Original Article

# Characteristics of Maxillary Sinus Ostia and their Correlation with Anatomic Variations of the Osteomeatal Complex: Indications for Sinus Floor Elevation

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**Abstract**

**Background:** Knowledge of the anatomy and variations of the maxillary sinus is essential for reducing oral surgery complications, such as sinus floor elevation, and increasing surgery success. The CBCT images of 385 patients were examined. **Materials and Methods:** The prevalence, localization, and height of PMO (Primer Maxillary Ostium) and AMO (Accessory Maxillary Ostium) were evaluated with respect to sex, dentition, dental treatment, Schneiderian membrane (SM) thickness, concha bullosa, Haller Cells, and septal deviation. **Results:** The PMO was present in 87.3% of all patients. Further analysis showed that the mean PMO diameter was 1.42 ± 0.62 mm. Although 11.6% of the PMO was in the inferior region, 60.4% was in the middle and 28% in the superior region. The effect of age and SM on the height and diameter of the PMO was found to be statistically significant. An AMO was present in 20% of the CBCT images. The mean AMO diameter was 2.55 ± 1.25 mm. Although 45.4% of the AMO was in the inferior region, 48% was in the middle and 6.6% was in the superior region. Moreover, SM thickness seemed to influence the height. A significant positive relationship was found between the PMO and AMO height. Also, a significant relationship was observed between the presence of the AMO and septum deviation. **Conclusion:** The presence of the AMO, PMO diameter, and height should be added to the preoperative evaluation criteria for the success of sinus floor evaluation. Specifically, sinonasal and demographic conditions should be carefully examined preoperatively for the long-term success of the surgery.

**Keywords:** *Accessory maxillary ostium, primary maxillary ostium, sinus lift*

## Introduction

Dental implant treatments are a widely used and safe treatment option to achieve functional and cosmetic results.[1] However, the residual bone height in the posterior maxillae decreases after a tooth extraction is caused by alveolar remodeling and sinus pneumatization. Sinus floor elevations are one of the preferred methods to increase insufficient residual bone height for restoring dentition. Prior to sinus floor elevation, the health condition of the maxillary sinus is a very critical component for long-term success. Cone beam computed tomography (CBCT) has been used in the literature for evaluating the health of the maxillary sinus region.[2] Either inflammatory diseases in dentition related to the maxillary sinus or preoperative changes in the maxillary region, such as concha bullosa (CB), Haller cells (HC), and septum deviation (SD), can lead to the disturbance in the mucociliary activity, causing the failure of dental implants after sinus floor elevation.[3] The primary maxillary ostium (PMO) is the most important anatomical structure that ensures the continuity of mucociliary activity.

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The PMO is usually located in the superomedial part of the medial wall of the maxillary sinus. Often, the oval-shaped PMO connects the maxillary sinus to the middle meatus of the nasal cavity. The pathological conditions around the ostium negatively affect mucociliary activity. These conditions can lead to inflammation in the maxillary sinus, causing the failure of sinus floor elevation.[3]

A second opening in the medial wall of the maxillary sinus, between the uncinate process and the inferior concha in a membranous area, is the accessory maxillary ostium (AMO).[2] Whether the AMO negatively affects maxillary sinus health is a matter of debate. On the one hand, some authors consider AMO to be a predisposing factor for sinusitis because 30% of patients with chronic sinusitis have AMO.[4] On the other hand, Yeung *et al*. showed that the AMO was an anatomic formation, with no relation to sinus pathology.[2-4]

The health status of the maxillary sinus has a close relationship with both anatomic formations.[2] For a better assessment of this critical region, a detailed examination of CBCT images with a large field of view (FOV) before surgery makes it possible to avoid intraoperative and postoperative complications and ensure long-term success.

This study aimed to examine the presence, location, and diameter of the PMO and AMO using CBCT images. Besides these factors, demographic data, SM thickness, dentition, endodontic treatment, periodontal diseases, CB, SD, and HC were analyzed for possible correlations. These examinations facilitated a long-term successful treatment outcome for clinicians.

## Materials and Methods

This retrospective study was performed on 385 CBCT images taken between December 2018 and December 2019. The radiographic images of 770 maxillary sinuses were taken from the database of a dental imaging center to evaluate anatomical structures and pathological changes in the maxillary sinus region. CBCT scans were included when both the maxillary sinus and the bilateral orbital floor were included in the radiographic image. This study was approved by the ethical review board of Gazi University Faculty of Dentistry (No. 21071282-050.99) and followed the Declaration of Helsinki. An informed consent form was signed by all patients prior to the study.

The CBCT images were inspected with Kodak Carestream Version 3.8.6.0 on a 15.6-inch screen with 1920 × 1080 resolution in a quiet room. The images were examined at 50-min intervals for a total of 4 h each day.

All images were analyzed by one examiner with 20 years of experience as a maxillofacial radiologist. After 2 weeks, 20% of the evaluation was re-evaluated.

Maxillary sinuses were examined in axial, sagittal, and coronal planes, and the primary ostium was detected from the coronal images of CBCT. The medial wall of the maxillary sinuses had a trapezoidal shape with a larger posterior side and was divided into the cranial and caudal parts by the inferior turbinate.[5] In every patient, the height of the sinus was traced from the superior part of the inferior concha's bone aspect to the highest point of the maxillary sinus on the posterior-most coronal image on which the primary maxillary sinus ostium was visible. The sinus region superior to the inferior concha was divided into three regions so that every region was one-third of the sinus height from the inferior concha (inferior/middle/superior) [Figure 1]. The measurements were standardized in parallel by drawing a vertical line perpendicular to the guiding horizontal line on the CBCT image [Figure 2]. In the sagittal planes, the anterior-posterior position of the ostium was assessed in relation to the teeth, if available. Also, the distance of the open ostium was measured in millimeters (orbital inferomedial edge-uncinate prominence) on the posterior-most coronal image on which the primary maxillary sinus ostium was visible.

The same measurements for the height were made for the AMO [Figure 3].

The coronal slices, where the SM was observed as the thickest, were examined. SM thickness was evaluated from the maxillary sinus floor to the thickest point of the membrane. According to Soikonnen and Ainoma, SMs thicker than 5 mm were accepted as pathological.[6]

The dentition type of the posterior maxillae, with the exclusion of the third molar, was recorded. Further, the status of the dentition was evaluated to account for endodontic treatment or periodontal disease that can affect the health of the maxillary sinus. HC, CB, and SD, as well as the patient-related parameters such as sex and age (at the time of CBCT), were recorded.

The Chi-square test and ANOVA were used to investigate the relationship and characteristics of the parameters. Cohen kappa values were evaluated for intraobserver repeatability.

## Results

A total of 770 maxillary sinus CBCT images taken from 385 patients, aged 18–79 years, were included in the study. Also, 63% ($n$ = 242) of the images were taken from female patients and 37% ($n$ = 143) of the images from male patients.

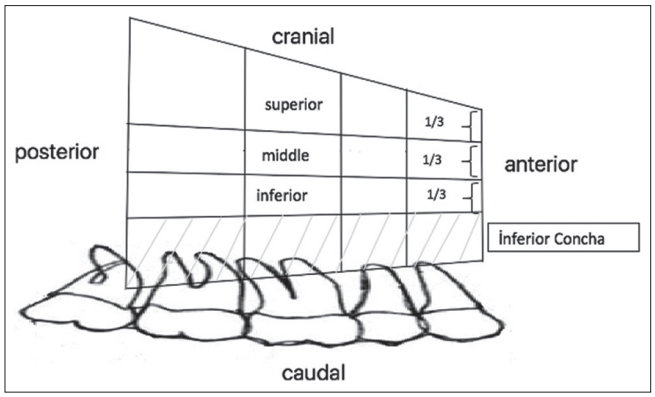


**Figure 1:** Medial wall of the maxillary sinus

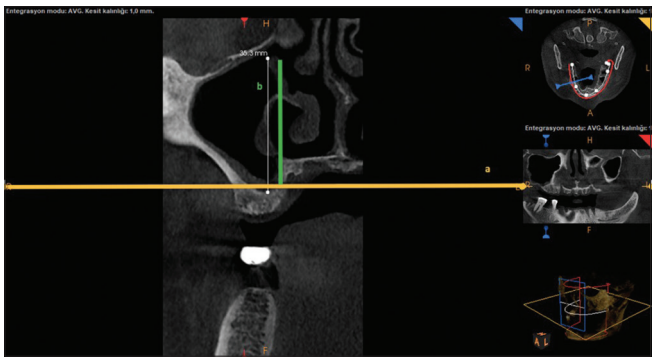

**Figure 2:** Height measurements in the coronal slices of a CBCT image [with the guiding horizontal line (a) and perpendicular vertical line (b)

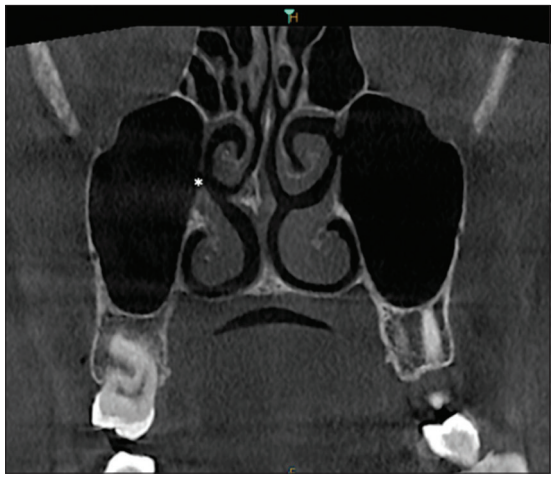

**Figure 3:** Visible AMO in coronal slices of the CBCT image (*AMO)

The intraobserver repeatability was very high in terms of the presence, height, and diameter of the PMO (kappa values = 0.94, 0.89, and 0.86, respectively), and the presence, height, and diameter of the AMO (kappa values = 0.94, 0.89, and 0.86, respectively).

The mean score for PMO presence was 87.3% [Tables 1 and 2]. Further analysis showed that the mean PMO diameter was 1.42 ± 0.62 mm. Although

**Table 1: Presence and localization of the PMO and AMO**

| | *n* | % |
|---|---|---|
| Coronal PMO | | |
| Visible | 672 | 87.3 |
| Obstructed | 98 | 12.7 |
| POM height (*n*=672) | | |
| Inferior | 78 | 11.6 |
| Middle | 406 | 60.4 |
| Superior | 188 | 28.0 |
| Sagittal PMO (*n*=672) | | |
| 1. Premolar (R) | 14 | 2.1 |
| 2. Premolar (R) | 120 | 17.9 |
| 1. Molar (R) | 183 | 27.2 |
| 2. Molar (R) | 8 | 1.2 |
| 1. Premolar (L) | 22 | 3.2 |
| 2. Premolar (L) | 144 | 21.4 |
| 1. Molar (L) | 176 | 26.1 |
| 2. Molar (L) | 5 | 0.7 |
| PMO diameter (*n*=672) Min-Max, Mean±SD | 0-7.2 | 1.42±0.62 |
| Coronal AMO | | |
| Visible | 152 | 19.7 |
| Obstructed | 618 | 80.3 |
| AMO height (*n*=152) | | |
| İnferior | 69 | 45.4 |
| Middle | 73 | 48.0 |
| Superior | 10 | 6.6 |
| AMO diameter (*n*=152) Min-Max, Mean±SD | 0.6-9.3 | 2.55±1.25 |

(R), Right maxilla; (L), left maxilla

11.6% of the PMO was in the inferior region, 60.4% was in the middle and 28% in the superior region [Table 1].

The effect of age on the patency, height, and diameter of the PMO was found to be statistically significant [Table 2]. The *P* value demonstrated an opposite and weak relationship between the height of the PMO and age. The sagittal position of the PMO in relation to the dentition is listed in Table 1.

The presence of the AMO was observed in approximately 21% of male patients and 19% of female patients. The mean AMO diameter was 2.55 ± 1.25 mm. Although 45.4% of the AMO was in the inferior region, 48% was in the middle, and 6.6% was in the superior region [Table 1]. A significant positive relationship was found between the PMO and AMO heights ($P = 0.00$).

Approximately 32% of female patients and 25% of male patients had no tooth deficiency. Table 2 shows the summary statistics for dentation.

Endodontic treatment was detected in 95 teeth in the examined images. A statistically significant relationship was not found between endodontic treatment and PMO/AMO patency, height, and diameter [Table 2].

**Table 2: PMO and AMO in relation to potential influencing factors**

| Potential influencing factors (*P*) | | PMO patency | PMO height | PMO diameter | AMO patency | AMO height | AMO diameter |
|---|---|---|---|---|---|---|---|
| Age (mean) | 46.66±5.487 | 0.00[a]* | 0.00[a]* | 0.00[a]* | 0.542[b]* | 0.616[b]* | 0.771[b]* |
| Sex | Female | 0.003[b]* (90%) | *P*=0.00[c]* (superior) | 0.919[d]* (1.457±0.6061) | 0.702[b]* (19%) | 0.004[c]* (middle) | 0.25[d]* (2.703±1.3277) |
| | Male | (83%) | (Superior) | (1.447±0.6082) | (21%) | (Middle) | (2.457±1.2033) |
| Dentition | Dentate | 0.305[a] (29%) | | | 0.788[a]* (4%) | | |
| | One tooth missing | (10%) | | | (2%) | | |
| | More than one | (20%) | | | (5%) | | |
| | Total | 28% | | | 6% | | |
| Endodontic treatment | Yes | 0.643[b]* (11%) | | | 0.450[b]* (23%) | | |
| | No | | | | | | |
| Periodontal disease | Periodontal healthy | 0.790[b]* (26%) | | | 0.419[b]* (64%) | | |
| | Periodontal disease | | | | 36% | | |
| SM thickening | Healthy (<5 mm) | 0.00[a]* (59%) | 0.00[a] | 0.00[a] | 0.575[a]* (11%) | 0.013[a]* | 0.846[a]* |
| | Pathology (>5 mm) | (41%) | | | (9%) | | |
| CB | | 0.00[a]* (45%) | 0.00[a] | | 0.407[a]* (14%) | | |
| SD | | 0.908[b]* (20%) | | | 0.0416[b]* (5%) | | |
| HC | | 0.507[b]* (17%) | | | 0.963[b]** (22%) | | |

[a]Chi-square; [b]continuity correction Chi-square; [c]Z test; [d]Mann-Whitney *U*, ***P*<0.05

Periodontal disease was observed in approximately 16% of the maxillary sinuses examined [Table 2]. The Chi-square analysis revealed a statistically significant relationship between SM thickness and periodontal disease ($P = 0.009$).

The thickest membrane height of 9.431 mm was seen in patient aged 65 years. A statistically positive relationship was observed between age and membrane thickness ($P = 0.00$). Also, SM thickness was observed to be severe in the absence of the PMO. The statistical analysis showed a significant relationship between SM thickness and PMO presence, diameter, and height ($P = 0.0$) [Table 2]. The SM was thicker in the presence of the AMO. Also, a statistically significant relationship was observed between the height of the AMO and Schneiderian membrane thickness ($P = 0.013$) [Table 2].

Interestingly, a significant relationship was noted between the presence of the AMO and SD [Table 2]. Among the 385 patients, CB was detected in 112 female patients and 68 male patients. A significant relationship was found between CB and PMO diameter, and SM thickness [Table 2].

## Discussion

This study aimed to figure out both dental and sinus-related variations according to maxillary ostia in 385 patients and 770 maxillary sinuses. It also assessed the importance of PMO and AMO in oral surgeries, especially sinus lift operations.

A study by Hwang *et al*. found that the PMO was localized 29.9 mm ± 5.1 mm above the palatal bone in the South Korean population, regardless of sex differentiation.[7] The difference between the outcomes might result from the difference in anatomical formations. The standardization of the area was difficult because of the complexity of the region. In the present study, the medial sinus wall was examined by dividing it into three parts to make more standard and comparable measurements.

Hwang *et al*. reported that the PMO moved inferiorly and laterally as age increased.[7] The reason for the displacement of the PMO was that the mid-face moved clockwise with respect to the cranial base as age increased. However, the number of participants in different age groups should be increased to better interpret the relationship between age and PMO height. The sinus lift should be carefully evaluated, especially in elderly individuals.

The results of this study showed a statistically meaningful relationship between age and PMO diameter.

However, Yeung *et al*. did not find any involvement between PMO diameter and age.[8] The difference between both studies might be due to the age distribution of the patient population included in the study.

A statistically meaningful relationship was detected between PMO diameter and CB. The PMO diameter was found to be 1.95 mm in the presence of CB. One of the significant findings of this study was that the increased PMO diameter in the presence of CB might negatively affect the airflow in the sinus.

Yeung *et al*.[8] reported that an obstructive PMO was more common in the case of a pathological increase in the thickness of the SM. Guo *et al*.[9] reported that the PMO was narrowed immediately after sinus floor augmentation surgery but returned to its baseline after 6 months. Shanbhag *et al*.[10] stated that narrowing in the PMO was frequently found on the SM with a thickness of more than 10 mm. A comparison of the findings with those of other studies confirmed that sinus drainage was impaired in the absence of the PMO, and therefore, SM thickening occurred.

In the present case, the PMO reached its maximum diameter in the presence of an SM with a thickness of more than 20 mm. The narrowing or widening of the PMO diameter, unlike its physiological width, caused similar effects on Schneiderian Membrane (SM). Kirihene *et al*.[11] stated that a widening of the maxillary ostium had negative effects because of the decrease in the nitric oxide (NO) level. The decrease in the NO level caused reinfection of the sinus, and hence, the SM thickness increased. One of the most important outcomes of the study was that the presence of the PMO decreased and the presence of the AMO increased when the thickness of the SM increased. A possible explanation for this might be that sinus drainage disorder occurred with SM thickening.

Another important result to mention was the relationship between PMO height and SM thickness. In the current literature review, there were no studies that addressed the relationship between these two factors. It is predicted that air circulation in the maxillary sinus is impaired with increasing PMO height, and thus SM thickening occurs.

The presence of the AMO has gained importance due to the increase in surgical procedures involving the sinus area.[8] However, the findings revealed that the SM was thicker in the presence of the AMO. This situation supported the assumption that the AMO was a pathological variation rather than a physiological one.

A statistically significant relationship was detected between the SD and the presence of the AMO. The study by Ozel *et al*.[12] found the AMO more frequently on the side with the SD. The reason for this was shown as the SD disrupting the airflow of the maxillary sinus and the pathological presence of the AMO.

PMO diameter, height, and presence of the AMO should be included along with the factors to be considered before a sinus lift, which Tavelli *et al.* listed in their systematic review in 2017.[13] Therefore, in the consensus decision published by the European Osseointegration Association in 2011, it was emphasized that expanding the FOV of the CBCT to include the osteomeatal complex is important to avoid postoperative complications.[14]

### Limitations

The findings of the present study cannot be extended to clinical data because the study was conducted only on radiographic findings.

## Conclusion

The width and height of the PMO and the presence of AMO have been showing a statistically significant increase in the SM thickness, due to this the CBCT images should be carefully evaluated Considering these factors during the treatment planning phase may ensure the avoidance of complications and long-term success.

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### Conflicts of interest

There are no conflicts of interest.

## References

1. Chan H-L, Wang H-L. Sinus pathology and anatomy in relation to complications in lateral window sinus augmentation. Implant Dent 2011;20:406-12.
2. Yeung AWK, Colsoul N, Montalvao C, Hung K, Jacobs R, Bornstein MM. Visibility, location, and morphology of the primary maxillary sinus ostium and presence of accessory ostia: A retrospective analysis using cone beam computed tomography (CBCT). Clin Oral Investig 2019;23:3977-86.
3. Manor Y, Mardinger O, Bietlitum I, Nashef A, Nissan J, Chaushu G. Late signs and symptoms of maxillary sinusitis after sinus augmentation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;110:e1-4. doi: 10.1016/j.tripleo.2010.02.038.
4. Şimşek Kaya G, Daltaban Ö, Kaya M, Kocabalkan B, Sindel A, Akdağ M. The potential clinical relevance of anatomical structures and variations of the maxillary sinus for planned sinus floor elevation procedures: A retrospective cone beam computed tomography study. Clin Implant Dent Relat Res 2019;21:114-21.
5. Rege ICC, Sousa TO, Leles CR, Mendonça EF. Occurrence of maxillary sinus abnormalities detected by cone beam CT in asymptomatic patients. BMC Oral Health 2012;12:30. doi: 10.1186/1472-6831-12-30.
6. Janner SF, Caversaccio MD, Dubach P, Sendi P, Buser D, Bornstein MM. Characteristics and dimensions of the Schneiderian membrane: A radiographic analysis using cone beam computed tomography in patients referred for dental

implant surgery in the posterior maxilla. Clin Oral Implants Res 2011;22:1446-53.

7. Hwang K, Wu X, Kim H, Kang YH. Localization of the maxillary ostium in relation to the reduction of depressed nasomaxillary fractures. J Craniofac Surg 2018;29:1358-62.
8. Yeung AWK, Tanaka R, Khong P-L, von Arx T, Bornstein MM. Frequency, location, and association with dental pathology of mucous retention cysts in the maxillary sinus. A radiographic study using cone beam computed tomography (CBCT). Clin Oral Investig 2018;22:1175-83.
9. Guo ZZ, Liu Y, Qin L, Song YL, Xie C, Li DH. Longitudinal response of membrane thickness and ostium patency following sinus floor elevation: A prospective cohort study. Clin Oral Implants Res 2016;27:724-9.
10. Shanbhag S, Karnik P, Shirke P, Shanbhag V. Cone-beam computed tomographic analysis of sinus membrane thickness, ostium patency, and residual ridge heights in the posterior maxilla: Implications for sinus floor elevation. Clin Oral Implants Res 2014;25:755-60.
11. Kirihene RK, Rees G, Wormald P-J. The influence of the size of the maxillary sinus ostium on the nasal and sinus nitric oxide levels. Am J Rhinol Allergy 2002;16:261-4.
12. Ozel HE, Ozdogan F, Esen E, Genc MG, Genc S, Selcuk A. The association between septal deviation and the presence of a maxillary accessory ostium. Int Forum Allergy Rhinol 2015;5:1177-80.
13. Tavelli L, Borgonovo AE, Re D, Maiorana C. Sinus presurgical evaluation: A literature review and a new classification proposal. Minerva Stomatol 2017;66:115-31.
14. Harris D, Horner K, Gröndahl K, Jacobs R, Helmrot E, Benic GI, *et al*. EAO guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. Clin Oral Implants Res 2012;23:1243-53.