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Research Article

Anatomical variations of sinonasal region: a CT scan study

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ABSTRACT

Multislice CT is currently the imaging modality of choice for evaluating PNS & adjacent structures. Such a method has been increasingly utilized in the assessment of anatomical variations, allowing their accurate identification with high anatomical details. Some anatomical variations may predispose to sinonasal disease, constituting areas of high risk for injuries & complications during surgical procedures. Therefore, the recognition of such variations is critical in the preoperative evaluation for endoscopic surgery.

Keywords: Multislice CT, PNS region, Anatomical variations, Surgical complications

INTRODUCTION

Paranasal sinuses are a group of air filled spaces developed as an expansion of nasal cavities, eroding the adjacent bone structures. According to the literature, some of such regions present a high risk for injuries and consequential intraoperative complications, with the ethmoid and frontal sinuses being most frequently affected. Anatomical variations, in association with their inherent conditions, are added to such risks. The anatomical knowledge on these structures is critical for endoscopic surgeons as well as for radiologists involved in the preoperative evaluation in order to avoid therapeutic failures and iatrogenic complications.

The acquisition of an excellent definition of the sinus anatomy for a preoperative endoscopic evaluation can be done by means of CT which is the gold standard in the study of such structures. This provides accurate information on soft tissues, bone structures and air, thus characterizing a highly sensitive imaging method. The present pictorial essay is aimed at demonstrating the main anatomical variations that may be detected in PNS by means of multislice CT.

Nasal septum

Septal deviation is shift of the midline associated with deformity or asymmetry of the adjacent turbinates or of the nasal wall structures, with variable presentation. Deviation of the nasal septum is measured by drawing a line from Crista galli to maxillary crest and another line to the maximum deviation of nasal septum. The angle formed is calculated.

Nasal septal spur is an asymptomatic bone deformity that may occasionally cause restriction of nasal air flow, and may be associated with septal deviation. Depending on the degree of obstruction and severity of symptoms surgical correction may be required.

Variations of the middle turbinates

Concha bullosa is pneumatization of the middle turbinate bone plate by extension of ethmoid sinus cells. It is explained by *e vacuo* theory and by the congenital theory. Such variation may be either unilateral or bilateral. Varied degrees of pneumatization of the concha may be observed, possibly causing middle meatus or infundibulum obstruction. Three types of Concha bullosa are described, a) lamellar type b) bulbous type and c) extensive type.

Other variation that is frequently associated with septal deviation and spur is unilateral hypoplasia. In cases of bilateral hypoplasia, it is associated with low fovea ethmoidalis. Paradoxical turbinates occur as the convexity of the middle turbinate is directed towards the medial wall of the maxillary sinus. Depending on the degree of curvature of the paradoxical turbinate, compression of the infundibulum and sinusal obstruction may be observed.

Uncinate process variation

The uncinate process is a superior extension of the lateral nasal wall that is anatomically relevant for draining the frontal recess. Variations such as hypertrophy, deviation and pneumatization may affect the drainage system generating abnormalities in the ostiomeatal complex and predisposing to obstruction.

Traditionally, the uncinate process is identified from its lower segment through the architecture of the ostiomeatal unit. Variations in the superior insertion of the uncinate process are classified according to the criteria developed by Landsberg & Friedman.[1] Anatomic variants in sinonasal CT were defined by Earwaker J.[2]

Maxillary sinuses septa

Maxillary sinus septa are thin walls of cortical bone present within the maxillary sinus with variable number, thickness and length. Such septa which arise from inferior and lateral wall of the sinus may divide the sinus into two or more cavities. Septa originating from teeth may be classified according to their development at the different phases of the dental eruption.

Accessory maxillary Ostia

Accessory maxillary ostia[3] are generally solitary, but occasionally may be multiple. Such variation may be congenital or secondary to sinusal diseases. Possible mechanisms involved in the development of such variation include: main ostium obstruction, maxillary sinusitis or anatomical/pathological factors in the middle meatus, resulting in rupture of membranous areas.

Para nasal sinuses pneumatization and extent

The sphenoid sinuses arise at 5th week from pre-sphenoid bone centers, with variable pneumatization and extent. In most of the cases, pneumatization presents recesses related to the greater sphenoid wing, although lateral extensions may also be observed in the smaller sphenoid wing, inferolateral and septal recesses.

Frontal sinus extension is a rare condition characterized by increased sinusal aeration beyond the normal margin of the frontal bone that originates from anterior extension of the anterior ethmoid air cells. Extensions related to the lamina of the frontal bone, crista galli, besides inferior, symmetric extension of the frontal sinus towards the anterior ethmoid air cells may also be found predominantly in male individuals in the age range between 20 & 40 years. Cases in children have not been reported.[4]

As regards the maxillary sinus, four recesses have been described 1) Palatine recess that extends inferomedially to the hard palate towards the midline 2) Alveolar recess, closely related to the molar and premolar teeth roots 3) Infraorbital recess, projecting anteriorly along the roof of the maxillary sinus and 4) Zygomatic recess that extends over the malar bone at variable distances.[5]

Ethmoid cells variations

Haller's cells first identified by Haller in 1965 are infraorbital ethmoid cells located inferiorly to ethmoid bulla along the orbital floor and adjacent to the natural ostium may cause mucociliary drainage impediment and predispose to the development of sinusitis.

Agger nasi cells, which are most anterior ethmoid cells, are located anteriorly to the plane of the maxillary sinus infundibulum. Studies demonstrate that their major dimensions are correlated with frontal sinus diseases and lacrimation.

Onodi cells are ethmoid cells that have migrated to the anterior region of the sphenoid sinus, with anterosuperior location, and intimately related to the optic nerve causing optic neuropathy in case of certain conditions that affect such cells.

Bulla frontalis are characterized by anterior ethmoid cells which invade the frontal bone, causing a bulge on its floor, but with no connection with this sinus. They are more easily demonstrated at sagittal CT, where they appear as ethmoid air cells located above the frontal sinus.

Depending on their size & pneumatization extent, such cells may affect the frontal sinus drainage, representing a real diagnostic challenge in addition to the difficulty of the surgical management of inflammatory disease involving such a sinus.

Other ethmoid cell variations may be found in the frontal recess, influencing its architecture that is determined by the patency of walls and boundaries of adjacent structures, such as frontal cells which are classified into 4 types, as follows:

Type 1: detected in 37% of frontal recesses; defined as a single ethmoid cell located anteriorly to the frontal recess and above the agger nasi cell;

Type 2: detected in 18% of cases; two or more ethmoid cells located anteriorly to the frontal recess, above the agger nasi cell;

Type 3: represents 6-8% of cases; a single, voluminous cell detected above the agger nasi cell, with extension to the frontal sinus;

Type 4: rarely found, it represents 2-4% of cases, corresponding to an ethmoid cell within the frontal sinus, with no connection with agger nasi cell.

Variation of the cribriform plate

The cribriform plate may present at variable levels and, in such cases it is classified according to the criteria developed by Keros which is based on the height of the olfactory fossa in relation to the roof of the ethmoid sinus as compared with the length of the lateral lamella of cribriform plate of ethmoid plate. The higher the keros grade the greater the chance of injury of the cribriform plate and olfactory fossa, with consequential risk of iatrogenic CSF fistula and olfactory impairment.[6]

METHODS

The consecutive nasal and paranasal sinus CT scans of 100 patients who attended ENT clinic at government McGann teaching hospital, Shivamogga between May 2013 and May 2014 were analyzed. All patients obtained CT scan for evaluation of symptoms of sinonasal region. Patients who underwent previous sinonasal surgery, neoplasm, facial trauma were excluded from the study. CT plane was direct coronal with 5 mm thickness obtained from glabella to the posterior wall of the sphenoid sinus while the patient is in prone position with neck extension. Radiologist's opinion was obtained in all the cases. Each patient was reviewed for the presence of below findings.

RESULTS

The mean age of the patient included in the study was 32 years and their ages varied from 8 to58 years. There were 54 males and 46 females in the study. Agger nasi cells were the most common variation and were observed in 68 patients (68%). In one study by Perez-Pinas et al., of 220 patients, 100% patients showed presence of Agger nasi.[7] Deviated nasal septum more than 3mm was second most common variant observed in 47 cases (47%). A study done by Dua et al.[8] showed 44% which is nearer to the incidence of our study. Concha bullosa of middle turbinate was observed in a total of 37 patients (37%) with equal distribution on both sides. Badia et al.[9] in his study of Concha bullosa variation in ethnic population showed 28% incidence. Pneumatization of nasal septum was found in posterior bony aspect including vomer and perpendicular plate of ethmoid in 30 patients (30%). Pneumatization of crista galli was observed in 28 patients (28%) which is comparatively higher than other studies. Som PM et al.[10] have reported 13% cases of pneumatization of crista galli in 200 adult cases. Interestingly none of the patients showed pneumatization of the inferior turbinate in our study.

Table 1: Types of ostiomeatal complex abnormalities.

Type	Uncinate process orientation	Ethmoidal bulla appearance
1	Vertical	Enlarged or prolapsed
2	Vertical	Normal
3	Vertical	Absent or hypo plastic
4	Horizontal	Enlarged or prolapsed
5	Horizontal	Normal
6	Horizontal	Absent or hypo plastic

Table 2: Anatomical variations of sinonasal region of 100 patients in study group.

	Side of sinus			Patient - 100	
	Right	Left	Both sides	Number	%
Agger nasi	10	08	50	68	68
Concha bullosa of middle turbinate	19	10	08	37	37
Paradoxical middle turbinate	04	05	03	12	12
Haller cell	04	07	02	13	13
Pneumatization of superior turbinate	02	03	01	06	06
Pneumatization of uncinate process	01	00	00	01	01
Septal deviation >3 mm	26	21	00	47	47
Pneumatization of posterior septum	00	00	00	30	30
Pneumatization of crista galli	00	00	00	28	28
Pneumatization of inferior turbinate	00	00	00	Zero	Zero
Lamina papyracea dehiscence	00	00	00	Zero	Zero
Dehiscent anterior ethmoidal artery	00	00	00	Zero	Zero

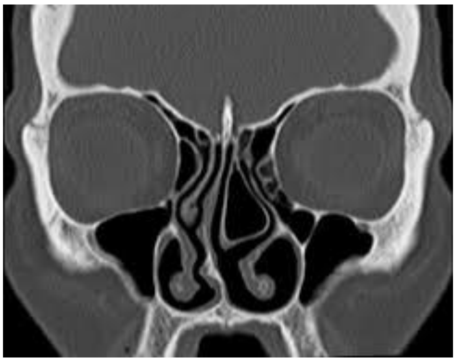

Figure 1: Radiological picture of concha bullosa.

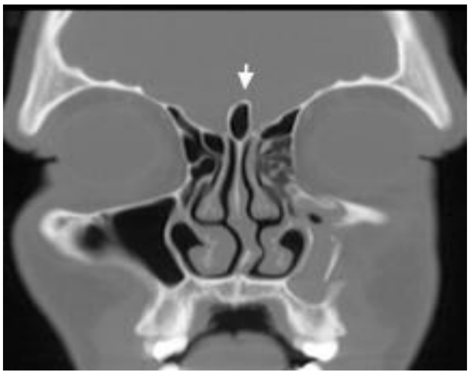

Figure 2: Radiological picture of crista galli pneumatization.

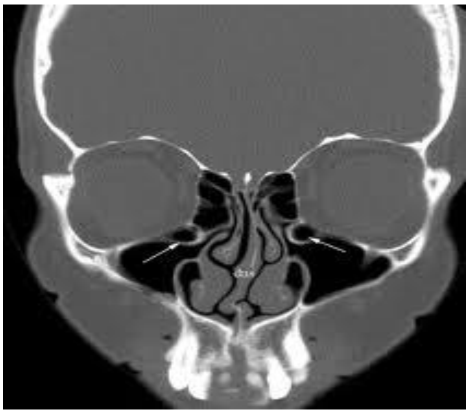

Figure 3: Arrow pointing towards Haller cells.

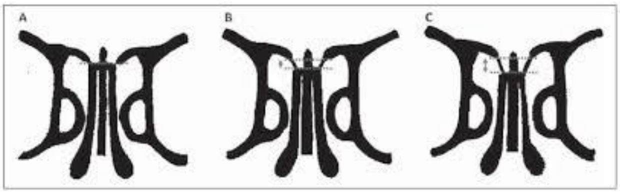

Figure 4: Schematic diagram depicting Kore staging of cribriform plate formation.

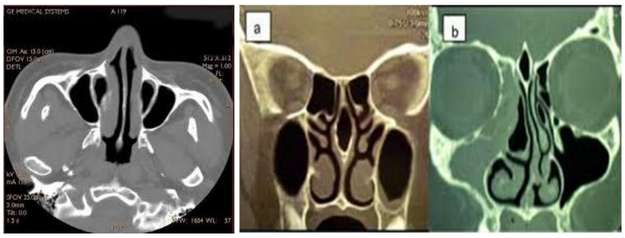

Figure 5: Radiological picture of maxillary sinus septum.

DISCUSSION

The surgical management of chronic sinonasal disease is evolved as the mainstay of treatment as the medical line of management has poor results. External facial incisions, extensive nasal packing and prolonged hospital stays have been replaced by minimally invasive surgery. It conserves resources and as well it is a teaching tool. This is on the basis of principle of Messerklinger's ventilation and drainage of sinus ostia with preservation of adjacent mucosa with intact cilia[11,12] with outstanding results reported in the literature.[13] This procedure needs sound endoscopic anatomic knowledge, given the close relationship of important structures such as skull base, orbit, major nerves and vessels. If complications occurs during surgery they are very dangerous and may be life threatening.

Anatomic variations in the sinonasal region are common. Recent advances in CT scan techniques and widespread application of FESS has made the variations apparent and thus reduction both in number and seriousness of surgical complications.

CONCLUSION

The incidence of variations in sinonasal anatomy was under rated earlier. Current study shows the CT scan has an important role in the identification of sinonasal anatomic variations as well as of sinusal diseases. CT scan is a mandatory tool for a better guidance in decision making in surgical approaches and to prevent on table and post-operative surgical disasters.

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