Importance of CT Scan of Paranasal Sinuses in the Evaluation of the Anatomical Findings in Patients Suffering from Sinonasal Polyposis

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Abstract Sinonasal polyps are benign lesions arising from nose and/or sinuses mucosa. Paranasal sinuses computed tomogram (CT) scan are important for functional endoscopic sinus surgery (FESS) as their information assist the surgeon in pre-operative planning. This study aimed to show importance of CT scan in evaluation of anatomical variations to prove a correlation with disease process and extent of disease in sinonasal polyposis patients. A study was done from Sept, 2010 to Sept, 2011 with 33 patients presenting with nasal polyps. All recruited patients, after thorough history, general examination and thorough ENT examination, were examined by nasal endoscopy and sinus CT scans. All scans were carried out using a 3 mm thickness in axial and coronal planes with sagittal reconstruction. An analysis was then carried out to see anatomical variations and disease extent in CT scans. Maxillary sinus was the most commonly and most severely affected sinus, while the sphenoid sinus was the least involved sinus. Ostiomeatal complex (OMC) was found to be blocked in 84.85 % cases. There were few anatomic variations

(57.58 %) found as hypertrophied uncinate process (30.30 %), septal deviation (21.21 %), skull base type-2, Concha bullosa, Haller's cell, Paradoxical middle turbinate, Onodi cell, pneumatized crista galli and dehiscent skull base. Hyperdense and heterogeneous opacification in paranasal sinuses was seen in 12.12 % patients. Importance of CT scans is to know anatomical variations as etiology, fungal etiology, to know extent of polyposis and anatomical variations to prevent complications during FESS and Navigation sinus surgery.

Keywords Nasal polyp · Sinus CT scan · Lateral nasal wall

Introduction

Benign sinonasal polyps (SNP) are lesions that arise from the mucosa of the nasal cavity and/or one or more of the paranasal sinuses, often at the outflow tract of the sinuses. Due to uncertain etiology, treatment options differ and no one treatment has been found to be universally effective.

The prevalence of SNP in general population is considered to be around 4 % [1]. In cadaveric studies, this prevalence has been shown to be as high as 32 % [2]. They predominantly affect adults and usually present in patients older than 20. They are uncommon in children under 10 and may be the presenting feature of cystic fibrosis. There is at least a 2:1 male to female preponderance. Up to a third of SNP patients have asthma, whereas polyps are only found in 7 % of asthmatics [3].

Etiology of SNP is unknown. Most theories consider polyps a consequence of chronic inflammation and therefore conditions leading to chronic inflammation in the nasal cavity can lead to nasal polyps. Anatomic factors may also

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play a role in the etiology of SNP as nasal polyps are mainly situated in the middle meatus and that they originate from the mucous membrane of the outlets (ostia, clefts, recesses) from the paranasal sinuses. The reason for this is unknown. The possibilities are:

- touching mucous membranes in the narrow ostiomeatal complex results in the release of proinflammatory cytokines from epithelial cells, affecting integrity of Sodium channels. This causes tissue edema which in due course may produce polyp [Bernstein theory],
- an influence of special airflow, air current and pressure in the upper part of nose [Bernoulli phenomenon],
- nerve endings near the borderline between the nose and paranasal sinuses are thin and may easily become damaged by cytotoxic proteins, released by eosinophils. This loss of autonomic innervations induces abnormal vascular permeability leading to tissue edema [Vasomotor theory].

Common medical conditions associated with polyps are non-allergic asthma, aspirin intolerance and cystic fibrosis. SNP are found in 36 % of patients with aspirin intolerance, 7 % of those with asthma and about 20 % of those with cystic fibrosis [3]. No evidence exists, however, for an allergic origin [4]. In allergic rhinitis the prevalence of symptomatic nasal polyps is low (1.5 %) and similar to that in the normal population (1 %). Polyps are statistically more common in non-allergic asthma than allergic asthma (13 % versus 5 %, $P < 0.01$) [3]. Patients with Samter's Triad (polyposis, asthma, and aspirin hypersensitivity) comprises almost 10 % of cases of nasal polyps.

Grossly polyps appear as pale bags of edematous tissue arising commonly from middle meatus and prolapsing into the nasal cavity. Their pale color is due to poor blood supply but with repeated trauma and inflammation polyps may become reddened and the surface becomes squamous rather than respiratory in type. They are usually bilateral and when unilateral require histological examination to exclude the transitional cell papilloma (also known as Ringertz's tumour or inverted papilloma) or malignancy [5]. Histologically polyps are characterized by ciliated columnar epithelium, thickening of the basement membrane, a loose avascular grossly edematous stroma and an infiltrate of plasma cells and many eosinophils. Eosinophils are found in 85 to 90 % of polyps. The majority of the remaining cells in polyps are polymorphonuclear cells.

Their main presenting symptom is nasal obstruction, which is constant, although it will vary with the size and position of polyps. Patients may also complain of watery anterior rhinorrhea (excessive nasal secretions) or mucopurulent postnasal drip, or both. Hyposmia and anosmia (reduced or absent sense of smell) with a concomitant alteration in taste are characteristic symptoms of nasal

polyps. Pain is an infrequent feature but does occur in patients with polyps and is usually over the dorsum of the nose, forehead and cheeks. It is worse when the nose is congested and there is secondary infection of the sinuses [6].

Diagnosis of SNP is made by rhinoscopy: anterior and posterior. The diagnosis is often easier if a small probe is used for gentle palpation as polyps are insensitive and are mobile on their pedicles [Probe test]. Plain radiographs of the paranasal sinuses are of no value in the diagnosis of nasal polyps although they may confirm opacification of the sinuses.

Computed tomography is a fast and readily accessible imaging technique. The examination is well tolerated and therefore suited to very elderly or infirm patients as well as children, people with claustrophobia, or patients who are critically ill. A CT scan shows the anatomical variations and the extent of the disease and is essential if surgical treatment is to be implemented. It should not be regarded as the primary step in the diagnosis of the condition, except where there are unilateral signs and symptoms or other sinister features, but rather corroborates history and endoscopic findings after failure of medical therapy. Intravenous contrast medium injection is not required unless a tumor, vascular lesion, or acute complication is suspected. Severe polyposis and unilateral opacification of the sinuses is accessed with a contrast-enhanced study to help distinguish mucosa, polyps, and fluid, and rule out any additional underlying pathology.

The aims of treatment of SNP are to relieve nasal obstruction, restore olfaction, and improve sinus drainage and to treat any accompanying rhinitic symptoms [7]. Corticosteroids are the only medical therapy to have a proven effect on the symptoms and signs of nasal polyps and can be used topically or systemically. As newer intranasal corticosteroids are introduced, sensory attributes and immediate efficacy may decide the patient preference and adherence to therapy and thereby reflect on treatment outcome. In one study by Varshney et al. [8], although their immediate efficacy and tolerability were comparable, an overall patient preference was for fluticasone propionate formulation rather than ciclesonide. In a recent retrospective review of litigation trends related to the administration of corticosteroids and the reported complications [9] it was advised that physicians should obtain informed consent prior to steroid therapy.

No single surgical technique has proved entirely curative and patients often undergo repeat procedures and receive long-term medical treatment. Recurrence is common and between 5 and 10 % of patients have recurrent severe disease [5]. The surgical management of nasal polyps has changed over the last two decades with the advent of FESS. The role of pre-operative CT scan is to see the anatomic variations which should be kept in mind during FESS to prevent

complications; and should be treated simultaneously with the disease proper during surgery for adequate improvement following surgery and to prevent recurrence. The helical CT scan is also a pre-requisite for Navigation sinus surgery which is typically used for revision sinus surgery and complicated cases such as mucocoeles, neoplasm, CSF leaks, and meningoencephaloceles.

Materials and Methods

We conducted a study at the Otorhinolaryngology outpatient department of Institute of Postgraduate Medical Education & Research (IPGME&R)/SSKM Hospital, Kolkata, India, between September 2010 and September 2011. Prior to study initiation, the protocol and informed consent documents were approved by the Institutional Ethics Committee.

A total of 33 patients, above 10 years of age, having sinonasal polyps and non-responsive to 3–4 weeks of medical treatment were included in the study while pre-malignant condition/malignancy patients were excluded from statistical analysis. Patients were excluded if they provided history of recent nasal biopsy, nasal trauma or surgery, atrophic rhinitis or rhinitis medicamentosa within last 60 days prior to screening; also excluded were expectant and nursing mothers. Written informed consent was obtained from each study participant. In the case of enrolled adolescent subjects (between 10 and 18 years), consent was provided by the legal guardian while they themselves provided assent.

All recruited patients, after thorough history, general examination and thorough ENT examination, were examined by nasal endoscopy and sinus CT scans. All scans were carried out using 3 mm thickness in axial and coronal planes with sagittal reconstruction. An analysis was then carried out to see the anatomical variations and extent of disease in the sinus CT scans. Preoperatively, after appropriate medical treatment, CT scans were evaluated as per modified Lund–Mackay scoring system [10] (Table 1).

Statistical analysis was performed on the intent-to-treat (ITT) population. For statistical analysis, data would first be entered in Microsoft excel database and subsequently processed by standard statistical software: Statistica version 6 [Tulsa, Oklahoma: Stat Soft Inc., 2001].

Results

A total of 33 patients were recruited to be included in the ITT population. There were no dropouts.

Table 1 Lund–Mackay scoring system

Sinus system	Left side	Right side
Maxillary (0,1,2)		
Anterior ethmoids (0,1,2)		
Posterior ethmoids (0,1,2)		
Sphenoid (0,1,2)		
Frontal (0,1,2)		
Ostiomeatal complex (0 or 2 only)		
Total points		

0 = no abnormality; 1 = partial opacification; 2 = total opacification

For Ostiomeatal complex: 0 = not obstructed, 2 = obstructed

A total score of 0–12 per side is possible, with the higher no. reflecting more severe rhinosinusitis and polyposis

The median (interquartile range) age of the participants was 33.41 (8–60) years while the median symptom duration was 19.18 (2–72) months. There were 18 (54.55 %) males and 15 (45.45 %) females.

On analysis of the CT scans of nose and paranasal sinuses, the most common sinus found to be involved was maxillary sinus (93.94 %) followed by anterior ethmoid (63.63 %), frontal (42.42 %), posterior ethmoid (33.33 %), while the sphenoid sinus (21.21 %) was the least involved sinus (Table 2; Fig. 1). The only sinus which was usually severely affected was maxillary sinus (90.91 %) while the other sinuses were only mildly affected or remained uninvolved. Ostiomeatal complex was found to be blocked in 84.85 % cases.

During the review of CT scans of the patients, the anatomic variations (57.58 %) found as hypertrophied uncinate process (30.30 %), septal deviation (21.21 %), skull base type-2 (15.15 %), Concha bullosa (9.09 %), Haller's cell (6.06 %), Paradoxical middle turbinate, Onodi cell, Pneumatized Crista galli and dehiscent skull base (Table 3; Figs. 2, 3, 4, 5). Hyperdense and heterogeneous opacification in paranasal sinuses was seen in 4 (12.12 %) patients.

Discussion

Nasal polyps have very remarkable effect on the quality of life. Nasal polyps typically present in adults with male preponderance—the pooled median age in our study was 33.41 years with males affected in 54.55 %.

The health and normal function of the paranasal sinuses and their lining mucous membranes depend primarily on the ventilation and drainage. The etiology of SNP is unknown. Some theories consider polyps a consequence of conditions which cause chronic inflammation in the nose

Table 2 Preoperative sinus involvement on CT scan (Lund–Mackay scoring system)

Sinus	0	%	1	%	2	%	Total affection (%)
Maxillary	3	9.09	1	3.03	30	90.91	93.94
Anterior ethmoid	11	33.33	11	33.33	10	30.30	63.63
Posterior ethmoid	21	63.63	9	27.27	2	6.06	33.33
Frontal	18	54.55	10	30.30	4	12.12	42.42
Sphenoid	25	75.76	6	18.18	1	3.03	21.21
OMC	6	18.18			28	84.85	84.85

Fig. 1 Preoperative sinus involvement on CT scan **Table 3** Anatomical variations

Anatomic variation	Patients	%
Septal deviation	7	21.21
Hypertrophied uncinate process	10	30.30
Concha bullosa	3	9.09
Paradoxical middle turbinate	1	3.03
Haller's cell	2	6.06
Onodi cell	1	3.03
Skull base type-2	5	15.15
Skull base dehiscent	1	3.03
Pneumatized crista galli	1	3.03
Overall	19	57.58

and nasal sinuses characterized by stromal edema and variable cellular infiltrate [11]. While many aspects have been documented to support this theory, the initiating cause remains unknown and may be different in many cases (e.g., mechanical trauma, bacteria, virus, fungi, etc.) [11]. Anatomic factors may also play a role in initiation of this inflammatory cascade, as SNP have been noted to appear predominantly in structurally tight areas of the sinonasal pathway when there is mucosal contact releasing proinflammatory cytokines from epithelial cells which results into cellular infiltrate and ultimately causing obstruction in the sinonasal pathway [11].

During the review of CT scans of the patients, there were few anatomic variations found which may or may not

be the etiologic factor for the origin of nasal polyposis as these were found only in 57.58 % which is statistically not significant. These were hypertrophied uncinate process (30.30 %), septal deviation (21.21 %), skull base type-2 (15.15 %), Concha bullosa (9.09 %) and Haller's cell (6.06 %). Paradoxical middle turbinate, Onodi cell, Pneumatized Crista galli and dehiscent skull base was found in 3.03 % cases each. In one previous report by Yuan Li et al. [12], anatomic variations were found in 50.8 % cases as septal deviation (35 %), hypertrophied uncinate process (22.4 %), Concha bullosa, paradoxical middle turbinate and Haller cell.

According to Mackay and Lund, the ostiomeatal complex acts a drainage pathway for maxillary, anterior ethmoids and frontal sinuses. Posterior ostiomeatal unit was considered as part of the sphenoid sinus. In several areas of the ostiomeatal complex, two mucosal layers contact with each other, thus increasing the likelihood of local impairment of mucociliary clearance. Secretions may then be retained at the site, creating the potential for infection even without ostial closure. Anatomically, the most likely areas of mucosal contact are in the narrow mucosa lined channels of the middle meatus and the ethmoidal infundibulum. Septal deviation is associated with middle turbinate and lateral nasal wall abnormalities which causes OMC obstruction resulting in sinusitis. Maxillary and anterior ethmoid sinusitis patients must be carefully investigated in cases with inferior turbinate hypertrophy.

Fig. 2 Anatomic variations in CT scan **Fig. 3** Crista galli and Concha bullosa **Fig. 4** Hyperdense and heterogeneous opacification involving right maxillary sinus and right OMC, Paradoxical Middle turbinate of left side

The ostiomeatal unit was found to be involved in 84.85 % of patients in our study.

These anatomic variations should be kept in mind during FESS to prevent complications; and should be treated simultaneously with the disease proper during surgery for adequate improvement following surgery and to prevent recurrence.

Fig. 5 Coronal view showing Onodi cell (OC), optic nerve (ON) and horizontal septum (HS)

The extent of surgery was determined by the severity of disease and extent of involvement of sinuses as per pre-operative CT scan and nasal endoscopy [11]. CT scan evaluation in this study showed the maxillary sinus to be mostly affected (93.94 %) followed by anterior ethmoid sinus in 63.63 % and frontal sinus in 42.42 % cases. The

sphenoid was the least involved (21.21 %). The posterior ethmoid sinus was found to be involved in 33.33 % cases. The only sinus which was usually severely affected was maxillary sinus (90.91 %) while the other sinuses were only mildly affected or remained uninvolved. Ostiomeatal complex was found to be blocked in 84.85 % cases. The extent of involvement reported by other authors was also in the same range. Maru [13] reported maxillary sinus involvement in 70.4 %, anterior ethmoid in 73.7 %, posterior ethmoid in 52.4 %, frontal in 48.3 % and sphenoid in 40.8 %.

An association between SNP and fungal cultures has been established for many years [14]. This recognition led to the term ‘allergic fungal sinusitis (AFS)’ which is clinically characterized by the presence of a positive RAS test to fungus; NP; asthma; peripheral eosinophilia; allergic mucus with histological evidence of eosinophilic preponderance with Charcot–Leyden crystals; identification of fungus (mainly *Aspergillus* species) in sinus mucus; type I hypersensitivity or atopic disease; and computerized tomographic (CT) findings of evidence of chronic rhinosinusitis (CRS), calcifications or hyperdense and heterogeneous opacification within the sinus, and often bone erosion [15]. In our study hyperdense and heterogeneous opacification in paranasal sinuses was seen only in 12.12 % patients.

Conclusions

Importance of CT scans in sinonasal polyposis patients are:

1. To know the anatomical variations as an etiology of sinonasal polyposis,
2. To help in the diagnosis of fungal etiology of nasal polyps,
3. To know the extent of polyposis and anatomical variations to prevent complications during FESS and Navigation sinus surgery.

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Conflict of interest None.

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