

CBCT Study of Morphologic Variations of Maxillary Sinus Septa in Relevance to Sinus Augmentation Procedures

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Abstract

Background: Augmentation of the maxillary sinus increases the lost height of ridge in the posterior maxilla. Bony convolutions from the floor of the sinus called septa may be encountered during the procedure and significantly impact the outcome of the procedure. **Materials and Methods:** For this retrospective study, 120 cone-beam computed tomography (CBCT) scans were collected from the archives of the department of oral radiology in the time period between January 2016 and August 2018. Planmeca Romexis® software version 3.2.7 was used to check for the incidence, and then among the septa, plane of orientation, location with respect to the wall of the sinus, and in terms of relation to tooth were examined. The average height and average width of all the septa were measured using a measuring tool in the software. **Results:** Thirty-five of the total 88 patients showed septa in 40 sinuses, in which 36 sinuses showed one septum and 4 sinuses showed 2 septa. Forty-one septa were located on the floor of the sinus in the frontal orientation and 3 septa were located on the lateral wall of the sinus in the axial orientation. The mean height and mean width of the 41 septa on the floor of the sinus were 5.72 mm and 3.47 mm, respectively. The mean height of septa found on the lateral wall of the sinus was 5.59 mm. **Conclusion:** Septa had a higher tendency to be in bucco-palatal direction and on the floor of the sinus and frequent occurrence in the region of molars. A thorough prediagnostic evaluation using CBCT is necessary prior to sinus augmentation procedures.

Keywords: Cone-beam computed tomography, maxillary sinus, maxillary sinus augmentation, maxillary sinus septa, Schneiderian membrane

INTRODUCTION

The increasing awareness of patients toward the advancing fields of dentistry demands the field to introduce treatment plans that provides for comfort, function, esthetics, and long-lasting results. As a consequence of tooth loss, the alveolar ridge adjacent to maxillary sinus often presents with reduced height due to the resorption of the ridge and pneumatization of the sinus.^[1] First invented by Tatum and documented by Boyne and James, sinus augmentation has proven to be a successful procedure and is still advocated widely today for increasing bone height. Understanding the anatomical and the physiological aspects of the maxillary sinus is a must for a favorable outcome of treatment.^[2]

This pyramidal shaped cavity is lined by the Schneiderian membrane which has osteogenic potential, hence favoring bone formation during augmentation. The approaches for

sinus augmentation involve either direct or indirect lifting of this membrane creating a tent which can be either grafted or left as it is for the formation of new bone. Hence, patency of the Schneiderian membrane is critical to the success of the treatment.^[3]

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Perforation of this membrane is seen as the most common complication during the surgery.^[4] Membrane perforation has been linked with many risk factors, but the most important factor is the presence of anatomical variations in the sinus called the septum.

Maxillary sinus septa, first discovered by Underwood,^[5] hence named Underwood's septa, are anatomical variations which can present either as a congenital anomaly^[6] or as a result of the irregularly expanding sinus floor after the loss of the tooth or teeth and are termed as primary and secondary septa,^[7] respectively.

Of importance in relevance to the placement of implants is the septa that are seen in the floor of the sinus or along the lateral wall, as these septa can interfere with the placement of an implant either directly by being present in its area of placement or indirectly by hindering the elevation of the wall during lateral sinus approach. Furthermore, the risk of tearing of the Schneiderian membrane is high in the presence of the septum.^[8] One more factor is the accidental or imprudent application of surgical technique leading to fracture of the septum causing a tear of the membrane.

Orienting the septum in different planes is helpful in analyzing the difficulty of the approach of the surgical procedure and helps in modifying the technique accordingly. The location of the septum is seen most often in the edentulous area and hence in the area of interest. The height of the septum can vary from small secondary septa to tall primary septa. Often similarly, the width of the septum varies at the level of the sinus floor.^[9]

A successful treatment can thus only be achieved by understanding the importance of this anatomical variance of septa in the maxillary sinus and its characteristics.

Aim

The aim of the study was to determine the incidence and the morphology of the septa.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Prosthodontics, of a teaching dental institution. Cone-beam computed tomography (CBCT) scans of the patient that were taken for preoperative assessment for the placement of implants in the posterior maxillary region from January 2016 to August 2018 were taken into the study. Patients considered in the study were above the age of 20 years, and the CBCT scans that showed partially edentulous alveolar ridge with respect to the maxillary sinus and completely edentulous alveolar ridges were only included. Patients below the age of 20 years and CBCT scans showing completely dentate with respect to sinus, radiologic presence of pathologies in the maxillary sinus or alveolar ridge, and the presence of artifacts in scans or

patient motion while taking the radiograph were excluded from the study.

One hundred twenty-four scans from 92 patients met the inclusion criteria and were considered in the study. Planmeca Romexis® software version 3.2.7 in by Planmeca Romexis 3D Mid 4.6 was used to analyze the CBCT scans. The study was focused on analyzing the incidence of septa in the study population. The scans involving septa were analyzed for localization, orientation, and height and width.

Scans were analyzed in the frontal, sagittal, and axial planes and skimmed three-dimensional (3D) reconstruction model [Figure 1].^[10] Once the presence of septa was determined, an appropriate plane was chosen, and it was located with respect to the wall of the sinus. For septa on the floor of the sinus, localization was done in relation to the tooth. The localization of septa was done at its point of origin from the sinus wall [Figure 2]. Axial sections were taken to determine the direction of the septa and accordingly oriented to the plane in which it was directed, i.e., in axial, frontal, or sagittal planes [Figure 3]. The height was measured at five different points along the length of the septa and an average of all the five measurements was taken as the final value. A baseline was drawn connecting the deepest points on either side of the septum. Using the measuring tool in the software, a line from the coronal most tip of the septa in that section was dropped to the point perpendicular to the baseline. The measurement of this line was taken as the height of the septa [Figure 4]. The height at five different points along the course of the septa was measured in the plane in which cross-section of the septa was visible. The final average of all the five measurements was documented as the height of the septa. The width of the septa was measured for septa that originated at the floor of the sinus. The axial section was taken to measure the width. The origin of the septa closest to the base of the sinus was focused and the measurements were made. Similar to height, width of the septa was measured at five different points and the final average of the five values was considered and documented [Figure 5].

The data obtained were entered into Microsoft Excel spreadsheet, and statistical analysis was done. The incidence of the septa present was documented with respect to the number of scans, number of patients, gender of patients, and sides of the maxillary sinus.

The presence of septa in different orientations, location in terms of the wall of the maxillary sinus, and relation to region of the tooth for those septa on the floor of the sinus were documented. These were represented in terms of frequency.

Mean and standard deviation of the height and width of the septa was calculated.

Association between age, gender, and presence of septa was calculated using Chi-square test.

RESULTS [TABLE 1-6]

Table 1: Distribution of septa among age and gender of the patients

	Septa		Total	Chi-square test	
	Absent	Present		χ^2	P
Gender					
Female	24 (60.0)	16 (40.0)	40 (100.0)	0.002	0.97 (NS)
Male	29 (60.4)	19 (39.6)	48 (100.0)		
Age (years)					
<30	6 (37.5)	10 (62.5)	16 (100.0)	9.01	0.03*
31-45	27 (75.0)	9 (25.0)	36 (100.0)		
46-60	12 (48.0)	13 (52.0)	25 (100.0)		
>61	8 (72.7)	3 (27.3)	11 (100.0)		

*P value <0.05 Statistically significant. NS=Not significant

Table 2: Descriptive Statistics of height of septa on the floor of the sinus**Height of septa on floor of sinus (mm)**

n: 41

Mean: 5.72

SD: 2.57

SE: 0.40

Minimum: 2.51

Maximum: 13.80

SD=Standard deviation; SE=Standard error

Table 3: Descriptive statistics of width of septa on the floor of the sinus**Width of septa on the floor of the sinus (mm)**

n: 41

Mean: 3.47

SD: 1.93

SE: 0.30

Minimum: 1.2

Maximum: 6.46

SD=Standard deviation; SE=Standard error

Table 4: Descriptive statistics of height and width of septa on the sinus floor in the left side of the sinus**Left side of the septa on the sinus floor (n=23)**

Height	Width
Mean: 5.64	Mean: 3.46
SD: 2.80	SD: 2.07
SE: 0.58	SE: 0.43
Minimum: 2.51	Minimum: 1.31
Maximum: 13.80	Maximum: 7.96

SD=Standard deviation; SE=Standard error

Table 5: Descriptive statistics of height and width of septa on the sinus floor in the right side of the sinus**Right side septa on the sinus floor (n=18)**

Height	Width
Mean: 5.83	Mean: 3.47
SD: 2.33	SD: 1.80
SE: 0.55	SE: 0.42
Minimum: 2.76	Minimum: 1.20
Maximum: 10.72	Maximum: 8.56

SD=Standard deviation; SE=Standard error

Table 6: Descriptive statistics of height of the septa on the lateral wall**Height of the septa on the lateral wall**

n: 3

Mean: 5.59

SD: 1.05

SE: 0.60

Minimum: 4.41

Maximum: 6.45

SD=Standard deviation; SE=Standard error

DISCUSSION

Ever since the significance of maxillary sinus septa in the field of implantology was understood, many studies were carried out to understand the morphological characteristics of this anatomical structure. From the time of its discovery in 1910 by Underwood and the embryology as explained by Neivert in 1930, the real relevance of septa with respect to implantology was acknowledged when a procedure for sinus augmentation was taken into consideration. Bett and Miloro^[11] in 1994 acknowledged the presence of maxillary sinus septa and described a modification in approaching the sinus through the lateral wall to accommodate the septa.

Membrane damage is seen to be mostly influenced by the thickness of the membrane and the presence of a septum.^[12-21] The Schneiderian membrane that lines along the inner wall of the maxillary sinus is said to be attached closely to a septum when present. Furthermore, as stated by Cakur *et al.*, thickness of the membrane is seen to reduce in case of the presence of a septa. Thus, the presence of septa further complicates the lifting of the membrane, as it provides an additional factor that can increase the chances of membrane perforation.

Septa whether of primary or secondary origin is seen to be prevalent in the range of 25%–66.7%. There was an increase in incidence reported when 3D radiographic techniques such as CT and CBCT were used to check for the existence of septa.^[22-32] CBCT over a CT further provides for the advantages of lesser radiation dose and reconstruction of the image in different panoramic and axial sections.

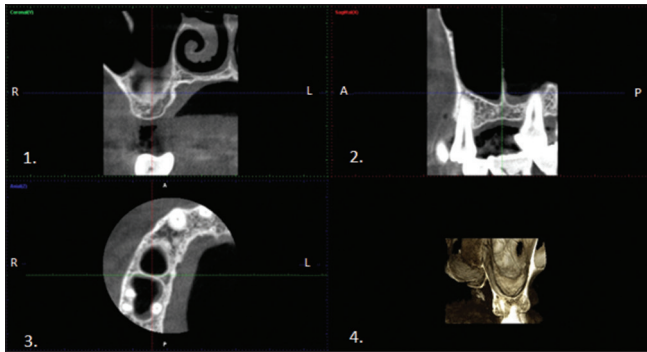


Figure 1: View of septa in all the planes

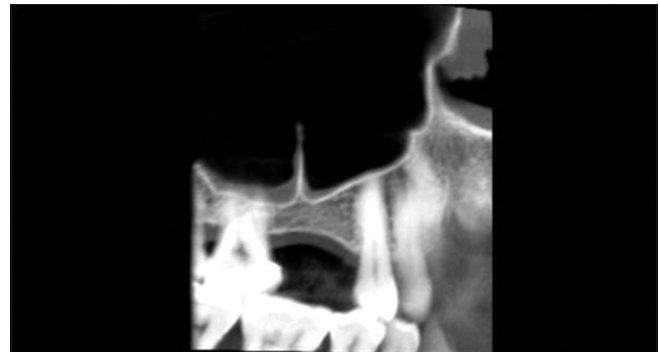


Figure 2: Localization of septa with respect to the wall of the sinus

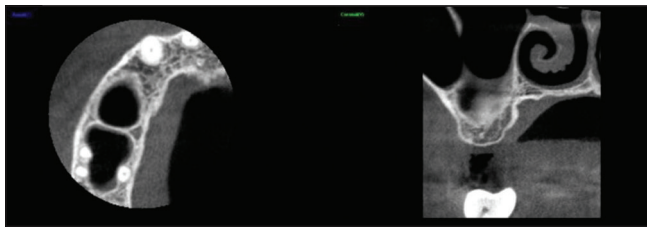


Figure 3: Orientation of septa

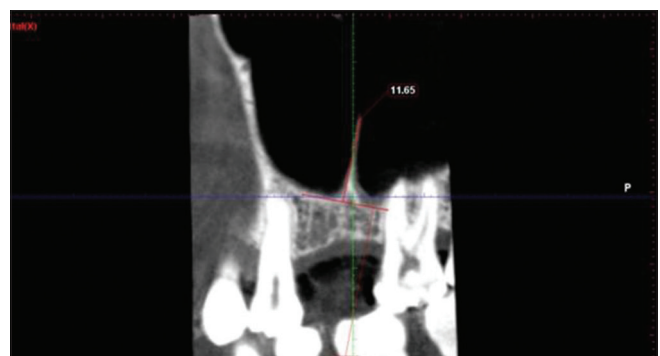


Figure 4: Measurement of height

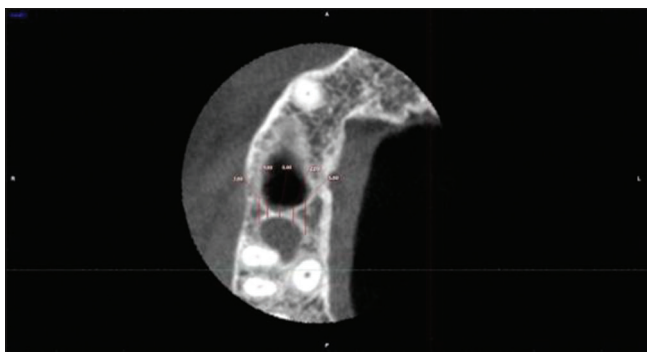


Figure 5: Measurement of the width of septa in five different areas

According to studies, sinuses with partially edentulous or completely edentulous areas presented with a greater prevalence of septa presenting in the range of 26.8%–53.9%. This increase in the presence of septa is most likely to be influenced by the phenomenon of uneven pneumatization of the sinus into the edentulous areas forming secondary septa. This expansion occurs in an unevenly fashion along different areas of the floor of the sinus owing to the differential rate of loss of teeth causing the bony cortical ridges to accentuate forming an irregularly shaped septum. These septa can be differentiated by their lack of regularly placed floor of the sinus on either side of the septa and their height which is generally lesser than the height of primary septa. A primary septum classically exhibits an inverted Gothic arch shape with a wider base tapering cranially that transmits the occlusal forces. However, Rancitelli *et al.* stated that the true origin of septa can only be established by a series of radiographs taken before and after exfoliation of the teeth.

In the present study, a total of 120 scans were considered from 88 patients. These scans were distributed as 45.45% (40) among females or 54.55% (48) among males.

Septa that were present on the floor of the sinus and on the lateral wall were only taken into consideration in the study. A total number of 44 septa were detected in the sinuses which were seen in 39.77% of the patients and 33.33% of the sinuses. This is in accordance with the previously reported studies where septa were reported in atrophic ridges in the range of 26.8%–53.9%. About 30% of the sinuses showed a single septum, while 3.33% of the sinuses showed two septa. In studying the distribution among the sides of the sinus, 24.24% on the left and 37.04% on the right showed one septum. About 6.06% on the left side showed sinus with two septa.

The distribution of septa when described among the gender, a total of 40% of the females and a total of 39.6% of the males presented with septa, i.e., an almost equal distribution of septa was seen among the gender groups. However, this association was not of statistical significance. It can be derived that the gender of the individual did not influence the presence of septa; however, further studies with a larger sample size can give a conclusive result.

Of the 44 septa seen, 93.18% of them originated from the floor of the sinus and 6.82% of them originated from the lateral wall. The location of septa that was on the floor of the sinus was designated corresponding to the area of teeth where it was present. About 15.91% was located in the first premolar region, 13.64% was located in the second premolar region, 40.90% was located in the first molar region, and 22.73% was located in the region of second molar. A higher number of septa were seen in the region of the first molar, followed

by the second molar and then the first premolar and second premolar.

Studies mentioned that 35.7%–70.94% of the septa were located in the middle region of the sinus that is in the region of the first and second molars. The present study also reported similar results where a majority of septa were concentrated in the region of the first and second molars. These multirooted molars often protrude into the sinus forming convolutions on the sinus floor, and also after their exfoliation, the socket takes a longer time to heal. These factors can impact on the effect of irregular pneumatization into the region of molars. As the formation of secondary septa is postulated due to uneven expansion of the sinus, this predominant location of septa in the region of sinus corresponding to molars can be explained.

The plane in which the septa were present determined the orientation of septa. Studies reported that a majority of septa were oriented in the bucco-palatal direction in the range of 61.8%–87.6%. Among the total 44 septa observed in the present study, the septa conforming to the floor of the sinus (93.18%) were all seen in a frontal plane traveling in a bucco-palatal direction. Three of the total septa that were seen originating from the lateral wall were seen in the axial plane (6.82%). The plane to which the septa conforms determines the modification of surgical approach. Opening the sinus through two access approaches on either side of the septa is suggested in both the orientations of septa.^[33]

Previous studies have mentioned the average height of the septa ranging from 5.4 to 7.3 mm when measured using 3D radiography. In the present study, an average height of septa was mentioned separately for those present on the floor of the sinus and those on the lateral wall. The average height measured for septa on the floor of the sinus was 5.72 ± 2.57 mm.

The width of the septa was also considered in the study. The bone type that a septum is made of is the cortical bone. As the density of the bone decreases, the stability of the implant also seems to decrease. Considering how the posterior maxillary bone is made predominantly of cancellous bone, engaging an implant in the available cortical bone of the septa can create an improvement in stability of the implant.^[34,35] The average width of the septa was hence measured at the level of its origin only for those that were present on the floor of the sinus to check for available width to engage an implant. The average width of the septa was 3.47 ± 1.93 mm. When placing an implant, there must be sufficient bone around it to stabilize the implant and allow for the remodeling that takes place during the healing phase. This required a minimum of 5 mm of bone width to be present to engage an implant. The present dimensions obtained were not wide enough to accept an implant. However, an absolute conclusion can only be derived by understanding this variance in a larger sample size.

The septa that were seen on the lateral wall were all oriented in the axial plane. According to studies, this type of septa is a rare occurrence reported in the range of 1.3%–7.6%.^[35] Of

significance to the placement of implant followed by sinus augmentation was that it can hinder in the opening of the window through lateral approach and cause difficulty in uplifting the membrane attached to the septum, and when it is placed at a lower height, it can physically hinder in the placement of the implant. Gülşen *et al.* had suggested a surgical approach to open two windows superior and inferior to the septa and augment them separately. When this type of septa is found closer to the floor of the sinus, it is recommended to remove the septa and proceed with the augmentation.

In the present study, a total of three septa were found on the lateral wall oriented in the axial plane. The average height was found to be 5.59 ± 1.05 mm.

A septum of this length can pose a problem in the treatment plan. Irinakis *et al.* had proposed a classification stating that axial orientation increases the difficulty level and requires significant operator experience to achieve a successful outcome.

The results obtained in the present study related to the studies previously performed, thus strongly opinionates on a detailed prediagnostic evaluation of maxillary sinus using CBCT and understanding the different treatment protocol while performing the treatment.

To obtain a definitive conclusion, randomized control trial can be conducted and a larger sample size would yield better results.

CONCLUSION

Within the limitations of the present study, it can be concluded that,

- Septa are seen to be occurring for one in every three patients in the present sample
- The most common orientation of septa is seen to be in the bucco-palatal direction, i.e., in the frontal plane
- Septa are frequently located on the floor of the sinus with a higher percentage in the region of the first molar
- The mean height of septa on the floor of the sinus was seen to be 5.72 ± 2.57 mm. The mean width of the septa on the floor of the sinus was 3.47 ± 1.93 mm. The mean height of septa on the lateral wall was 5.59 ± 1.05 mm
- The mean width of the septa was 3.47 ± 1.93 mm and is not sufficient enough to engage an implant.

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Conflicts of interest

There are no conflicts of interest.

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