Sinonasal Anatomical Variants: CT and Endoscopy Study and Its Correlation with Extent of Disease

Vandana Mendiratta¹ · Nitish Baisakhiya^{2,6} · Dalbir Singh³ · Ginni Datta² · Amit Mittal⁴ · Parveen Mendiratta⁵

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Abstract To evaluate the incidence of anatomical variations in sinonasal area by nasal endoscopy and CT scan paranasal sinuses and to correlate the anatomical variations in sinonasal area with extent of disease. The present study was conducted on 40 patients of chronic sinusitis. All the patients underwent CT scan paranasal sinus axial and coronal view and nasal endoscopy. The most common anatomical variations were agger nasi cells (80 %), deviated nasal septum (72.5 %) and concha bullosa (47.5 %). Other anatomical variations seen in sinonasal region were uncinat process variations, paradoxical middle turbinate, haller cells, accessory ostia of maxillary sinus, multiseptated sphenoid. Osteomeatal unit (87.5 %) and maxillary sinuses (87.5 %) were the most commonly involved which was followed by anterior ethmoids (70 %), posterior ethmoids (50 %), frontal sinuses (32.5 %) and the sphenoids (20 %). Considering the results obtained, we believe that anatomical variations may increase the risk of sinus

mucosal disease. We therefore, emphasize the importance of a careful evaluation of CT study in patients with persistent symptoms of chronic rhinosinusitis.

Keywords CT Scan Paranasal sinuses (CT PNS) · Osteomeatal complex (OMC) · Functional endoscopic sinus surgery (FESS) · Concha bullosa · Haller cell

Introduction

Osteomeatal complex (OMC) is an important functional unit. OMC is a narrow anatomical region consisting of: Multiple bony structures—middle turbinate, uncinat process, bulla ethmoidalis; Air spaces—Frontal recess, ethmoidal infundibulum, middle meatus; Ostia—anterior ethmoidal, maxillary and frontal sinuses. The classic OMC as mentioned above has been described as the anterior osteomeatal unit. The sphenoethmoidal recess and superior meatus is referred as the posterior osteomeatal unit. The osteomeatal complex is the key area for the pathogenesis of chronic rhinosinusitis [1].

Ciliary activity in the sinuses directs the flow of mucous towards these ostia. Every episodes of rhinosinusitis hampers the ciliary movement and resulting in stasis of mucous inside the sinuses. Sinonasal mucosa becomes engorged thus closing the ostia [2]. This process is usually reversible and once the osteomeatal complex is reopened, the secondary disease within the larger maxillary and frontal sinuses usually resolve spontaneously. If, however there is an anatomical variant that narrows this key area, then a minimal amount of mucosal oedema may predispose the patient to recurrent infection and may result in chronic inflammatory changes in the mucosa [3].

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✉ Nitish Baisakhiya
nitish.baisakhiya@gmail.com; baisu@rediffmail.com

¹ Department of Otolaryngology, GMERS Medical College, Gandhinagar, India

² Department of Otolaryngology, MMIMSR, Mullana, India

³ Department of Otolaryngology, PIMS, Jalandhar, India

⁴ Department of Radiology, MMIMSR, Mullana, India

⁵ Department of Surgical Oncology, GCRI, Ahmedabad, India

⁶ Department of ENT, MMIMSR, MMU, Mullana, Ambala 133207, India

With the advent of CT scan and nasal endoscopy, there have been tremendous changes in understanding osteomeatal complex anatomy and also in making diagnosis involving various diseases of this region. Subtle anatomic variations such as Haller cell, pneumatization or paradoxical curvature of middle turbinate and variations in ethmoid bulla, uncinate process, agger nasi cells and frontal recess can now be imaged through CT scan with increased level of clarity and accuracy. As variations and anomalies of these anatomic structures have been implicated in etiology of chronic recurrent rhinosinusitis, axial and coronal plane CT Scan of paranasal sinuses is being routinely used now a days in evaluation of patients with sinus diseases, because even minor anatomical variation of OMC can be evaluated in details by using different plane of CT Scan i.e. axial, coronal and sagittal. Stammberger and Hawke [4] have shown that CT examination of the paranasal sinuses will provide an anatomic road map of the paranasal sinuses to identify the presence of significant anatomic abnormalities, their location, severity of the disease and also exact location of the obstruction. To avoid complications during endoscopic sinus surgery, CT scan should be studied thoroughly before surgery. Imaging in coronal plane is generally recommended. The coronal plane optimally shows the osteomeatal unit, the relationship of skull base, ethmoid roof and relationship of orbits to paranasal sinuses [5].

The keystone of functional endoscopic sinus surgery is the ability to accurately treat even relatively minor changes in osteomeatal complex that interfere with mucociliary clearance of the frontal, ethmoid and maxillary sinuses. CT scan and nasal endoscopy provides the ability to accurately access this area for evidence of localized disease or any anatomic defect that compromise ventilation and mucociliary clearance.

The present study was undertaken in order to study the incidence of anatomical variations in sinonasal area by nasal endoscopy and CT scan paranasal sinuses and to correlate the anatomical variations in sinonasal area with extent of disease.

Materials and Methods

The present prospective study was conducted on forty patients in the Department of Otorhinolaryngology, Maharishi Markandeshwar Institute of Medical Science and Research, Mullana, Ambala. Patients with any nasal mass, previous sinus surgery, allergic disorder were excluded from study.

Endoscopy was done using 4 mm 0° or 30° nasal endoscope and findings were recorded. CT scan of Paranasal sinuses was done in 5 mm axial slices. Thin reconstruction in soft tissue paranasal sinuses and bone window

was done with coronal images. Scoring was done in accordance with Lund-Mackay CT classification system.

Lund-Mackay staging system for chronic sinusitis (Fig. 4)

- 0 Points—No abnormality;
- 1 Points—Partial opacification;
- 2 Points—Total opacification.

A total was calculated for each side for Maxillary sinus, Anterior ethmoids, Posterior ethmoids, Sphenoid sinus and Frontal sinus.

Osteomeatal complex (scored only with a 0 or 2) 0 Point—Not Occluded, 2 Points—Occluded.

Left and right sides were staged separately and scores were summed up so that total score may ranges from 0 to 24.

The statistical analysis was useful to assess the relationship between common and uncommon anatomical variations and the presence of unilateral or bilateral sinusitis. Association were evaluated using the Fisher's exact test (where frequencies were <5) and Chi-Square test (where frequencies were more than 5).

Results

A total of 40 patients were included in the study. Majority of the patients were males (70 %) with females (30 %). Maximum cases 21 (52.5 %) were found in age group of 15–30 years. Post nasal drip was the most common symptom occurring in 85 % cases followed by anterior nasal discharge (77.5 %), headache (70 %), nasal obstruction (55 %) (Fig. 1). Maximum numbers of patients (65 %) were having symptoms from 1 to 5 years (Fig. 2).

CT scan paranasal sinuses coronal and axial views were done to see anatomical variations of sinonasal region and

Fig. 1 Distribution of patients according to symptomatology

Fig. 2 Distribution according to duration of symptoms

Fig. 3 Incidence of mucosal hypertrophy on CT scan

extent of mucosal hypertrophy. Mucosal hypertrophy was seen most commonly in osteomeatal complex in 35 (87.5 %) patients which was unilateral in 16 (40 %) patients and bilateral in 19 (47.5 %) patients and maxillary sinus mucosal hypertrophy was seen in 35 (87.5 %) patients which was unilateral in 13 (32.5 %) patients and bilateral 22 (55 %) in patients. Anterior ethmoid sinus mucosal hypertrophy was present in 28 (70 %) patients which was unilateral in 13 (32.5 %) patients and bilateral in 15 (37.5 %) patients., while posterior ethmoids were involved in 20 (50 %) patients which was 10 (25 %) patients both unilateral and bilateral. Frontal sinus mucosal hypertrophy was present in 13 (32.5 %) patients which was unilateral in 11 (27.5 %) and bilateral in 2 (5 %). Sphenoid sinus involvement was seen in 8 (20 %) of patients which was unilateral in 5 (12.5 %) and bilateral in 3 (7.5 %) (Fig. 3).

According to Lund Mackay scoring, the osteomeatal unit was found to be maximally involved in 67.5 % and sphenoid sinus least involved in 6.9 % (Fig. 4).

Fig. 4 Lund Mackay scoring on CT scan

The most common anatomical variation was agger nasi cell which was present in 32 (80 %) patients [(unilateral in 7 (17.5 %) and bilateral 25 (62.5 %)]. Deviated nasal septum was present in 29 (72.5 %) patients [(unilateral in 28 (70 %) and bilateral 1 (2.5 %)]. Concha bullosa was present in 19 (47.5 %) patients which was unilateral in 15 (37.5 %) and bilateral in 4 (10 %). Uncinate process was found rotated medially in 8 (20 %) patients and lateral rotation in 5 (12.5 %). Paradoxical curvature of middle turbinate was seen in 10 (25 %) patients which was unilateral in 6 (15 %) and bilateral in 4 (10 %). Haller's cell was seen in 3 (7.5 %) which was unilateral in 2 (5 %) and bilateral in 1 (2.5 %) (Table 1).

On endoscopy, mucosal hypertrophy was seen most commonly in maxillary sinus (77.5 %) patients, followed by anterior ethmoid sinus mucosal hypertrophy (55 %) patients while posterior ethmoids were involved in (40 %), Frontal sinus mucosal hypertrophy was present in (25 %), Sphenoid sinus involvement was seen in (15 %) (Table 2).

It was observed that anatomical variations were same as with CT scan except deviated nasal septum which is (77.5 %) on endoscopy and (72.5 %) on CT scan.

Discussion

While doing endoscopy, our special emphasis was to assess condition of sinonasal area and to find any anatomical variations in that area. The various anatomical variations of sinonasal area were noted and their frequency of occurrence determined. Advances in the understanding of mucociliary drainage patterns and the pathophysiology of paranasal sinus inflammatory disease, coupled with the availability of high resolution CT and improvement in endoscopic instrumentation, necessitate the clinician to have a precise knowledge of nasal sinus anatomy and its variation in this region.

Table 1 Incidence of anatomical variations on CT scan

Anatomical variations	Total no. of patients	%	Unilateral		Bilateral	
			Total no. of patients	%	Total no. of patients	%
Agger nasi cell	32	80	7	17.5	25	62.5
Deviated nasal septum	29	72.5	28	70	1	2.5
Concha bullosa	19	47.5	15	37.5	4	10
Uncinate process variations	13	32.5	13	32.5	0	0
Paradoxical middle turbinate	10	25	6	15	4	10
Haller's cells	3	7.5	2	5	1	2.5
Septal cells	2	5	2	5	0	0
Multiseptate sphenoid	2	5	2	5	0	0

Table 2 Incidence of mucosal hypertrophy on nasal endoscopy

Diseased area	Total no. of patients	%	Unilateral		Bilateral	
			No. of patients	%	No. of patients	%
Maxillary sinus	31	77.5	9	22.5	22	55
Anterior ethmoid	22	55	10	25	12	30
Posterior ethmoid	16	40	6	15	10	25
Frontal sinus	10	25	8	20	2	5
Sphenoid sinus	6	15	4	10	2	5

The extent of sinonasal inflammatory pathology, important anatomic landmarks and their variations can be easily detected on CT scan which provided a reliable road map for endoscopic sinus surgery. CT scan with its excellent capability of displaying bone and soft tissue is the current diagnostic modality of choice for sinonasal disease. In contrast to standard radiographs, CT scan clearly shows the fine bony anatomy of the osteomeatal complex. It readily identifies even the minor anatomic variations and resulting mucosal changes. CT scans are performed after a course of adequate medical therapy to eliminate reversible mucosal inflammation.

Duration of Symptoms (Fig. 2)

According to Sheetal et al. [6] study, the average duration of the disease was 1–5 years. In the present study also most of the patients (65 %) suffered from the disease for a similar duration i.e. 1–5 years and only 20 % had symptom for <1 year. Shortest duration of symptoms was 7 months present in 3 (7.5 %) patients.

Symptoms and Signs (Fig. 1)

Post nasal discharge was the most common symptom occurring in 34 cases (85 %), anterior nasal discharge in 31

cases (77.5 %), headache in 28 cases (70 %), nasal obstruction in 22 cases (55 %), sneezing in 15 cases (37.5 %) and epistaxis in 1 case (2.5 %). Salam and Cable [7] observed post nasal discharge (88.2 %), nasal obstruction (84.3 %) and headache (78.4 %) as major symptoms in their study of 51 patients. Sheetal et al. [6] studied the symptoms and disease severity in chronic rhinosinusitis and concluded that common symptom of presentation was headache (90 %), followed by nasal discharge (80 %). Wani et al. [8] concluded that headache and facial pains were the main symptoms (90 %) followed by nasal discharge (86.6 %) and nasal obstruction (85.33 %).

Common clinical signs in the present study were deviated nasal septum (66 %), inferior turbinate hypertrophy (57.5 %), discharge in nasal cavity (52.5 %) and posterior pharyngeal wall secretions (38 %). Prabhakar et al. [9] in their study of 75 patients of chronic sinusitis found nasal discharge in 69 %, septal deviation in 51 %, inferior turbinate hypertrophy in 52 % and congestion of posterior pharyngeal wall in 29 % of patients.

CT Scan (Fig. 3)

CT scan paranasal sinuses coronal and axial views were done to see extent of mucosal disease and anatomical

variations of sinonasal region. CT scans showed osteomeatal complex involvement in 87.5 % of patients in our study. This was confirmed by endoscopy. Maxillary sinus mucosal hypertrophy was seen in 85 % patients. Wani et al. [8] found in 70 %, Bolger et al. [10] in 77.7 % and Maru and Gupta [11] in 70.4 %.

Anterior ethmoids were involved in 70 %, posterior ethmoids in 50 %, frontal sinuses in 32.5 % and sphenoid sinuses in 20 % of patients. Bolger et al. [10] reported anterior ethmoids involvement in 84.3 %, posterior ethmoids in 38.6 %, frontal sinus in 36.6 % and sphenoid sinus in 25.4 %. Maru and Gupta [11] reported anterior ethmoids involvement 73.7 %, posterior ethmoids in 52.4 %, frontal in 48.3 % and sphenoids in 40.8 % patients. Wani et al. [8] found anterior ethmoid involvement in 87.33 %, posterior ethmoids in 38 %, frontal sinus 15 % and sphenoid sinus 8.66 %.

The mucosal abnormalities were graded as per Lund Mackay system of scoring. The osteomeatal complex and maxillary sinus were most commonly involved. This was followed by anterior ethmoids, posterior ethmoids, frontal sinuses and sphenoids which were minimally involved. If the number of sinus (1,2) sides were counted and multiplied by the score of individual unit (0–2), then the osteomeatal unit was found to be maximally involved 108/160 (67.5 %) and sphenoids least involved in 11/160 (6.9 %). Dua et al. [12] found osteomeatal unit involved in 75 % and sphenoid in 8 % patients.

However during surgery the mucosal hypertrophy was seen in less number of cases as compared to CT scan. During surgery maximal incidence of mucosal hypertrophy was seen in maxillary antrum in 31 (77.5 %) patients [unilateral 22 (55 %); bilateral 9 (22.5 %)]. Anterior ethmoidal disease was present in 22 (55 %) patients [unilateral 10 (25 %); bilateral 12 (30 %)].

Posterior ethmoids were found involved in 16 (40 %) patients [unilateral 6 (15 %), bilateral 10 (25 %)]. Frontal sinus was found involved in 10 (25 %) patients [unilateral 8 (20 %); bilateral 2 (5 %)]. Sphenoid sinus was involved in 6 (15 %) patients [unilateral 4 (10 %); bilateral 2 (5 %)]. The lesser incidence of mucosal involvement during surgery could be due to the time elapsed between CT scan and surgery; and also preoperative course of antibiotics and antihistaminics leading to receding of mucosal disease.

Anatomical Variations (Table 1)

Agger Nasi Cells

The most common anatomical variation was Agger nasi cells which was present in 80 % patients (unilateral 17.5 %, bilateral 62.5 %). Agger nasi cells are present in the area anterior and superior to the insertion of middle turbinate at

the lateral nasal wall. Even when not diseased they may narrow the frontal recess depending upon the pneumatization and may completely block it when diseased.

The incidence was same as our study i.e. 80 % by Leunig et al. [13], less as compared to 88.5 % by Maru and Gupta [11] and more as compared to 68.8 % by Gupta et al. [14] and 40 % by Dua et al. [12]. During FESS same number of patients had agger nasi cells.

Deviated Nasal Septum

Deviated nasal septum was present in 72.5 % patients which was comparable to 45 (65.2 %) patients by Gupta et al. [14] more than 55.7 % in study by Maru and Gupta [11] and 44 % by Dua et al. [12]. However, during endoscopy and FESS deviated nasal septum was present in 77.5 % of patients.

The mere presence of a septal deviation does not suggest pathology. However, a marked deviation can force the middle turbinate laterally, thus narrowing the osteomeatal complex.

Concha Bullosa

Concha bullosa was found by CT scan in 47.5 % of cases (unilateral in 37.5 % and bilateral in 10 %) and were confirmed intraoperatively in same number of patients. Concha Bullosa is a ballooned out middle turbinate due to pneumatization. The pneumatization can grow to such an extent that the bulging end of turbinate completely fills the space between the septum and lateral wall resulting in the blockade to the entrance to the middle meatus. The incidence of concha bullosa was comparable to reported incidence of 49.3 % by Fadda et al. [15] more as compared to 42.6 % by Maru and Gupta [11] and less as compared 53.6 % by Bolger et al. [10]. Out of 15 patients having unilateral concha bullosa 10 patients had more extensive disease on the side of concha bullosa and all patients having large concha bullosa had more extensive mucosal disease.

Paradoxical Curvature of Middle Turbinate

Paradoxical curvature of middle turbinate was seen in 25 % cases unilaterally in 15 % and bilateral in 10 %. This anomaly consists of a reversal of the normal outward concavity of middle turbinate. The inferior edge of middle turbinate may have various shapes which excessive curvature which in turn may obstruct the nasal cavity, infundibulum and the middle meatus. The incidence was comparable to Bolger et al. [10] (27 %) and Gupta et al. [14] (1.44 %) but less as compared to Tonai and Baba [16] (29.8 %).

Uncinate Process

Medially curved uncinate process was found in 20 % of patients when uncinate process is bent or curved it can impair sinus ventilation especially in the anterior ethmoid frontal recess and infundibulum regions. Incidence was comparable to 22.8 % by Fadda et al. [15] higher than 9.8 % by Maru and Gupta [11] and 2.5 % by Bolger et al. [10] Laterally rotated uncinate process was found in 12.5 % of patients. Incidence was found to be 21.4 % by Fadda et al. [15], 9.5 % by Krzeski et al. [17].

Haller's Cell

Haller's cell were seen in 7.5 % patients (unilateral 5 % and bilateral 2.5 %) in CT scans confirmed by nasal endoscopy. Haller's cells are ethmoid air cells that project beyond the limits of the ethmoid labyrinth into the maxillary sinus. They are considered as ethmoid cells that may grow into the floor of orbit and may narrow the adjacent ostium of maxillary sinus especially if they become infected. It was comparable to 3.62 % by Gupta et al. [14] but less than reported by Maru and Gupta [11] 36 %.

Some of the other anatomical variations seen in CT scans were multiseptated sphenoid in 2 (5 %) patients, septal cells in 2 (5 %) patients.

Superior attachment of uncinate process was at lamina papyracea in 65 % cases, middle turbinate in 5 % cases and skull base in 10 % cases which was comparable to study of Turgut et al. [18] in which uncinate process was attached to lamina papyracea in 63 %, to skull base in 14 % and to middle turbinate in 8 %, According to Krzeski et al. [17] uncinate process was attached to lamina papyracea in 17.83 %, to skull base in 33.12 % and to middle turbinate in 14.33 %. During FESS accessory ostia of maxillary anterior were found in 1 (2.5 %) of patients which is comparable to 1 (0.72 %) by Gupta et al. [14].

Statistical Correlation Between Anatomical Variations and Sinusitis

We found a statistically significant correlation between septal deviation and maxillary sinusitis (p value comes out to be 0.019 which is <0.05 . So, ' p ' value is significant), between concha bullosa and maxillary sinusitis (p value comes out to be 0.049 which is <0.05), between medial deviation of uncinate process and anterior ethmoid sinusitis (p value comes out to be 0.009 which is <0.05) and there is also statistically significant correlation between paradoxical middle turbinate and maxillary sinusitis with ' p ' value 0.0274 (<0.05). It was observed that while CT scan has got better diagnostic abilities to diagnose anatomical variations like multiseptate sphenoid, it is highly sensitive

and over diagnose mucosal disease patterns, while nasal endoscopy is more sensitive to diagnose deviated nasal septum because of inability of CT to detect deviations of cartilaginous part of nasal septum.

Conclusions

CT (PNS) scan and nasal endoscopy were complementary to each other to see mucosal disease patterns and planning of management. Considering the results obtained, we believe that there is a significant correlation between some anatomic variations and extent of sinus mucosal disease. We therefore, emphasize the importance of a careful evaluation of CT study in patients with persistent symptoms of chronic rhinosinusitis. In view of the presence of these significant variations, we reemphasize the need for proper preoperative assessment in every patient in order to accomplish a safe and effective endoscopic sinus surgery.

References

1. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H (1987) Paranasal sinuses: CT imaging requirements for endoscopic surgery. *Radiology* 163:769–775
2. Lloyd GAS, Lund VJ, Scadding GK (1991) CT of the paranasal sinuses and functional endoscopic surgery: a critical analysis of 100 symptomatic patients. *J Laryngol Otol* 105:181–185
3. Stammberger H, Hawke M, Eugene Yu (2006) Anatomical variants of the osteomeatal complex in the paranasal sinuses. In: Shankar L, Evans K (eds) *An atlas of imaging of the paranasal sinuses*, 2nd edn. Martin Dunitz Ltd, London, p 61
4. Stammberger H, Hawke M (1993) *Essentials of endoscopic sinus surgery*. Mosby, St. Louis, p 43
5. Zinreich SJ (1992) Imaging of chronic sinusitis in adults: X-ray, computer tomography and magnetic resonance imaging. *J Allergy Clin Immunol* 90:445–451
6. Sheetal D, Devan PP, Manjunath P, Martin P, Satish Kumar K, Sreekantha, Satisha TG, Manjunatha GBK (2011) CT PNS – Do we really require before fess? *J Clin Diagn Res* 5(2):179–181
7. Salam MA, Cable HR (1993) Middle meatal antrostomy. Long term patency and results of chronic maxillary sinusitis—a prospective study. *Clin Otolaryngol* 18:135–138
8. Wani AA, Kanotra S, Lateef M, Ahmad R, Qazi SM, Ahmad S (2009) CT scan evaluation of the anatomical variations of the osteomeatal complex. *Indian J Otolaryngol Head Neck Surg* 61:163–168
9. Prabhakar S, Mehra YN, Talwar P, Mann SBS, Mehta SK (1992) Fungal infections in maxillary sinusitis. *Indian J Otolaryngol Head Neck Surg* 1(2):57–60
10. Bolger WE, Butzin CA, Parsons DS (1991) Paranasal sinus bony anatomic variations and mucosal abnormalities. CT analysis for endoscopic sinus surgery. *Laryngoscope* 101:56–64
11. Maru YK, Gupta V (2001) Anatomic variations of the bone in sinonasal C.T. *Indian J Otolaryngol Head Neck Surg* 53(2):123–128
12. Dua K, Chopra H, Khurana AS, Munjal M (2005) CT scan variations in chronic sinusitis. *Ind J RadiolImag* 15(3):315–320

13. Leunig A, Betz CS, Sommer B, Sommer F (2008) Anatomical variations of the sinuses: multiplanar CT-analysis in 641 patients. *Laryngorhinootologie* 87(7):482–489
14. Gupta AK, Gupta B, Gupta N, Tripathi N (2012) Computerized tomography of paranasal sinuses: a roadmap to endoscopic surgery. *Clin Rhinol Int J* 5(1):1–10
15. Fadda GL, Rosso S, Aversa S, Petrelli A, Ondolo C (2012) Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. *Acta Otorhinolaryngol Ital* 32:244–251
16. Tonai A, Baba S (1996) Anatomic variations of the bone in sinonasal CT. *Acta Otolaryngol* 525:9–13
17. Krzeski A, Tomaszewska E, Jakubczyk I, Galewicz A (2001) Anatomic variations of the lateral nasal wall in the computed tomography scans of patients with chronic rhinosinusitis. *Am J Rhinol* 15(6):371–375
18. Turgut S, Ercan I, Sayın I, Başak I (2005) The relationship between frontal sinusitis and localization of the frontal sinus outflow tract: a computer-assisted anatomical and clinical study. *Arch Otolaryngol Head Neck Surg* 131:518–522