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# Extensive maxillary sinus pneumatization*

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SUMMARY

***Aim:*** *To determine the incidence of variations of maxillary sinus pneumatization especially when it is extensive and the associated anomalies.*

***Study design:*** *Two hundred consecutive direct coronal paranasal sinus computed tomography (CT) scans were reviewed retrospectively. Extensive maxillary sinus pneumatization (EMSP) was defined as one in which the largest horizontal and / or vertical dimension of the maxillary sinus equalled or exceeded 90% of the corresponding diameter of the orbit. Further subtype I, II & III were defined depending on whether the pneumatization was extensive in one dimension (horizontal or vertical), two dimensions (horizontal & vertical) and by the presence of sphenomaxillary plate, intermaxillary plate or extension into frontal recess.*

***Results:*** *EMSP was found in 8%, of these 7% were bilateral and 1% was unilateral. (Subtype I, II and III constituting 1%, 3% & 4% respectively).*

***Conclusion:*** *EMSP has been defined as a group and a classification proposed. EMSP will result in an atypical clinical picture, has a role in the pathogenesis of frontal sinusitis in some cases and may predispose injury to the orbit during endoscopic sinus surgery (ESS).*

*Key words: maxillary sinus, maxillary sinus hypoplasia (MSH), extensive maxillary sinus pneumatization (EMSP)*

## INTRODUCTION

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 (Berenholz et al., 2000). 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 pneumatization continues mainly in an inferior direction after eruption of the upper teeth. Adult size is reached by the age of 15 to 18 (Kosko et al., 1996).

The maxillary sinus pneumatization may extend into nearby bony elements as recesses - infero-medially into hard palate, laterally into zygomatic bone and posteriorly into ethmoids (Lang, 1989). We have set out to determine the incidence of this condition and associated anomalies in patients presenting with sino-nasal symptoms. We have termed it as “extensive maxillary sinus pneumatization (EMSP)”. Maxillary sinus hypoplasia (MSH) is a well-recognised entity (Bassiouny et al., 1982; Bolger et al., 1990; Meyers and Valvassori, 1998; Sirikci et al., 2000). Surprisingly, EMSP has received little attention in the literature as isolated reports of large / giant maxillary sinuses (Francis and Bosshardt, 1969; Hall, 1969; Godfrey, 1974; Karmody et al., 1977; Nicodemo et al., 1979). This paper highlights the implications and importance of understanding this condition.

## MATERIALS AND METHODS

The CT scans of the paranasal sinuses of 200 consecutive patients with sino-nasal symptoms, performed at The Warrington General Hospital, Warrington, England, United Kingdom between January 1, 2001 to December 31, 2001, were reviewed retrospectively. Contiguous 3mm thick images were obtained perpendicular to the hard palate through all the paranasal sinuses in the direct coronal projection using a standard algorithm. Images were viewed at both bone and soft tissue window settings. A single observer interpreted all the scans, with specific attention paid to the pneumatization of the maxillary sinuses and the associated anomalies if any.

The scans in which the orbit and maxillary sinus appeared in their largest form were selected. The vertical and horizontal diameters of these structures were measured. When either / both of the maxillary sinus diameters was greater than or equal to 90% of the corresponding orbital diameter(s) then the maxil-

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lary sinus pneumatization was considered to be extensive (EMSP). They were further subdivided into mild, moderate and severe (Table 1) depending on whether it was one or two diameters and the associated findings of sphenomaxillary plate (antero-posterior dimension), intermaxillary plate (infero-medial extension from either side) and extension into frontal recess (supero-medial extension: 'the fronto-maxillary plate').

The scans were also assessed to identify associated anomalies such as concha bullosa, paradoxical middle turbinate, hypoplastic/absent uncinate process, orbital floor anomalies and radiological evidence of sinusitis.

## RESULTS

The classification suggested for EMSP is in parallel to that of MSH and is simple, objective and reproducible (Table 1). The demographic data shows slight preponderance of female patients in all groups for no obvious reasons. In this study EMSP was more common than MSH (Table 2). EMSP is usually bilateral and of the severe variety while MSH is unilateral and that of mild variety (Table 2 & 3). Uncinate anomalies are not seen in EMSP. Significant associated anomalies are the presence of spheno-maxillary plate, intermaxillary plate, extension of maxillary sinus into frontal recess, oblique orbital floor and wavy thinned orbital floor. The incidences of concha bullosa and paradoxical middle turbinate have been the same in MSH and EMSP and hence were considered incidental (Table 4). Radiological evidence of sinusitis was found in 163 out of 200 scans studied (81.5%), the most common site being the anterior ethmoids. Soft tissue opacity in the maxillary sinus was found in 7 of the 16 EMSP and 2 of the 5 MSH.

Table 1. Three distinct patterns of extensive maxillary sinus pneumatization (EMSP).

| Type of EMSP | Description |
|---|---|
| I | **Mild EMSP**. Horizontal **or** vertical dimension of maxillary sinus ≥ **90%** of the corresponding orbital dimension. |
| II | **Moderate EMSP**. Horizontal **and** vertical dimension of maxillary sinus ≥ **90%** of the corresponding orbital dimensions. |
| III | **Severe EMSP**. Same as Type II but in addition presence of inter-maxillary plate, spheno-maxillary plate or extension into the frontal recess. |

Table 2. Relative distribution of EMSP* & MSH** (n = 200).

| **Variation of maxillary sinus pneumatization** | GENDER | | LATERALITY | |
|---|---|---|---|---|
| | **Male** | **Female** | **Unilateral** | **Bilateral** |
| **EMSP** | 7 (3.5%) | 9 (4.5%) | 2 (1%) | 14 (7%) |
| **MSH** | 1 (0.5%) | 4 (2%) | 4 (2%) | 1 (0.5%) |

* EMSP Extensive Maxillary Sinus Pneumatization 16/200 = 8%

** MSH Maxillary Sinus Hypoplasia 5/200 = 2.5%

Table 3. Frequency of occurrence of the various types of MSH and EMSP.

| **Types of** | **EMSP*** | **MSH**** |
|---|---|---|
| Mild | 1% | 1% |
| Moderate | 3% | 1% |
| Severe | 4% | 0.5% |
| TOTAL | 8% | 2.5% |

* Classification proposed in this study for EMSP (S. Kalavagunta et al.).

** Classification proposed for MSH (Bolger et al., 1990; Sirikci et al., 2000).

Table 4. Relative incidences of the co-existing anomalies. The absolute percentage is taking n=200 while the relative percentages are taking the n (EMSP) =16 and n (MSH) = 5 into consideration.

| Associated anomaly | In EMSP | In MSH |
|---|---|---|
| | Absolute (Relative) | Absolute (Relative) |
| Hypoplastic uncinate process | - | 1.5% (60%) |
| Concha bullosa | 4.5% (56%) | 1.5% (60%) |
| Paradoxical middle turbinate | 3.5% (43%) | 1% (40%) |
| Spheno-maxillary plate | 3% (37%) | - |
| Inter-maxillary plate | 2% (25%) | - |
| Extension into frontal recess | 0.5% (6%) | - |
| Oblique orbital floor | 3.5% (43%) | - |
| Wavy thinned orbital floor | 2.5% (31%) | - |

## DISCUSSION

In this paper we have set out to study variations of pneumatization of maxillary sinuses and the associated anomalies. Maxillary sinus hypoplasia (MSH) is a well-recognised entity (Bassiouny et al., 1982; Bolger et al., 1990; Meyers and Valvassori, 1998; Sirikci et al., 2000) while EMSP – Extensive maxillary sinus pneumatization is not. EMSP occurs more commonly than MSH and literature over its possible implications to sinus disease and its treatment, is scarce. To the best of our knowledge EMSP has not been identified as a group and hence its incidence not determined, though anecdotal references of large maxillary sinuses are found in the literature (Francis and Bosshardt, 1969; Hall, 1969; Godfrey, 1974; Karmody et al., 1977). The term maxillary sinus hyperplasia has been intentionally avoided as it would abbreviate to MSH and this could cause confusion. MSH has been defined as the maxillary sinus, the maximum horizontal / vertical diameter of which is less than 50% of the orbital diameter (Sirikci et al., 2000). To define the other end of the spectrum we found 90% and above - of orbital diameter formed a reasonable limit to term maxillary sinus pneumatization as extensive – as this group was associated with spheno-maxillary plate, intermaxil-

lary plate, extension into frontal recess (frontomaxillary plate) or zygoma.

*Atypical Clinical Presentation*

There are no characteristic signs or symptoms of EMSP. These may range from no symptoms, a sinusitis picture or an atypical clinical presentation. The atypical clinical picture may mimic neurological, dental, temporo-mandibular joint syndrome, refractive errors or an atypical facial pain. This is due to the fact that the maxillary sinus in EMSP crosses the conventional anatomical limit. EMSP may also present as refractory primary headaches (migraine, cluster, tension type) presumably due to ventilatory dysfunction affecting a large sinus with pain-sensitive mucosa. ESS should decrease pain severity or headache frequency in such cases. Clerico et al, (1979) reported a case series of patients with refractory primary headaches who did not have significant sinus symptoms but revealed a high prevalence of sino-nasal abnormalities on coronal CT scans and responded favourably to ESS. In this condition whether mucociliary clearance is a problem or is it only that of ventilation giving rise to vacuum headaches, is yet to be studied.

The following extensions of the maxillary sinus into neighbouring bony elements were identified in this study:

1) The zygomatic process (Figure 2),
2) The frontal recess (frontomaxillary junction or plate – Figure 3),
3) The posterior ethmoids either partially or completely – forming a junction directly with the sphenoid (the sphenomaxillary plate – Figure 4), &
4) The hard palate (forming the intermaxillary plate when bilateral – Figure 5).

It is important to mention here regarding the ethmo-maxillary sinus, which is the extension of the posterior ethmoid air cells into the maxillary sinus (Khanobthamchai et al., 1991) and the

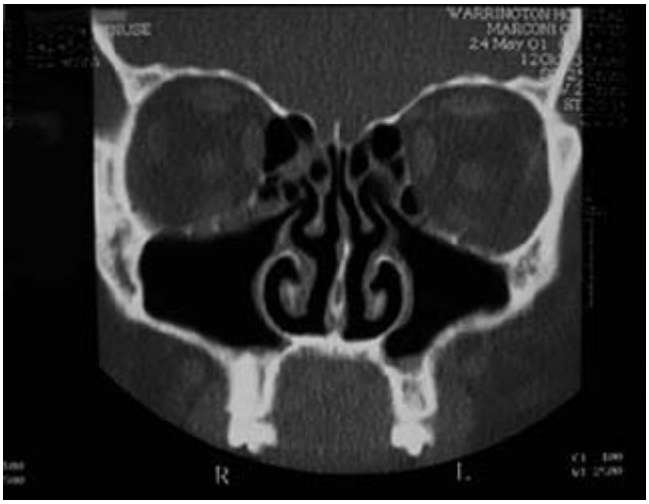


Figure 1. Unilateral Type I EMSP – Mild.

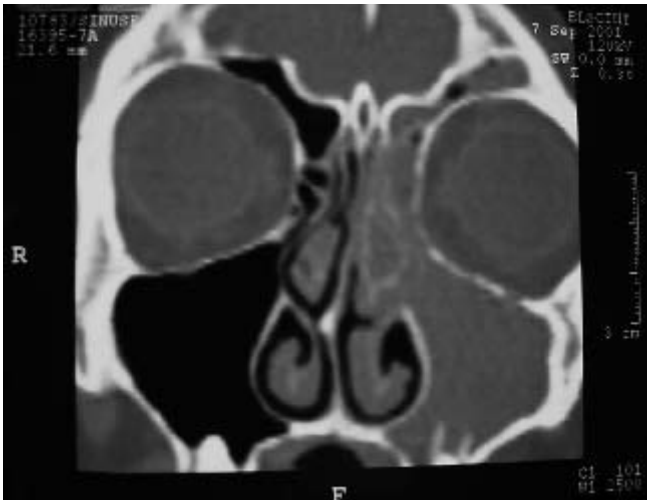


Figure 3. Bilateral Type III EMSP – Frontal recess extension.

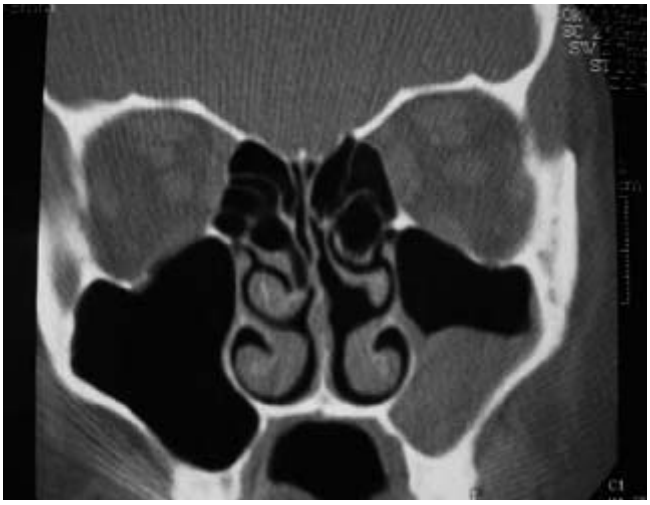

Figure 2. Bilateral Type II EMSP – Moderate.

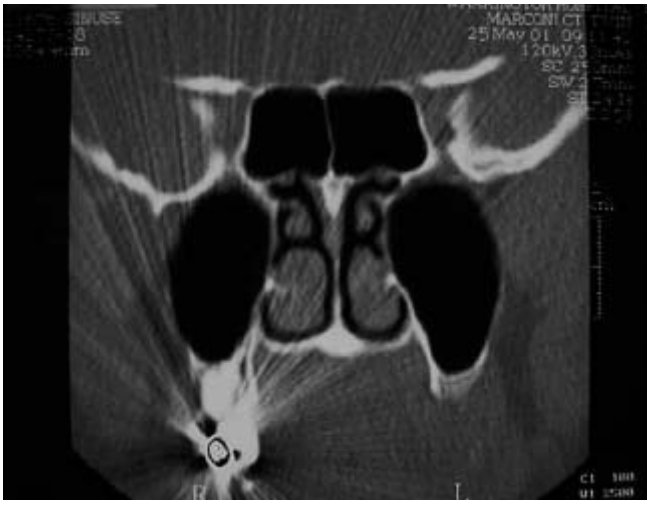

Figure 4. Bilateral Type III EMSP – Sphenomaxillary plate.

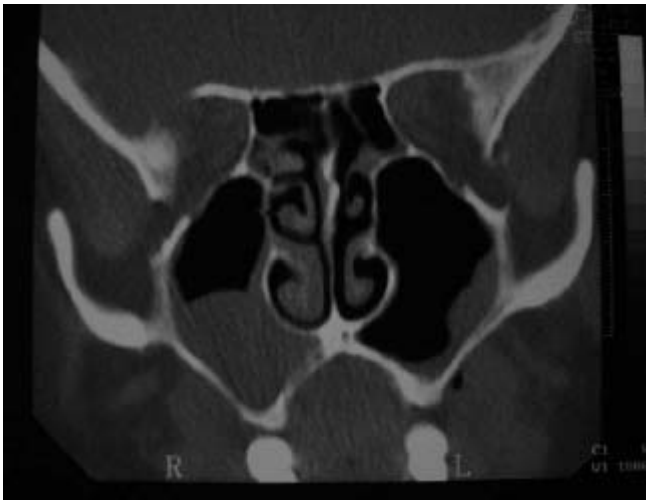


Figure 5. Bilateral Type III EMSP – Intermaxillary plate.

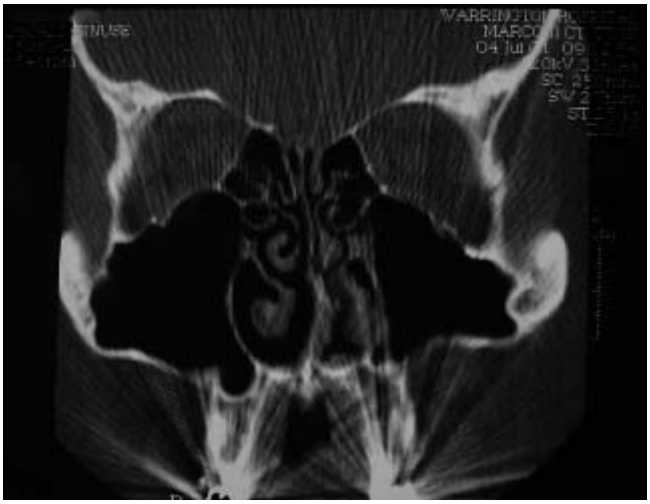

Figure 7. Bilateral Type III EMSP – Thin wavy orbital floor.

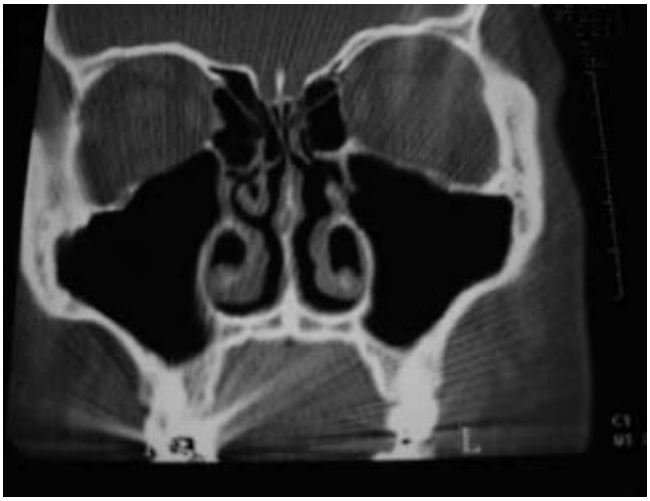


Figure 6. Bilateral Type III EMSP – Oblique orbital floor.

reverse of this is seen in EMSP, when the maxillary sinus invades the ethmoid cells and may form the spheno-maxillary plate (Figure 4). It is also essential to distinguish pneumosinus dilatans of the maxillary sinus from EMSP. Pneumosinus commonly occurs in the frontal sinus but can rarely involve the maxillary sinus (Wolfensberger, 1984). This is characterised by bone destruction, and expansion of a normally aerated paranasal sinus. The facial contours change slowly; the patient complains of mild pain and feeling of pressure.

*Fronto-maxillary sinusitis*

The maxillary sinus is known to have various recesses or extensions (Lang, 1989). Supero-medial extension of the maxillary sinus into the frontal recess region has not been recognised as an important variation of sino-nasal anatomy. It assumes importance in the pathogenesis and the surgical management of sinus disease affecting this area (Figure 3). Such variations raise an important question, whether the bony sino-nasal anatomy determines the ventilation and the mucociliary drainage pattern of sinuses as being separate channels or as a continuum. It is also interesting to note that the maxillary sinus and the frontal sinus are affected in conjunction in such cases. Hence, the endoscopic aims of treating such conditions may be limited to providing adequate drainage to the maxillary sinus alone. Further studies are needed to confirm the pattern of ventilation / drainage in such occasional cases (Fronto-maxillary sinus).

*Risk of Orbital Damage*

EMSP occasionally like MSH presents a narrow infundibular passage and hence predisposes the orbit to injury during ESS. (Figures 1 and 3) This is due to the absence or hypoplasia of the anterior ethmoidal air cells and it being replaced by a narrow extension of the maxillary sinus. Most cases of EMSP were associated with oblique inferior orbital *wall* (Figures 2, 6 & 7). While performing a middle meatal antrostomy the medial orbital *wall* and medial orbital *floor* may be damaged. Our study indicates that EMSP and MSH together constitute nearly one-tenth of coronal CT scans performed on patients presenting with sino-nasal symptoms. Otolaryngologists undertaking endoscopic surgery must be aware of the relative incidence of these conditions and of them being possible risk factors in ESS.

During ESS the other possible risk factors, suggested, include asymmetry (height and contour) of ethmoid roof (Stammberger, 1993; Dessi et al., 1994; Lebowitz et al., 2001; Grevers, 2001), right-sided ethmoidectomy performed by a right-handed surgeon, instrument positioning and visualization (Freedman and Kern, 1979; Lawson, 1991) However, all these studies could not directly correlate any of the said risk factors. Further studies are needed to substantiate the contribution made by these possible risk factors when they exist concurrently.

The limitations of our study in drawing conclusions are the absence of a statistically significant correlation between the incidence of EMSP and 1) atypical clinical presentation or 2) that of orbital trauma during ESS. The former may be overcome with a prospective randomised controlled trial, though the numbers needed to get a statistically valid conclusion will be very high and this is a limitation as it is not a common condition. To overcome the latter, is improbable, as risk quantification and contribution by each of the possible risk factors is a difficult task, as these complications are neither predictable nor reproducible. Operative conditions may be mimicked in an experimental set up, where endoscopic surgeons of varying experience may be judged operating on cadavers, using extremely precise (Reittner et al., 2002) electromagnetic tracking systems to which they are blinded. This will objectively define the relative contribution of these anatomical variants as possible risk factors in ESS. Such studies will aid in identifying the 'difficult' cases that need intra-operative image guidance.

## CONCLUSION

Extensive maxillary sinus pneumatization (EMSP) is more common than maxillary sinus hypoplasia (MSH). The classification suggested for EMSP is simple, objective and reproducible. The diagnosis and assessment of EMSP can be made successfully with CT.

EMSP has the following implications as it may result in: a) atypical clinical presentation and b) possible risk of damage to the medial and infero-medial orbital wall during ESS. Sinusitis in cases where EMSP extends into the frontal recess has implications in its pathogenesis and management. Recognition of EMSP by the rhinologist by a paranasal sinus CT is essential.

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