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Role of computed tomography in the assessment of anatomical variations of maxillary sinus

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Abstract
Background: Maxillary sinus shows normal anatomical variations and it is important to know about them. Evaluating maxillary sinus and identifying its variations on computed tomography not only detects the different variations but also helps in planning and guiding various sinus surgery and preventing possible complications.
Purpose: Aim of this study was to detect anatomical variations of maxillary sinuses in patients using Multi-detector Computed Tomography.
Materials and Methods: Paranasal sinuses of 56 patients who were subjected to Computerised Tomography of Paranasal Sinus with CT (Seimens 16 slice Somatomscope) machine were studied.
Results: A total Para Nasal Sinuses of total 56 patients were studied. Out of which only 33 patients had maxillary sinus variations. Among accessory ostia of maxillary sinus was the commonest anatomical variation and was seen in 14(25%) of cases. Hyper pneumatization of maxillary sinus was detected in 12 cases (21.4%) and maxillary antral septa were found in 7 cases (12.5%).
Conclusion: Accurately assess the maxillary sinus on Computed Tomography and to determine the various anatomical variations of the same so as to differentiate pathological lesions from an anatomical variation and avoiding unnecessary surgical explorations and complications.

Keywords: Computerised Tomography (CT), Functional Endoscopic Sinus Surgery (FESS), Paranasal Sinuses (PNS)

1. Introduction
Multiplanar CT reformats to identify various details of the paranasal sinuses including the maxillary sinus. A precise knowledge about the various normal anatomical variations of maxillary sinus is essential to understand the impact of it in the disease process and management. Also, with the advent of various new techniques of surgeries it's important to know about exact anatomical details of the maxillary sinuses to guide the surgeons and thus preventing the avoidable complications.
Endoscopic sinus surgery has emerged as a method of treating patients with sino-nasal symptoms. Pre-operative sinus CT scan is an essential investigation to delineate the intricate anatomy of the sinuses of each individual patient. The embryological development is the basis for the diverse variations in sino-nasal anatomy. The maxillary sinus begins as a lateral pouching of the ethmo-maxillary recess mucosa during the 10th to 12th weeks of gestation. This is associated with resorption of the surrounding tissue and growth of the maxillary pouch. The maxillary antrum is identifiable at the 16th week of gestation. The maxillary sinuses are pyramidal shaped cavities located in the face lateral to the nasal cavity on either side with its base directed towards the lateral nasal wall and apex extends to the zygomatic process of maxilla [1].

2. Aims and Objectives
To evaluate the normal anatomical variations of Maxillary sinus using Computed Tomography.

3. Materials and Methods
It is a retrospective study and was carried out for a period of 12 months. The CT PNS of 56 patients were performed who were referred to the Department of Radio diagnosis at Sree mookambika institute of medical sciences, kulasekharam, kanniyakumari. The clinical and demographic data were recorded after due consent. The patients with tumours, polyposis, previous trauma or surgery were excluded from the study.
Competed Tomography optimally displays air within the sinuses, soft tissue and bony structure and thus provides an excellent depiction of the anatomy as well as the disease extent, in and around the sinuses.

All the patients were subjected to computerized tomography of the PNS with CT (Seimens 16 slice somatomscope) machine. Direct scans of 1 mm thickness with an increment of 0.5 mm were made.

Multiplanar reconstruction was done in axial, coronal, and sagittal planes. For the axial scans the orbito-meatal line was taken as reference with the patient in supine position.

The exposure settings used were 100 kVp and 300 to 325mAs. For the evaluation of maxillary sinus septations the axial images were used. Whereas for evaluation of the presence of mucosal thickening on the maxillary sinus floor and patency of the antral sinus ostium the coronal images were used.

4. Results

The present study was carried out to describe normal anatomical variations of maxillary sinus. Only patients fulfilling the inclusion and the exclusion criteria were included in the study.

Findings in the patients studied were tabulated using Microsoft Excel software. During the period of 24 months of the study, total 56 patients were studied. Out of 56 patients 33 patients i.e., 58.92% patients have anatomical variations in the maxillary sinus.

The demographic profile of the patients with variations in the maxillary sinus were given in (Figure 1) with the sex distribution of the same mentioned in (Figure 2). The incidences of different anatomical variations of the maxillary sinus were detailed in. (Table 1)

The study was done among 56 individuals. Among them, 30 were males and 26 were females. This is given in the following table.

Table 1: Distribution of study population according to sex (n = 56)

S. No	Sex	Number	Percentage (%)
1	Male	30	53.57
2	Female	26	46.43
	Total	56	100

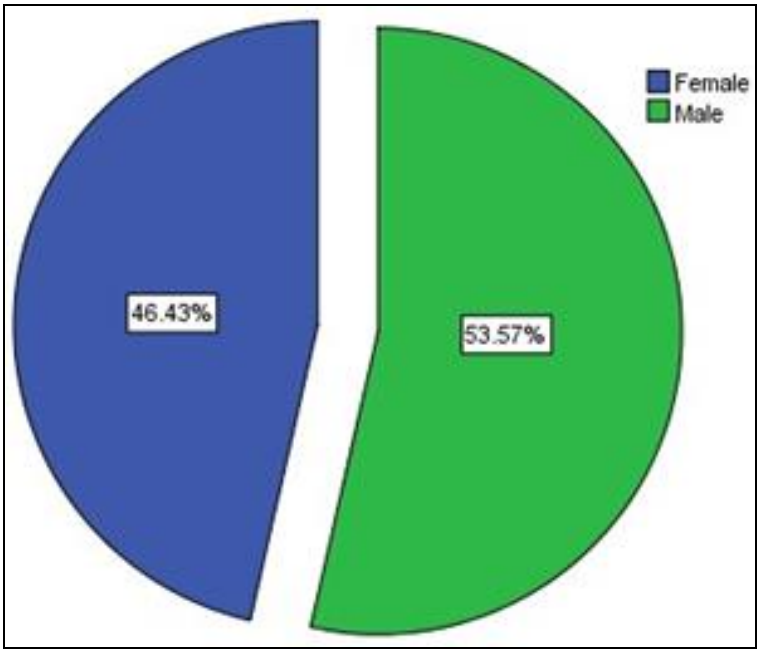

Fig 1: Distribution of study population according to sex (n = 56)

The mean age of the study population was 40.66 years with a standard deviation of 13.75 years. The minimum and maximum ages were 8 and 72 years respectively. The distributions of study population in different age categories are listed in table 2.

Table 2: Distribution of study population according to age (n = 56)

S. No	Age in years	Number	Percentage (%)
1	18 – 20	4	7.14
2	21 – 30	8	14.28
3	31 – 40	19	33.92
4	41 – 50	13	23.21
5	51 – 60	8	14.28
6	≥ 70	4	7.14
	Total	**56**	**100**

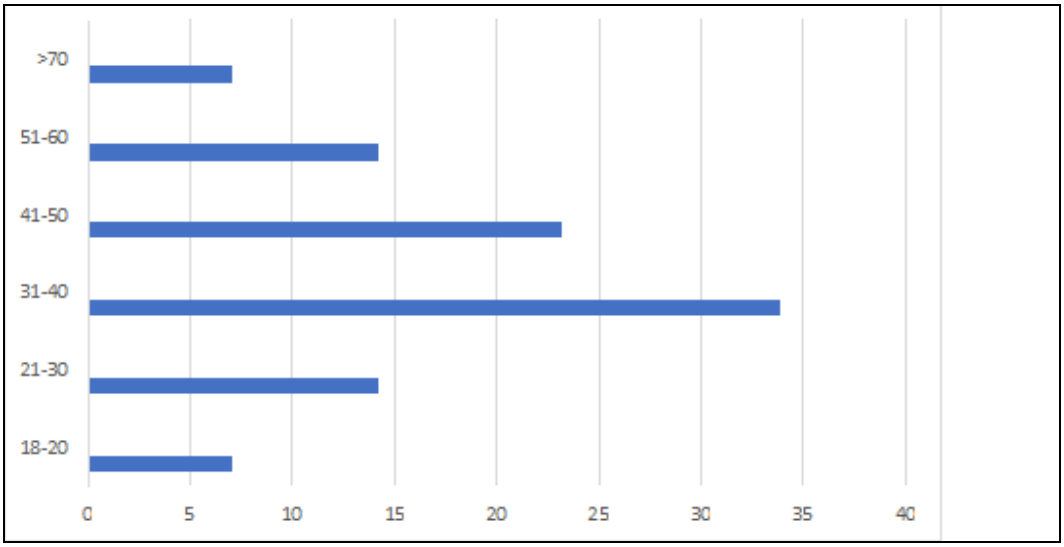

Fig 2: Distribution of study population according to age (n = 56)

Table 3: Types of maxillary sinus variations

S. No	Variations	Present in number cases	Percentage
1	Accessory ostia	14	25%
2	Hyperpneumatization	12	21.4%
3	Septa	7	12.5%

5. Discussion

Normal anatomical variations and congenital anomalies in the paranasal sinus region are significant findings as they at times have pathological consequence or may be the source of difficulty/complication during sinus surgeries. CT is the preferred modality for evaluation of paranasal sinuses. Although the associations of the normal variations with sinusitis is not exactly known, detailed anatomical knowledge of maxillary sinus and their normal anatomical variations should be pursued before any surgical intervention to avoid potential dreadful complications.

Hyper-pneumatised Maxillary Sinus

The maxillary sinus, also known as the "antrum of Highmore," is the largest of the paranasal sinuses and the first to develop embryologically at 16 weeks of gestation. 1 The sinus is pyramidal in shape and is composed of four walls, including a base formed by the lateral wall of the nose and an apex that extends into the zygomatic process [2, 3]. It lies within the body of the maxillary bone on the lateral side of the nasal cavity [4].

Sinus pneumatization is a continuous physiological process that causes the paranasal sinuses to increase in volume [5]. Sinuses give resonance to voice, contribute to the shape of the face, and provide some degree of warmth and humidification to inspired air [6].

After birth, the maxillary and ethmoidal sinuses are fully developed [7] and continue to pneumatize as the permanent teeth erupt [8]. The pneumatization extends inferomedially, through nearby bony elements into the hard palate, laterally into the zygomatic bone, and posteriorly into the ethmoids [9]. According to some authors, the most common site to undergo pneumatization is the anteromedial wall of the maxillary sinus [10, 11].

However, pneumatization may sometimes be extensive and may expose the roots, resulting in the engagement of the maxillary molar and premolar roots within the floor of the sinus. This may lead to complications during extractions and difficulties during implant placement [12, 13].

It is believed that tooth loss induces maxillary sinus pneumatization, which may lead to a union between the sinus floor and the crest of the alveolar bone in extreme cases [14]. Some studies that compared pre- and post-extraction radiographs suggest that maxillary sinus pneumatization may occur after posterior tooth extraction [8]. A study conducted in Israel that compared the dimensional changes in the alveolar ridge and the corresponding maxillary sinus following tooth extraction, with or without socket preservation, showed that tooth extractions in the posterior maxilla may lead to sinus pneumatization and crestal bone loss [15].

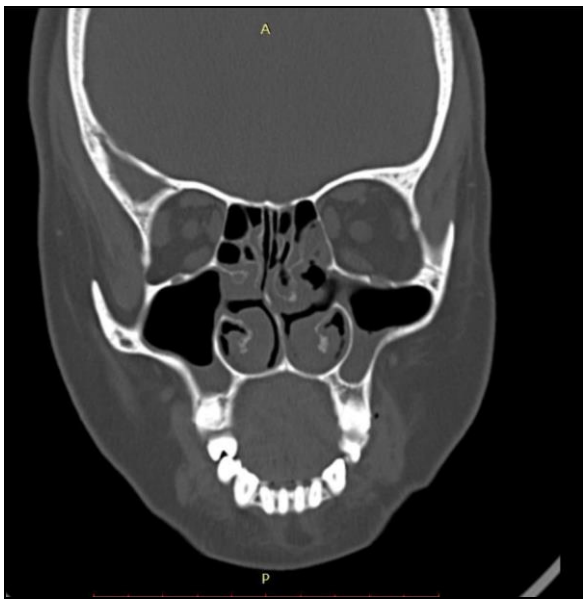

Fig 3: Coronal CT section of PNS shows hyper pneumatisation of right maxillary sinus into alveolar recess.

Septa within the Maxillary Sinus

Sinus septa were first described in literature in 1909 by Underwood. They are bony walls rising from the sinus floor and divide the cavity into compartments. Septa, if missed, may cause unexpected difficulties during surgery with the increasingly importance of peri-implant surgery, the understanding of the presence of septa has vastly increased. They have become an obstacle and may significantly hinder sinus augmentation procedures. To overcome this problem, common surgical methods had to be modified. The purpose of this review is to indicate the prevalence of septa, illustrate the most adequate diagnostic method and further discuss pre-operative considerations and implantological implications.

These are uncommon and septa usually divide the maxillary antrum into anterior and posterior parts, each of them may drain via accessory ostia into the nasal fossa. Very rarely, a horizontal septum can divide the maxillary antrum into superior and inferior parts, or the maxillary antrum may be divided by a sagittal septum into medial and lateral parts.

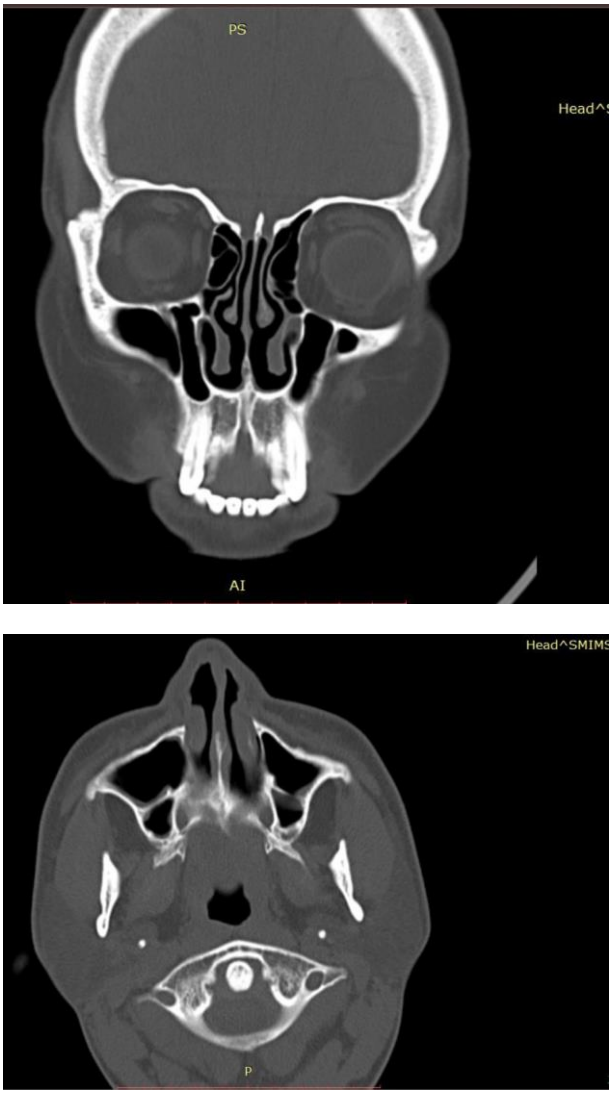

Fig 4: Coronal and axial section of PNS shows bilateral maxillary sinus septa.

Accessory Ostia of Maxillary sinus

The accessory ostium of the maxillary air sinus is an anatomical variation that may play a role in the development of chronic sinusitis [16, 17]. Accessory maxillary ostia are most commonly located in the posterior nasal fontanelle of the middle meatus and may occur unilaterally or bilaterally [18, 19]. Accessory maxillary ostium is usually located on the lateral nasal wall and should not be confused with the maxillary hiatus. Between the uncinate process and the inferior concha there is a membranous area on the lateral nasal wall, covered by mucoperiosteum. This area is the fontanelle, the fontanelle is separated into anterior and posterior fontanelle by the ethmoid process of the inferior concha [20].

In most individuals, the maxillary sinus opens to the anterior part of the posterior fontanelle, on the inferior part of the ethmoid infundibulum. The active mucociliary transport in the maxillary sinus is directed toward the natural ostium only. Accessory maxillary ostium does not contribute to the physiological transport inside the maxillary sinus even if the natural ostium is blocked [20]. Accordingly, it may have a role in the development of chronic sinusitis. Accessory maxillary ostium is reported to be present in 30% of the patients diagnosed with chronic maxillary sinusitis and in 10–20% of normal individuals [21, 22]. It is unclear whether chronic sinusitis leads to accessory ostium formation or the presence of an accessory ostium leads to chronic sinusitis by recirculation of mucus secretions [23, 24, 25].

The greater frequency of accessory maxillary ostia in patients with a previous history of multiple episodes of maxillary sinusitis suggests that accessory ostia may occur as a consequence of pathology. Guerra-Pereira *et al*. stated that radiological imaging is an important tool in maxillary sinus pathology diagnosis and CT can complement the diagnosis of odontogenic sinusitis [26].

A possible mechanism for the development of accessory ostia is impediment of the main ostium by mucosal edema due to chronic sinusitis or other anatomical or pathological factors in the middle meatus that leads to rupture of membranous part of the lateral nasal wall.

Fontanelle defects and formation of accessory ostia could serve to maintain chronic inflammation of the maxillary sinus by permitting mucus recirculation between adjacent openings [27].

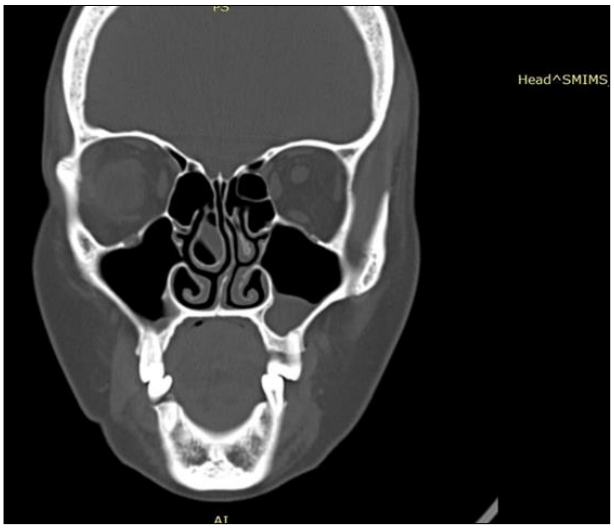

Fig 5: Coronal CT section of PNS shows accessory ostia in right maxillary sinus.

6. Conclusion

Accurate imaging assessment of maxillary sinus reveals anatomical variations of the maxillary sinus on

Multidetector computed Tomography and it is important to detect them so as differentiate between pathological lesion form and anatomical variation. Since some of these variations can modify the surgical planning to more specialized procedures, they are crucial to be recognized and mentioned to avoid unnecessary surgical explorations and potential complications. Today Computed Tomography is an integrated diagnostic method for assessing the maxillary sinus variations.

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