Radiological and NASAL Endoscopic Study of Sinonasal Anatomical Variations in 50 Cases of chronic Sinusitis Undergoing functional endoscopic sinus surgery (FESS)

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ABSTRACT
BACKGROUND

The present study was conducted on 50 cases of chronic sinusitis undergoing Functional Endoscopic Sinus Surgery (FESS). Each case was subjected to computerized tomographic scan (Coronal section) paranasal sinus and standard three pass diagnostic nasal endoscopy and different sinonasal anatomical variations observed were recorded and these sinonasal anatomical variations were evaluated in order to determine their clinical significance.

RESULTS

The presence of various significant sinonasal anatomical variations were observed that accentuate the need for proper preoperative assessment OF every patient in order to accomplish a safe and effective endoscopic sinus surgery.

CONCLUSION

The prevalence of the various anatomical variations as determined by this study correlate well with that of other authors studying similar patient groups. This study re-emphasize the need for detailed clinic-radiological evaluation before proceeding for a endoscopic sinus surgery.

KEYWORDS: Nasal Endoscopy, Chronic Sinusitis, Computed Tomographic Scan, Endoscopic Sinus Surgery

BACKGROUND

Chronic sinusitis is repeated bouts of acute infection or persistent inflammation of sinuses. Sinusitis is a very common disease and factors which cause immunosuppression or any blockage of normal sinus drainage are responsible for this condition. CT scan is imaging modality of choice in chronic sinusitis, revealing anatomical details of the sinuses and adjacent soft tissues.

With the advent of functional endoscopic sinus surgery (FESS) as treatment of choice for chronic sinusitis, considerable attention has been directed towards analysis of paranasal sinus anatomy through coronal plane computerized tomographic (CT) imaging. Subtle anatomical variations such as Haller's cells, pneumatization or paradoxical curvature of middle turbinate, and variations in the conformation of ethmoid bulla, uncinate process, agger nasi cell and frontal recess can now be imaged through CT.(Bolger et al, 1991)[1]
All cases of chronic sinusitis are associated with anatomical variations and/or pathological abnormalities of the 'osteomeatal area'. It is recommended, therefore, that during the diagnosis and treatment of chronic sinusitis, attention should be given to the region of the middle meatus

and anterior ethmoidal complex (or 'osteomeatal area') for any anatomical variations and/or pathological abnormalities in order to avoid recurrence of sinusitis. (Kamel 1989)[2]
The safe and effective performance of any surgery is dependent on a sound knowledge of anatomy. This is most true during endoscopic sinus surgery because of the intimate association with such vital structures as the orbit, optic nerve, anterior and posterior ethmoidal vessels, skull base and internal carotid artery. The difficulty is compounded by the occurrence of variations in sinonasal anatomy. The incidence with which these variations are seen in a normal population is less frequent than in those individuals with chronic sinusitis. (Zinreich 1998)[3].
Magnetic Resonance Imaging (MRI) is superior to CT in the delineation of mucosal disease, but it is not routinely used in evaluating patients for FESS. Poor delineation of the bone-air interfaces result in poor visualization of the osteomeatal unit, necessary in determining patients for FESS. (Zinreich 1992)[4]
This study aimed to study the various sinonasal anatomical variations in our population and their frequency of occurrence in patients with chronic sinusitis.

REVIEW OF LITERATURE
The mucociliary transport system of paranasal sinuses was discovered in the 1930s by Anderson C. Hilding and endoscopically illustrated by Messerklinger and colleagues. The work of Wigand and Messerklinger has shown that limited procedures established ventilation and drainage and led to healing of severe mucosal changes.
Endoscopy of the nose received impetus with the improvements by Hopkins between 1951 and 1956. These included a light source that was separate from the instrument, excellent resolution with high contrast, wide angle of vision and true fidelity of colour.
In 1981, Wigand[5] reported on the use of a suction-irrigation surgical endoscope with rotatary and interchangeable angled telescope that could be used in situ for a longer timewithout lens getting fogged or stained with blood. Around the same time, Stammbergerand several other workers started reporting on the use of angled vision endoscopes.
Yamashita[6] (1984) and Lancer[7] et al (1986) have reported the role of flexible rhinolaryngoscope with 3.4 mm diameter, 85 degree angle vision and 230 degree arc of visual field mainly for diagnostic purposes. Their role for therapeutic purposes is not established.
Lloyd[8] et al (1991) studied CT scans of 100 patients in order to test the percepts forming the basis of functional endoscopic sinus surgery. They concluded that obstruction in the middle meatus and osteomeatal complex was associated with an increased incidence of opacity in the sinuses but the primary site of disease was not established: the concept that sinus disease takes origin in the middle meatus was not proven. Anatomical variants in the middle meatus were not associated with an increase in sinus opacity and there was no evidence that these anomalies have any effect on sinus disease by causing middle meatal stenosis. The radiological assessment of patients with inflammatory nasosinus disease should start with plain X-ray. CT is unnecessary as a routine examination. It should be reserved for the pre-operative assessment of patients for endoscopic surgery, its main function being to show important anatomical landmarks.
According to Stammberger[9] et al (1991) the bulla may be excessively pneumatized to the extent of blocking the hiatus semilunaris, extending beyond the uncinate or sometimes extending out of the middle meatus between uncinate and middle turbinate.
Scribano[10] et al (1993) in the study involving 71 cases and 59 normal subjects noted concha bullosa, Aggernasi cells, septal spur and septal deviations as most common anatomical variations.

Wang R[11] et al (1997) studied 32 high-resolution coronal CT scans were studied in patients with septal deformity or sinusitis and demonstrated four variations of the uncinate process 1) Medial deviation 2) Laterally deviated 3) Pneumatized and 4) Hypertrophied. The following conclutions were drawn(1)the anatomic variations in ostiomeatal complex is responsible for the formation of chronic sinusitis; (2)for patients with chronic sinusitis, uncinatectomy is the treatment of choice; (3)preoperative and intraoperative studies of CT scans are mandatory for avoidance of complications.

Arslan[12] et al (1999) noted supraorbital recess in 6%, concha bullosa in 30%, Haller's cells in 6%, Onodi cells in 12%, pneumatization of the uncinate process in 2%, paradoxical curvature of middle turbinate in 3%, septal deviation in 36% of patients.

Liu[13] et al (1999) explored the relationship between anatomic variations in the ostiomeatal complex and chronic sinusitis. Coronal plane CT scans of the paranasal sinuses showing the ostiomeatal complex including the middle turbinate, uncinate process, ethmoid bulla, aggernasi and Haller cell were analyzed in 297 individuals. The anatomic variations included paradoxical curvature of the middle turbinate (13.97%), the pneumatized middle turbinate (34.85%), uncinate hyperplasia (19.36%), deviation of uncinate (45.27%), large ethmoidal bulla (30.30%), large agger nasi (0.70%) and Haller cell (1%). They concluded that the occurrence of OMC variation is common. The variations may be one of the causes of chronic sinusitis. Therefore, properly handling the variations is important in the endoscopic sinus surgery.

Antoni[14] K et al (2001) studied preoperative CT scan of 157 patients suffering from chronic sinusitis, the CT scans were evaluated using the method of the four- zone interpretation. Zone I - the frontal sinus region, Zone II- the anterior ethmoid region, Zone III- the posterior ethmoid region and Zone IV – the sphenoid sinus region. Uncinate process was included in the Zone-II and they found incidence of uncinate process attachment: Type I 17.83%, Type II 33.12%, Type III 14.33% and imposible to access 34.71%. Uncinate process variations normal 55.73%, elongated uncinate process 17.52%, medial deflection 8.6%, lateral deflection 9.55%, pneumatized uncinate process 0.96% and uncinate hypoplasia 7.64%.

Midilli[15] et al (2005) studied anatomic variations of the paranasal sinuses detected by computed tomography and the relationship between variations and sex. They studied computed tomography scans of the paranasal sinuses of 464 patients (266 males, 258 females; mean age 37.5 years; range of 4-87 years) and were retrospectively analyzed. It was found that most common anatomic variation was aggernasi cells (80.4%) followed by pneumatization of the middle concha (37%). Frequency of variations did not differ significantly with respect to gender ($p>0.05$) except for frontal hypoplasia, which was more often in females ($p<0.05$).

CT SCANNING PROTOCOLS

Stammberger et al[9] (1991) recommends the following parameter. Imaging should be in the coronal plane perpendicular to infra-orbito-meatal line. Slice thickness should be set at 4 mm andwhen extra detail is required at 2 mm. When no sagittal or axial reconstruction iscontemplated, contiguous 4 mm thickness scans should be taken. When reconstruction isplanned, thinner or overlapping slices should be chosen. The position of the patientshould be prone with head hyperextended. The scan time should be 5 to 7 seconds,window width of +1500 to 2000 HU centered at a level of -150 HU.

Bhatt[16] NJ (1997) recommends that contrast is not required for uncomplicated chronic sinusitis and is to be used only in case of suspected pyocele, mucocele and malignancy.

Wigand[5] (1990) recommends quasi-frontal coronal sections with high resolution bone window and slice thickness of 2 mm and slice interval of 5 mm.

METHODS

Inclusion criteria:

All the patients with chronic sinusitis not responding to medical treatment and willing to undergo endoscopic sinus surgery and CT scanning of paranasal sinuses.

Exclusion criteria:

1. Patients who had previous endoscopic sinus surgery and hence would be undergoing revision procedure.
2. Patients who had undergone previous septal or turbinate surgery.
3. Patients with chronic sinusitis who did respond to medical management.
4. Patients not consenting to participate in the study.

Method of collection of data:

1. The cases selected for the study were subjected to detailed history and evaluation.
2. Routine investigations like hemogram, bleeding and clotting time and routine urine evaluation were done for the patients.
3. Those patients in active stage of the disease were treated with a course of antibiotics, analgesics and decongestants. However, steroids will not be given either topically or systemically for any patient before surgery.
4. The patients had undergone standard three pass diagnostic nasal endoscopy using 0 degree and 30 degree Hopkin's rod telescopes.
5. The patients had undergone CT scanning of paranasal sinuses.
6. Finally, the patients had undergone endoscopic sinus surgery, the extent of which was dictated by the disease extent by the above procedures (CT scan and Diagnostic endoscopy).

Equipments used:

1. Nasal endoscopes: 0 degree, 30 degree and 45 degree Hopkins rod endoscopes.
2. Cold light source.
3. Fiber optic light cord.
4. Single chip camera.
5. 14 inch colour monitor.
6. Savlon as antifog solution.
7. Standard endoscopic sinus surgery instruments.

The method of diagnostic nasal endoscopy used:

After testing the patient for lignocaine sensitivity, diagnostic endoscopy was performed using the standard three pass technique. During the first pass, the endoscope was passed along the floor of the nasal cavity noting the status of the inferior turbinate, septum, Eustachian tube orifice, fossa of Rosenmuller, nasopharyngeal mucosa and nasolacrimal duct orifice. During the second pass, the scope was introduced along the superior surface of the inferior turbinate and directed into the sphenoethmoidal recess. While withdrawing the scope, the sphenoid ostium, sphenoethmoidal recess and superior turbinate were visualized and any variations noted. During the third pass, the agger nasi area, uncinate, middle meatus and frontal recess area were visualized and variations noted.

Technique of CT scanning performed:

The scanning was done on Spiral CT Scanner.

Patient position: Supine with head extension. In patients in whom head extension was contraindicated due to cervical spondylosis, gantry tilt was suitably adjusted.

Angulation: Perpendicular to hard palate.
Extent: From the nasion to posterior extent of sphenoid. Thickness: 5 mm thickness with 5 mm shift to get contiguous sections.
Exposures: 120 kV, 4.5 sec scan time, 300 mA, window width of 2500 to 3000 HU and window level of 250 to 300 HU.
The images were recorded onto compact disc and photographic plates. The photographic plates were displayed in the operation theater at the time of surgery.

Technique of endoscopic sinus surgery:

The patients underwent endoscopic sinus surgery after obtaining written informed consent for the same.
The extent of the procedure was dictated by the extent of disease as determined by nasal endoscopy, CT scanning and intraoperatively. A typical complete procedure included the following:
1) Infundibulotomy
2) Middle meatalantrostomy
3) Clearance of frontal recess
4) Opening bulla and exenteration of anterior ethmoids
5) Posterior ethmoidexenteration
6) Sphenoid exenteration.

Following the above procedures, the findings were recorded. The results were tabulated. The various variations were analyzed as a percentage of the total and reported.

RESULTS

The present study was conducted among 50 patients of chronic sinusitis who were undergoing endoscopic sinus surgery.Thus, a total of 100 nasal cavities were examined by diagnostic nasal endoscopy, CT scanning and at the time of definitive surgery. The various anatomical variations of each patient were noted and their frequency of occurrence was determined.

Age and sex distribution: The age of the patients varied from 10 years to 62 years.The sex distribution showed a male preponderance with 68% males and 32%females.

Septal deviation: Septal deviation was found in 70% of cases with preponderance of deviation to left in 64% patients.

Agger nasicells: In 70% of the cases, pneumatization of the agger nasi cells was found with bilateral involvement in 80% patients.

Frontal cells: We found frontal cells in22 sides. Out of these 15 were of type I, 2 of type II, 2 of type III and 3 sides had type IV frontal cells.

Frontal sinus: In the present study, the frontal sinus was found to be non pneumatised in 8% cases. In our patients, frontal sinuses on either side were always asymmetrical with right being large in 46.66% and the left sinus being large in 53.33% cases.

Frontal recess: In our study we found that the frontal recess was obstructed in 21.7%.Out of these, in 45% cases the obstruction was by the agger nasi cells, in 15% by frontal cells, in 20% by ethmoid bulla or accessory cells and in 20% by polyps.

Middle turbinate: We found the pneumatised middle turbinate in 34% cases. Of these, 32.4% showed lamellar pattern, 20.6% showed bulbous pattern and 47.1% showed true concha bullosae. We found paradoxical curvature of middle turbinate in 9% cases.

Bulla ethmoidalis: The bulla was found to be enlarged in 20% cases in our study.

Uncinate process: Out of the possible 100 sides, superior process of uncinate process could be identified definitely for 86 sides. Type I uncinte process was seen in 80.23% cases with type II in 16.27% and type III Uncinate process was seen in 3.48% cases.

Pneumatised uncinate process: In our study, uncinate bulla was seen in 3% of cases.
Maxillary intrasinus septa: We found maxillary sinus septa in 4% of sides.
Acessory ostia: The accessory ostia of maxillary sinus were present in 15% of nasal cavities. Anterior fontanelle (10%) was found to be present more than posterior which was only 5%.
Inferior turbinate hypertrophy: We found inferior turbinate enlargement in 50% cases.
Pneumatized superior turbinate: The superior turbinate was found to be pneumatised in 7% cases and we could not discern the presence of supreme turbinate in any of our cases.
Onodi cells: Onodi cells were seen in 17% sides with **Haller cells** in 5% sides.
Supraorbital ethmoidal cells were seen in 18% cases.
In our study the sphenoid sinus was found to be absent or non pneumatised in 2% cases with conchal type of sphenoid sinus in 2%, preseller type in 32% and sellar type in 64% cases.
Intra sphenoid projections: Optic nerve was seen in 27%, maxillary nerve in 34% and vidian nerve in 29% sides.
Skull base depth was observed as Keros type I olfactory fossa in 14%, type II in 70% and type III in 16% nasal cavities.

DISCUSSION

Age and sex distribution: There were no significant effects or co relations between participant's age and sex.
Septal deviation: The mere presence of a septal deviation does not suggest pathology. However, a marked deviation can force the middle turbinate laterally, thus narrowing the entrance to the middle meatus.
Agger nasi cells: Pneumatization of the agger nasi cells was found in majority of the cases with bilateral involvement in 80% patients.The prevalence of agger nasi cells varies widely as reported by 40% by Dua[17]et al in 2005 and 86.7% by Tonai and Baba[18] in 1996. Depending on the degree of pneumatization, Agger nasi cells may reach literally to the lacrimal fossa and superiorly to cause narrowing of frontal recess.
On coronal CT scan, these cells appear inferior to frontal recess and lateral to the middle turbinate.Because of this intimate relationship these cells form excellent surgical landmarks. Opening the agger nasi cells usually provide a good view of the frontal recess. Therefore identification of this variation is important in diagnosis and treatment of recurrent or chronic frontal sinusitis.
Frontal cells: Frontal cells are derived from anterior ethmoid sinus behind the agger nasi cells and they pneumatize the frontal recess above the agger nasi cells. Meyer et al[19] in 2003 in their study of 768 CT scans described 14.9% type I, 3.1% type II, 1.7% type III and 2.1% type IV frontal cells .

Frontal sinus and Frontal recess: The frontal sinus was found to be non pneumatised in 8% cases and frontal recess was obstructed due to multiple pathologies in our study.
Middle turbinate:Normally the middle turbinate is said to have convex medial and concave lateral surfaces with smooth uniform curvature with no obstruction to middle meatus and adequate space between the turbinate and septum. However, the middle turbinate is known for several variations like pneumatised middle turbinate, lamellar pattern, bulbous pattern and true concha bullosae. Our results are close to that reported by Zenreich et al[20] in 1987.
Presence of a concha bullosa does not suggest a pathological finding. However, in the setting of chronic sinus disease, resection of concha bullosa should be considered to improve the paranasal sinus access.

Paradoxically bent middle turbinate: A middle turbinate which is distorted such that the convex surface faces towards the meatus is in itself not pathologic but can contribute to severe narrowing of the middle meatus if other mucosal derangements are present. The paradoxical curvature of middle turbinate in 9% cases was similar to that reported by Dua et al[17] in 2005 i.e. 10% and Lusk et al[21] in 1996 I.e. 8.5%.

Bulla ethmoidalis: Hypoplastic bulla is defined as one in which the distance between the lateral surface of middle turbinate and summit of bulla is more than 4 to 5 millimetres.

Uncinate process: Normally, the uncinate process is a sagitally oriented structure with adequate space between it and bulla ethmoidalis, middle turbinate and lamina papyracea. The medially deviated uncinate may contact the middle turbinate or can also narrow the middle meatus. a lateral deviation of uncinate process will make the infundibulum narrow. Because of the reduced distance between the lateralised uncinate process and lamina payracea, orbital injury must be taken care of during surgical procedures.

A pneumatised uncinate process is also called as uncinate bulla. It can narrow the infundibulum, frontal recess and middle meatus. Bolger et al[1] in 1991 found incidence of uncinate bulla to be 2.35%.

Maxillary intrasinus septa: An intrasinus maxillary septum can convert the maxillary sinus into two chambers. Maxillary septa can lead to impaired drainage of in part of the maxillary sinus, while the rest of it is normal.

Inferior turbinate hypertrophy: The large inferior turbinate is associated with ipsilateral maxillary sinus pathology.

Intra sphenoid projections: The high incidence of intra sphenoid projections means that in addition to optic nerve and carotid artery, even maxillary nerve and vidian nerve are at high risk during sphenoid surgery.

Skull base configuration:

The roof of the ethmoid bone is formed by the fovea ethmoidalis laterally and the cribriform plate medially. The lateral lamella of the cribriform plate is thin and may be of substantial height making it vulnerable to injury.

The anatomy of the anterior ethmoid is critical for two reasons. First, the area is most vulnerable to iatrogenic CSF leaks. Second, the anterior ethmoid artery is vulnerable to injury which can cause devastating bleeding into the orbit.

Summary and Conclusions

In view of the presence of these significant variations we re-emphasize the need for proper preoperative assessment in every patient in order to accomplish a safe and effective endoscopic sinus surgery.

The various anatomical variations encountered with their clinical significance is described.The prevalence of the various anatomical variations as determined by this study correlated well with that of other authors studying similar patient groups.

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