia occurring from pressure on the nerve during the flap retraction or dissection of the soft tissues.[32] Additionally, overfilling of the graft material should be avoided because it may lead to the obstruction of the antral meatal ostium complex leading to congestion and chronic sinusitis at a later date.[33]

Acute postoperative complications include pain, swelling, oedema, infection of the surgical site and sinus, sinusitis, bone resorption, bleeding, oral and nasal ecchymosis and hematoma (especially hemosinus), emphysema, wound dehiscence, incisional breakdown, the loss of the graft, BPPV (Benign paroxysmal positional vertigo), and temporary or permanent palatal numbness.[34]

Maxillary Sinusitis-

Maxillary sinusitis is characterized by a triad of symptoms that include nasal congestion, purulent discharge and headaches.[35] Preoperative selection and screening of patients with predisposing factors for sinusitis is a pre-requisite to reduce the incidence of sinusitis developing after augmentation surgery. Preoperative use of antibiotics, steroids, and nasal decongestants are advised to reduce the risk of obstruction of the ostium postoperatively.[2] However, if the patient suffers from postoperative transient sinusitis, nasal decongestants' steam inhalation and antibiotic therapy is recommended. If the symptoms persist even after 2 weeks and becomes chronic, functional endoscopic sinus surgery may be necessary.[2]

BPPV (Benign paroxysmal positional vertigo)

A faulty technique using a mallet and an osteotome for elevation of the inferior border of maxillary sinus can lead to occurrence of BPPV. This disorder might occur when otoliths (ear rocks) in the utricular macula get detached by the impact of malleting and moves every time the head position of the patient is changed, causing dizziness and vertigo. Informed consent must always be taken before surgery if use of an osteotome is necessary. People aged 50 to 69 years are inflicted with this condition most often and the incidence of BPPV increases with age. When BPPV occurs, the symptoms are improved by the Epley manoeuvre. The Epley manoeuvre is a method of returning displaced otoliths to their original position by changing the position and direction of the patient's head.

Finally, chronic postoperative complications include infection, sinusitis, implant periapical lesion, and postoperative maxillary cyst.[34]

Graft infection

Infection of the sinus graft is a rare but important complication with a reported incidence up to 4.7%.[36] Predisposing factors include pre-existing sinus infection,

sinus membrane perforation, salivary contamination of the graft, wound dehiscence, and improper aseptic technique. The symptoms of the graft infection include tenderness, fistulous tract formation, suppuration and pus discharge, oedema, hyperthermia and loss of graft particles through the fistulous tracts (popcorn sign). The condition is addressed urgently to prevent intra orbital or intra cranial spread of the infection. Several modalities of treatment includes irrigation of the sinus cavity, drainage, administration of systemic antibiotics and partial or total removal of the infected graft material.[37] Mahler et al.[38] have described "the Dome phenomenon," which refers to a dense, solid, hard tissue maintained in the superior most aspect of the grafted area in case of a graft infection. They reported successful outcomes with partial removal of the infected graft until this dome-shaped area is reached, indicating the regenerative potential of the Schneiderian membrane.[38]

Other complications-

Any invasive surgical procedure may get complicated by post-operative swelling, purulent discharge and development of a hematoma. Protocols to reduce post-operative swelling include pharmacological control in the form of non-steroidal anti-inflammatory drugs and steroids. Management of purulent discharge includes complete drainage along with antibiotic therapy.

Bleeding postoperatively may occur because of improper proper flap management and closure. Pressure placed over the surgical area immediately following closure may reduce the incidence of postoperative bleeding. The incidence of membrane perforation has been discussed previously and may play a role in epistaxis postoperatively. Close monitoring of the patient for infection is recommended. Proper tissue handling is important closure of the wound after surgery. A tension-free flap is deemed necessary to ensure undisturbed healing with decreased chance for dehiscence. The use of membranes, particularly non-resorbable membranes used over the lateral window osteotomy site may cause an increase in dehiscence and incision line opening after sinus augmentation surgery that directly affect implant survival rate.[39]

Finally, **chronic postoperative complications** include infection, chronic maxillary sinusitis, implant periapical lesion, and postoperative maxillary cyst.[34]

Cystic lesions

Three cystic lesions may be found in the maxillary sinus: (1) pseudocysts; (2) retention cysts; and (3) mucoceles.[34] Pseudocysts lack a definitive epithelial lining and were previously termed as non-secreting cysts. Retention cysts are cystic enlargements of glandular ducts and are lined with epithelium, previously termed as secreting cysts. Mucoceles are extravasations of mucous into the surrounding soft tissues occurring secondary to trauma or obstruction of salivary flow.[40,41] Garg et al.[27] stated the presence of a mucocele that was not revealed during pre-operative initial radiographic assessment. In his report, complete removal of the cyst was performed through curettage and irrigation without any untoward post-operative complications. Pikos[42]recently introduced a one stage technique that permits simultaneous removal of retention cysts and augmentation of the maxillary sinus. After complete removal of the cyst, slow resorbing collagen membranes are adapted to completely cover the void left behind by the mucous retention cyst. With this approach, even when large perforations are encountered, early termination of sinus augmentation procedures are eliminated.

Implant periapical lesions

These rarely occur in the maxilla after sinus augmentation procedures but they occasionally when excessive heat is generated during drilling. An interval of at least one

minute should be present between two successive drilling sessions to reduce the amount of generated heat. Chilled saline in place of saline at room temperature also helps. Irrigation can be performed by inserting a syringe needle tip inside the osteotomy site resulting in lowering of the temperature inside the bone and removal of the bone chip debris generated during drilling.

Conclusion

Maxillary sinus augmentation procedure prior to dental implant placement is a predictable and safe procedure for atrophic maxillary ridges. Certain complications arising intra-operatively may influence the outcome of therapy. Proper pre-operative planning and patient assessment will result in avoidance of or early detection of the complications. Early management of these complications will minimize the negative effects on therapy and can prolong the long-term success and survival of the implant prosthesis.

References

1. O. T. Jensen, L. B. Shulman, M. S. Block, and V. J. Lacono, “Report of the sinus consensus conference of 1996,” International Journal of Oral and Maxillofacial Implants, vol. 13, supplement, pp. 11–34, 1998.
2. N. M. Timmenga, G. M. Raghoebar, G. Boering, and R. Van Weissenbruch, “Maxillary sinus function after sinus lifts for the insertion of dental implants,” Journal of Oral and Maxillofacial Surgery, vol. 55, no. 9, pp. 936–940, 1997.
3. L. Pignataro, M. Mantovani, S. Torretta, G. Felisati, and G. Sambataro, “ENT assessment in the integrated management of candidate for (maxillary) sinus lift,” Acta Otorhinolaryngologica Italica, vol. 28, no. 3, pp. 110–119, 2008.
4. S. Torretta, M. Mantovani, T. Testori, M. Cappadonna, and L. Pignataro, “Importance of ENT assessment in stratifying candidates for sinus floor elevation: a prospective clinical study,” Clinical Oral Implants Research, 2011.
5. Bathla SC, Fry RR, Majumdar K. Maxillary sinus augmentation. J Indian Soc Periodontol 2018;22:468-73.
6. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986;30:207 -29.
7. Bathla SC, Fry RR, Majumdar K. Maxillary sinus augmentation. J Indian Soc Periodontol 2018;22:468-73.
8. Veen M, Lardenoye J, Kastelein G, Breslau P. Recording and classification of complications in a surgical practice. European Journal of Surgery 1999; 165:421-4.
9. Karmody CS, Carter B, Vincent ME. Developmental anomalies of the maxillary sinus. Trans Sect Otolaryngol Am Acad Opthalmol Otolaryngol. 1977:84(4 Pt 1): 723-728
10. Standring S. Gray's anatomy: the anatomical basis of clinical practice. 41st ed. London: Elsevier Health Sciences; 2015.
11. Duncavage J. The maxillary sinus: medical and surgical management. New York: Thieme Medical Publishers; 2011.
12. Moore WJ. The Mammalian Skull. Cambridge: Cambridge University Press; 1981
13. McGowan DA, Baxter PW, James J. The Maxillary Sinus and its Dental Implications. Oxford: Wright, Butterworth-Heinemann Ltd.; 1993:1-25.
14. Krennmair G, Ulm CW, Lugmayr H, Solar P. The incidence, location, and height of maxillary sinus septa in the edentulous and dentate maxilla. J Oral Maxillofac Surg. 1999; 57(6):667-671; discussion 671-672.

15. Boyne PJ. Grafting of the maxillary sinus floor with autogenous marrow and bone. Journal of Oral Surgery. 1980;38:613-616
16. Engelke W, Deckwer I. Endoscopically controlled sinus floor augmentation. A preliminary report. Clinical Oral Implants Research. 1997;8:527-531
17. Barone A, Santini S, Sbordone L, Crespi R, Covani U. A clinical study of the outcomes and complications associated with maxillary sinus augmentation. Int J Oral Maxillofac Implants 2006;21:81-5.
18. Underwood AS. An Inquiry into the anatomy and pathology of the maxillary sinus. J Anat Physiol. 1910;44:354-369.
19. Velasquez-Plata D, Hovey LR, Peach CC, et al. Maxillary sinus septa: A 3-dimensional computerized tomographic scan analysis. Int J Oral Maxillofac Implants. 2002;17:854-860.
20. Kim YK, Kim JA. Evaluation of factors which affect the prognosis of sinus bone graft and implant placement. J Dent Implant Res 2012;31:31-7.
21. Hernández-Alfaro F, Torradeflot MM, Marti C. Prevalence and management of Schneiderian membrane perforations during sinus-lift procedures. Clin Oral Implants Res 2008;19:91-8.
22. Choi BH, Zhu SJ, Jung JH, et al. The use of autologous fibrin glue for closing sinus membrane perforations during sinus lifts. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101:150-154.
23. Shin HI, Sohn DS. A method of sealing perforated sinus membrane and histologic finding of bone substitutes: A case report. Implant Dent. 2005;14:328-333.
24. Sullivan SM, Bulard RA, Meaders R, et al. The use of fibrin adhesive in sinus lift procedures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997;84:616-619.
25. Maridati P, Stoffella E, Speroni S, Cicciu M, Maiorana C. Alveolar antral artery isolation during sinus lift procedure with the double window technique. The Open Dentistry Journal. 2014;8:95
26. Solar P, Geyerhofer U, Traxler H, et al. Blood supply to the maxillary sinus relevant to sinus floor elevation procedures. Clin Oral Implants Res. 1999;10:34-44.
27. Garg AK. Augmentation grafting of the maxillary sinus for placement of dental implants: Anatomy, physiology, and procedures. Implant Dent. 1999;8:36-46.
28. Flanagan D. Arterial supply of maxillary sinus and potential for bleeding complication during lateral approach sinus elevation. Implant Dent. 2005;14:336-338.
29. Gurr P, Callanan V, Baldwin D. Laser-Doppler blood flowmetry measurement of nasal mucosa blood flow after injection of the greater palatine canal. J Laryngol Otol. 1996;110:124-128.
30. Aparicio C, Lang NP, Rangert B. Validity and clinical significance of biomechanical testing of implant/bone interface. Clinical Oral Implants Research. 2006;17:2-7
31. Nakamura N, Mitsuyasu T, Ohishi M. Endoscopic removal of a dental implant displaced into the maxillary sinus: Technical note. Int J Oral Maxillofac Surg. 2004; 33:195-197.
32. Tourbah B, Maarek H. Complications of maxillary sinus bone augmentation: Prevention and management. In: Sinus Grafting Techniques. Cham, Switzerland: Springer; 2015. pp. 195-233
33. Maridati P, Stoffella E, Speroni S, Cicciu M, Maiorana C. Alveolar antral artery isolation during sinus lift procedure with the double window technique. The Open Dentistry Journal. 2014;8:95

34. Kim J, Jang H. A review of complications of maxillary sinus augmentation and available treatment methods. J Korean Assoc Oral Maxillofac Surg 2019;45:220-224. https://doi.org/10.5125/jkaoms.2019.45.4.220
35. Yonkers AJ. Sinusitis—Inspecting the causes and treatment. Ear Nose Throat J. 1992;71:258-262.
36. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: Clinical results with different bone grafts and bone-substitute materials. The International Journal of Oral & Maxillofacial Implants. 2009;24:218-236
37. Urban IA, Nagursky H, Church C, Lozada JL. Incidence, diagnosis, and treatment of sinus graft infection after sinus floor elevation: A clinical study. The International Journal of Oral & Maxillofacial Implants. 2012;27:449-457
38. Mahler D, Levin L, Zigdon H, Machtei EE. The "dome phenomenon" associated with maxillary sinus augmentation. Clinical Implant Dentistry and Related Research. 2009;11:e46-e51
39. Ewers R. Maxilla sinus grafting with marine algae derived bone forming material: A clinical report of long-term results. J Oral Maxillofac Surg. 2005;63: 1712-1723
40. Gardner DG, Gullane PJ. Mucoceles of the maxillary sinus. Oral Surg Oral Med Oral Pathol. 1986;62:538-543.
41. Gardner DG. Pseudocysts and retention cysts of the maxillary sinus. Oral Surg Oral Med Oral Pathol. 1984;58:561-567.
42. Pikos MA. Maxillary sinus membrane repair: Update on technique for large and complete perforations. Implant Dent. 2008;17:24-31.

How to citation this article: Dr. Mohsina Hussain, Dr. Madhumaitri Patra, Dr. Anik Sarkar, Dr. Debabrata Gayen, Dr. Subhajit Saha, "A brief review of complications of maxillary sinus augmentation – etiological factors and existing treatment options", IJMACR- July- August - 2020, Vol – 3, Issue -4, P. No. 25 – 33.