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MINIREVIEWS

Evaluation of anatomical considerations in the posterior maxillae for sinus augmentation

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Abstract

The edentulous posterior maxilla is considered a clinical challenge during dental implant treatment for many dental practitioners. This is because its insufficient bone quality, deficient alveolar ridge, spiny ridges, undercuts, and sinus pneumatization are often encountered after tooth loss. To overcome these problems, several approaches have been developed and are currently used, including sinus augmentation and bone augmentation. Today, two main procedures of sinus floor elevation for dental implant placement are in use: a two-stage technique using the lateral window approach, and a one-stage technique using a lateral or a crestal approach. In this study, we deal with the anatomic relations of the structures of the maxillary sinus during sinus augmentation. These anatomical findings can help in complications and potential injuries of the maxillary sinus procedures. It can be suggested that pre-operative evaluation is helpful for diagnosis and treatment planning and minimizing complication during the surgery.

Key words: Anatomy; Intraoperative complications; Sinus floor augmentation

Core tip: The edentulous posterior maxilla is considered a clinical challenge during dental implant treatment. Sinus augmentation and bone augmentation are used to overcome these problems. Maxillary sinus septa have been related to increased risk of perforation of the membrane during sinus augmentation. The lateral window design may be modified by the making of two windows or one w-shape window if the septum is lower. The branches of the maxillary artery should be taken into consideration to avoid bleeding complications. It can be suggested that pre-operative evaluation is helpful for diagnosis and treatment planning and minimizing complication during the surgery.

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INTRODUCTION

For many dental practitioners, the edentulous posterior maxilla is considered a clinical challenge during dental implant treatment[1]. This is because its insufficient bone quality, deficient alveolar ridge, spiny ridges, undercuts,

Figure 1 Buccal and clinical view. A: Buccal view after elevation of sinus membrane; B: Buccal view after installation of dental implants; C: Clinical view after application of graft material.

and sinus pneumatization are often encountered after tooth loss. Several approaches have been developed and are currently used to overcome these problems, two of them being sinus augmentation and bone augmentation[2,3]. Elevation of the maxillary sinus floor was first published by Boyne *et al*[4] in 1980. After these reports, several techniques were reported for successful sinus floor elevation, including crestal and transalveolar approaches[5,6]. A crestal approach uses the osteotome technique introduced by Summers in 1994[5]. Today, dental practitioners use two main procedures of sinus floor elevation for dental implant placement: a two-stage technique using the lateral window approach, and a one-stage technique using a lateral or a crestal approach (Figure 1)[7].

In this report, we have reviewed anatomical consideration in the posterior maxillae for sinus augmentation, to ensure predictable sinus graft surgery and help decide surgical technique with minimum complication. Preoperative evaluation seems necessary for implant surgery to succeed without complication.

ANATOMY OF MAXILLARY SINUS

Before performing sinus augmentation surgery, it is crucial to understand the anatomy of maxillary sinus. The function of the maxillary sinus is not yet well known. Theories on its physiologic function include: (1) weight reduction to maintain equipoise of the head; (2) protection of intracranial structures; (3) thermal insulation of vital parts; (4) humidification and warming of inhaled air; (5) secretion of mucus to moisten the nasal cavity; (6) secretion of mucus to moisten the nasal cavity; (7) increasing the area for olfaction; and (8) imparting resonance to the voice[8].

The maxillary sinus is the largest and most constant of the paranasal sinuses. After birth, it undergoes two periods of rapid growth, first between birth and 3 years since, and then between ages 7 and 18 years[9]. The maxillary sinus has a pyramidal shape, with an anterior wall corresponding to the facial surface of the maxilla. Its posterior bony wall separates it from the pterygomaxillary fossa medially and from the infratemporal fossa laterally. Its medial wall is the lateral nasal wall and separates the sinus from the nasal cavity and communicates with the nasal cavity *via* the ostium semilunaris to the hiatus semilunaris (middle meatus)[10]. The ostium of the maxillary sinus is high up on the medial wall and on average is 2.4 mm in diameter[10].

The Maxillary sinus floor consists of the alveolar process of the maxilla. The sinus floor is usually convex, with its lowest point around the first and second upper molars[11]. As aging occurs, the sinus floor tends to resorb and form dehiscences around the roots[12]. The root ends may jut into the cavity, covered only by the Schneiderian membrane and a small bone cortex flap[13].

SINUS PNEUMATIZATION AND RESIDUAL BONE RESORPTION

Maxillary sinus pnematization is a physiologic process

Figure 2 Panoramic view from cone beam computed tomography showing septum.

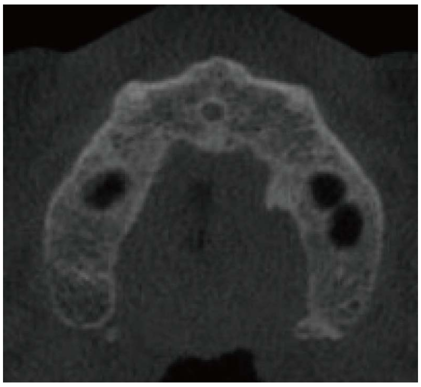

Figure 3 Axial view from cone beam computed tomography with septum on left maxillary sinus.

that occurs in all paranasal sinuses during the growth period, causing them to increase in volume[14]. The reasons for sinus pneumatization are poorly understood, but factors that cause this process include heredity, the pneumatization drive of the nose's mucous membrane, craniofacial configuration, density of the bone, growth hormones, sinus air pressure, sinus surgery, and posterior tooth extraction[15]. According to a radiographic study, pneumatization was more significant after extraction of teeth enveloped by a superiorly curving sinus floor, extraction of several adjacent posterior teeth, and extraction of second molars as opposed to first molars[15].

Residual ridge resorption following tooth extraction is unavoidable process in posterior maxillary area. Extensive ridge resorption is one of the many problems for implant-prosthetic treatment in the posterior maxillae. Although resorption rate is subject to individual variability and almost resorption occurs in 6 mo after extraction, the alveolar ridge resorption persists for subsequent years to decades[16,17].

Available alveolar bone may be compromised in the in the posterior maxillae may be compromised because of sinus pneumatization and/or residual ridge resorption after tooth loss. The average height of the available bone in the edentulous maxilla was classified into three classes[14]. Class 1 had a residual bone height of 10 mm, usually found in edentulism of no more than 5 years' standing. Class 2 had a residual bone height of 5-10 mm, usually found in edentulism of 5-10 years. Class 3 indicated a bone height of 0-5 mm, usually found in edentulism of more than 10 years. A previous report has recommended that sinus augmentation be performed in classes 2 and 3. If the implant with 10 mm length is planned, sinus augmentation should be considered in Classes 2 and 3.

SEPTA OF THE MAXILLARY SINUS

Maxillary sinus septa are barriers of cortical bone that divide the maxillary sinus into multiple compartments, known as recesses. Diagnosis of septa presence by computed tomography is important for planning maxillary sinus elevation surgery and later separating the sinus membrane from the septa (Figures 2 and 3)[18]. Septa have become increasingly important in maxillary sinus anatomy as surgical technique has developed. The cause of antral septa has been described previously[19]. Congenital septa are thought to have evolved during the growth of the middle part of the face, and the other, secondary septa are reported to be arisen from irregular pneumatization of the sinus floor after tooth extraction. Other reports classify septa as primary septa if they are located above the maxillary tooth and as other septa if they are located above an edentulous ridge, since septa may be either primary or secondary, or a combination of both types[20,21].

A previous report has showed that septa are significantly higher in the atrophic sinus than in the dentate maxillae, and septa are more commonly located in the molar regions than in the premolar and retromolar areas[22]. Prevalence of sinus septa is between 20% and 35%[19,23], and the mean height of septa is 7.5 mm[22]. Diagnosis using two-dimensional panoramic radiographs yields incorrect results in 29% of cases, and it has been suggested that three-dimensional computed tomography may be used to avoid complications during sinus augmentation[22].

The septum has been related to increased risk of perforation of the membrane during sinus augmentation[24,25]. The lateral window design may be modified by the making of two windows or one w-shape window if the septum is lower (Figure 4). Septa may be cut with a chisel and be removed so that the graft can be placed without interruption[20].

VASCULAR SYSTEM OF THE MAXILLARY SINUS

The blood supply of the maxillary sinus is derived from three arteries: the infra-orbital artery, the posterior lateral nasal artery, and the posterior superior alveolar artery[26,27]. Among these arteries, the posterior superior alveolar artery and the infra-orbital artery supply the buccal part of the maxillary sinus, and they also supply local oral mucosa as well as the mucous membrane in a double

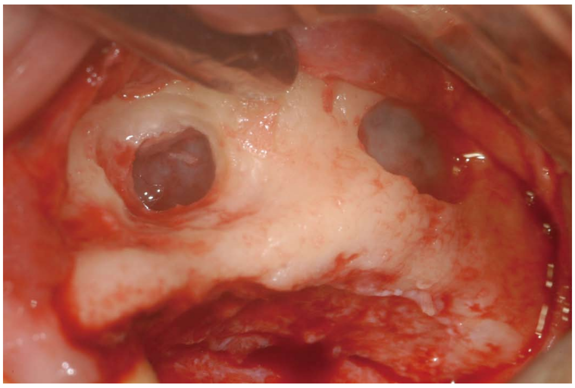

Figure 4 Buccal view showing lateral window design having two windows.

arterial circle[28]. The posterior superior alveolar artery enters the pterygopalatine fossa, and divides into one extraosseous and one intraosseous branch, which enter the maxillary tuberosity[29]. To prevent damage to the extraosseous anastomosis, it is crucial to analyze its height from the cortical bone, its diameter, and the course of the artery. The anastamosis forms a concave arch at the first molar, and that is the lowest point of the bony canal's arch course, and the mean distance between the bone crest and the canal is 19 mm[26,30]. An intraosseous vascular canal at the lateral antral wall has been found in over 50% of cases[28]. To avoid bleeding complications, the branches of the maxillary artery should be taken into consideration.

SCHNEIDERIAN MEMBRANE

The Schneiderian membrane lines the inner walls of the sinus, which is represented by ciliated columnar cells, goblet cells, and basal cells resting on the basement membrane[10]. The membrane's thickness varies but is generally 0.3-0.8 mm in unfixed, fresh cadavers without sinusitis[31]. A study with cone beam computed tomography has showed that individuals vary greatly in the thickness of their Schneiderian membranes, from 0.16 to 34.61 mm, and the highest mean values have been found in the midsagittal aspect[32]. Other local or systemic factors that influence the thickness of the Schneiderian membrane are described in previous reports. Gingival thickness and sex are reported to be related to the Schneiderian membrane's thickness: the membrane is thicker in patients with thick gingival biotype and thinner in female subjects[32-34]. Higher Schneiderian membrane thickness has been noted next to restored teeth and periodontal and endodontic lesions. Especially in molar regions with periodontal destruction, the Schneiderian membrane has thickened, particularly when there are small bone layers above the root tips or periapical lesions. In addition, inflammation or allergic phenomena, as well as smoking, are correlated with increased mucosal thickness[35].

It has been shown that the Schneiderian membrane swells significantly, by 6.7 mm, after sinus augmentation, and that this swelling disappears three weeks later[36]. In one report, patients' computed tomographic scans have been compared before bone grafting and 4 to 6 mo after bone grafting[37]. Sinus membrane thickness differs significantly before (0.8-1.2 mm) and after (1.5-1.3 mm) augmentation surgery, with a mean increase of 0.8-1.6 mm (maximum: 4.4 mm), and only 28% of augmented sinuses do not show membrane thickening. Other reports, however, show no significant change in the membrane thickness between computed tomographic scans taken before operation and an average of 8.9 mo after operation[38]. This discrepancy may be explained by the study design: the latter study excluded bilateral sinus augmentations and had higher membrane thickness before operation, with a higher history of periodontitis (75.7 %).

Which types of mucosal thickening require therapy is still unknown, but historically 2 mm is considered a reliable threshold for pathological mucosal swelling[39]. Since the most frequent surgical complication occurring during sinus augmentation is perforation of the Schneiderian membrane (10%-56%)[40], it is crucial to check the Scheniderian membrane status by cone beam computed tomography or with an endoscope, and to eliminate sinusitis and other potential pathological conditions before any surgery. A previous study shows that 38.2% of presumably reversible ear, nose, and throat contraindications have been detected and resolved before sinus augmentation, and the same study suggests that a careful multitasking preoperative management, including an ear, nose, and throat assessment with fiberoptic endoscopy and a radiological evaluation extended to the ostiomeatal complex, may be very useful in candidates for sinus augmentation[41].

CONCLUSION

In this report, we have dealt with the anatomic relations of the structures of the maxillary sinus during sinus augmentation. These anatomical findings can help with complications and potential injuries in procedures involving the maxillary sinus. It can be suggested that preoperative evaluation is helpful for diagnosis and treatment planning, as well as for minimizing complications during surgery.

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