Original Article

Indian Journal of Anatomy
Volume 5 Number 1, January - April 2016
DOI: http://dx.doi.org/10.21088/ija.2320.0022.5116.4

Anatomical Study of the Osteo Meatal Complex of the Middle Meatus

Gayatri Girish Muthiyan*, Shanta Sunil Hattangdi, Payal Arvind Kasat*****

Abstract

Introduction: Middle turbinate is an important landmark of lateral nasal wall during endoscopy. The aim of this study was to examine the surgical anatomy of middle turbinate in hemisected heads which allows better visualization of the middle turbinate and middle meatus and to provide anatomical knowledge to the surgeons performing Endoscopic Sinus Surgeries (ESS) and middle turbinectomies. *Method:* The openings of paranasal sinuses in middle meatus were studied in 100 hemisected adult Indian cadaveric heads. *Results:* The mean angles between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f'*, middle ethmoidal cells i.e. *m'*, maxillary sinus i.e. *s'* were 64.8°, 46.71°, 38.59° respectively. The mean distance between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f*, middleethmoidal cells i.e. *m*, maxillary sinus i.e.*s*.are 41.07 ± 4.86 mm, 43.56 ± 3.8 mm, 36.84 ± 3.96 mm.The difference observed in the readings for the two sides is not statistically significant.

Three percent cases showed two middle ethmoidal cell openings.Fivepercentcases showed dual maxillary sinus openings.Fourpercent cases showed absence of maxillary sinus openings.

Keywords: Endoscopic; Surgeons; Middle; Osteomeatal; Complex.

Introduction

A Chinese fortune teller regards the nose as a hill of the face generating will power and representing intellectual capabilities. And especially in the present scenario with the advanced modalities of treatment, nasal anatomy with respect to nasal conchae has become very significant for the otorhinologists while performing Endoscopic Sinus Surgery (ESS).

A series of air filled expansions, the paranasal sinuses, lie within either the lateral walls of the nasal cavities or in communication with them in adjacent bones.The nasal apparatus serves to warm, humidify, and to some extent filter, particles from the inhaled air.

Author's Affiliation: *Assistant Professor, Department of Anatomy, Topiwala National Medical College, Mumbai, Maharashtra, India – 400008. **Professor and Head, Department of Anatomy, Lokmanya Tilak Memorial Medical College, Sion, Mumbai, Maharashtra, India - 400022. ***Speciality Medical Officer, Seth Gordhandas Sunderdas Medical College, Parel, Mumbai, Maharashtra, India – 400012.

Corresponding Author: Gayatri Girish Muthiyan, Flat No. 28, 4th Floor, Building No. 1, Government Colony, Near I.m.a. Hall, Haji Ali, Mumbai, Maharashtra, India – 400034.
E-mail: muthiyang@yahoo.com

The middle turbinate is an important landmark of lateral nasal wall during endoscopy[1]. Middle turbinate, also called middle concha, is a medial process of the ethmoidal labyrinth.The area under the middle turbinate into which the maxillary sinus, the frontal sinus and anterior ethmoidal and middle ethmoidal systems open is termed the osteomeatal complex. It is located above inferior turbinate. Anterior ethmoid – middle meatal area is an important site for early involvement in most inflammatory sinuses diseases [2].

The middle meatus presents the ethmoidal bulla produced by the bulging of the middle ethmoidal air cells, which open on or above the bulla. Anterior to the bulla is a curved two dimensional slit, the hiatus semilunaris, which leads into the ethmoidal infundibulum. It is continuous with the frontonasal recess into which the frontal nasal sinus often opens. The anterior ethmoidal cells open into the infundibulum or the frontonasal recess[2]. The maxillary sinus ostium is usually present on the lateral aspect of the infundibulum between its middle and posterior third; and accessory ostium may be present anterior or posterior to the lower part of the uncinate process[2].

Since ESS proceeds in an anterior to posterior direction.The variations in osteomeatal complex are paradoxical curvatureand hypertrophy of middle turbinate, pneumatized middle turbinate, uncinate hyperplasia, deviation of uncinate process,concha bullosa, large ethmoidal bulla, large agger nasi,septal deviation, Onodi cell and Haller cell. These variations may be one of the causes of chronic sinusitis [3].

So this present study was designed to examine the anatomy of middle meatus in fully exposed hemisected nasal cavities. The aim was at finding such variations in the the osteomeatal complex, which may have clinical implications and thus provide guidelines to ENT surgeons, especially in Indian populations.

Aims

The aim was to study the openings of paranasal sinuses in middle meatus.Objectives wereto study openings of paranasal sinuses in middle meatus in detailed manner:

1. To study the mean angles between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f'*, middle ethmoidal cells i.e. *m'*, maxillary sinus.i.e..*s'*.
2. To study the mean distance between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f*, middle ethmoidal cells i.e. *m*, maxillary sinus i.e.*s*.
3. Comparison between the left and right side readings of the above mentioned parameters.
4. To provide Indian data for above mentioned parameters.
5. To note any variations while studying these parameters.

Methods

One Hundred hemisected adult Indian cadaveric heads were used in this study. These were obtained from the cadavers used for gross anatomical dissections by different medical and dental colleges. Due permission was obtained from the concerned authorities of these medical colleges, prior to beginning the study. Consent was not required being a cadaveric study.

Fifty two of these hemisected adult cadaveric heads involved the right side and forty eight involved the left side. Their ages ranged from 25 years to 75 years. Eight six specimens were obtained from male cadavers and fourteen were from females. No specimen showed evidence of prior nasal surgery or gross pathology of their middle turbinates.

Wherever available the 'body cutting machine' was used to obtain the hemisections. At other places, a saw was used for the same. Wherever present the nasal septum was cut with the help of long scissors, scalpel and toothed forceps, so as to view the lateral nasal wall directly. Any secretions, dust etc. was cleared off from the surface and underneath the superior turbinate, middle turbinate and Inferior turbinate. This made the area of study clearly visible.

1. Hemisected heads of Indian cadavers were obtained.
2. Of these the cadavers without evidence of prior nasal surgery or gross pathology of their middle turbinates were selected.
3. The measurements were taken from the lowermost portion of limen nasi, the anterior most landmark when inserting the endoscope and other surgical instruments.
4. Vernier Caliper and a protractor were used for measurements. The protractor was leveled with the help of 'acrylic cutting machine'.
5. The openings of the paranasal air sinuses in middle meatus were studied as illustrated in schematic figures 1 to 3 and figures 1-2. For studying these openings the middle turbinate was reflected upwards detaching it slightly from its anterior end. The angles and distances were measured from the lowermost portion of the limen nasi. Careful measurements were done and recorded. The range for each parameter and their means were recorded.

Results

In the present study, the angles and the distances of the apertures of sinuses opening into the middle meatus have been studied from the standard point i.e. the lowermost portion of the limen nasi.

Angles

Note:

- Only 97 readings for the ethmoidal cells are considered as three specimens showed two openings for the middle ethmoidal cells.
- Similarly, for the maxillary sinus of the 100 readings, 9 readings showed variations as four specimens showed complete absence of maxillary sinus openings, and rest five showed

dual openings for the maxillary sinus.

1. The mean angle between the lowermost portion of limen nasi and opening of frontal sinus i.e. *f'* is 64.8° (range: 47°- 72°). Frequency distribution chart for these readings has been prepared as seen in Figure 3.
2. The mean angle between the lowermost portion of limen nasi and opening of middle ethmoidal cells i.e. *m'* is 46.71° (range: 33°- 62°).
3. The mean angle between the lowermost portion of limen nasi and opening of maxillary sinus i.e. *s'* is 38.59° (range: 20°- 66°). The SD is 8.24° for *s'*. This larger value indicates that the range is wide when compared to the other angles.
4. Table 1 shows the mean, mode, median etc. values for *f'*, *m'*, *s'*.
5. The mean, mode and median are approximately close and so the readings are normally distributed for all the three angles.

Also, comparison between the left and right side readings were done for these parameters (Table 2).

1. The mean value of *f'* for left side is 65.40° and for right side is 64.25°.
2. The mean value of *m'* for left side is 46.90° and for right side is 46.53°.
3. The mean value of *s'* for left side is 38.89° and for right side is 38.30°.

In general, the left side readings were found to be greater than the right side. However, these are not statistically significant.

Distances

(Table 3 shows the mean, mode, median etc. values for *f*, *m*, *s*.)

1. The mean distance between the lowermost portion of limen nasi and opening of frontal sinus i.e. *f* is 41.07 ± 4.86 mm (range: 31.48 to 50.0 mm). Frequency distribution chart for these readings has been prepared as seen in Figure 4.
2. The mean distance between the lowermost portion of limen nasi and opening of middle ethmoidal cells i.e. *m* is 43.56 ± 3.8 mm (range: 35.82 to 54.14 mm).
3. The mean distance between the lowermost portion of limen nasi and opening of maxillary sinus i.e. *s* is 36.84 ± 3.96 mm (range: 26.08 to 46.68 mm).

Also, comparison between the left and right side readings were done for these parameters.

1. The mean value of *f* for left side is 41.15 mm and for right side is 41mm.
2. The mean value of *m* for left side is 43.35 mm and for right side is 43.76mm.
3. The mean value of *s* for left side is 36.21 mm and for right side is 37.47mm.

It is observed from the table above that for *f* the overall mean readings on the left side are higher as compared to right side. They are however statistically not significant.

Similarly, it is observed from the table above that for *m*&*s* the overall mean readings on the right side are higher as compared to left side. They are however statistically not significant.

Variations

1. While deriving the results of the measurements related to the apertures of middle ethmoidal air cells, three readings out of hundred were excluded where dual middle ethmoidal openings were found. Thus 3% cases showed more than one middle ethmoidal opening on the bulla ehtmoidalis as seen in figure 5. (Table 5 shows the readings in three specimens with two openings for the middle ethmoidal cells.) Thus it is important for the endoscopist to remember that more than one middle ethmoidal opening at varied angles and distances can be present. This is also confirmed in other literatures [2].

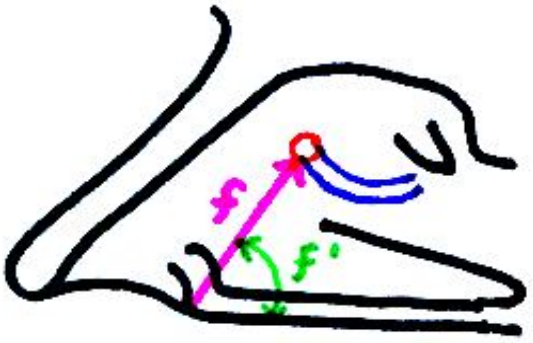
   This could be normal and sometimes pathological, in cases of chronic sinusitis where a normal ostium is blocked and a new ostium is naturally created for drainage of air cells.
2. Figure 6 also shows middle ethmoidal ostium on undersurface of bulla ethmoidalis, opening in hiatus semilunaris. This is against the usual description of these ostia being present on the bulla ethmoidalis. In this case the ethmoidal bulla is minimally pneumatized.
3. Similarly, while studying the maxillary sinus apertures it was found that four specimens did not show any maxillary sinus openings, inspite of all attempts to find any such opening in the hiatus semilunaris and beneath it. This definitely is not a normal finding. Interestingly, apertures were bilaterally absent in one cadaver. Pathologically these apertures could be blocked because of thick adherent secretions or presence of mucocoeles / polyps.
4. Rest five cases showed dual maxillary sinus openings. It was bilaterally present in one

cadever and unilaterally in three cadavers.

It was observed that, of these two opening one was usually large (more than 5 mm in diameter) and other small (less than 4 mm diameter). These were present at varied angles and distances from the standard point i.e. lowermost portion of limen nasi. However, in two cases the openings were almost of similar diameter. Such cases of accessory maxillary ostia have been described earlier[2](Table 6 shows the readings in five specimens with dual openings for the maxillary sinus)

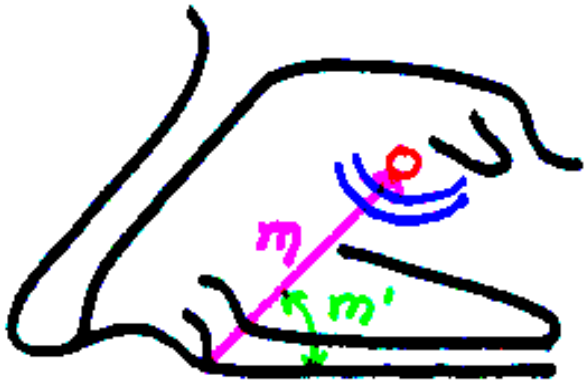
5) In cases with large maxillary sinus openings, these were found to be > 5 mm or 5 – 8 mm were observed, usually underneath hiatus semilunaris and placed anteriorly (Figure 6).

Openings of the Paranasal Sinuses in Middle Meatus



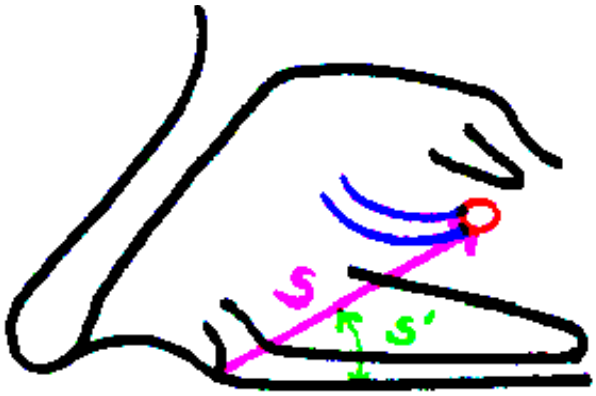
Schematic Fig. 1: Measurement of *f, f'*

1. *f* = distance between lowermost portion of limen nasi and opening of frontal sinus.
2. *f'* = angle between lowermost portion of limen nasi and opening of frontal sinus.



Schematic Fig. 2: Measurement of *m, m'*

1. *m* = distance between lowermost portion of limen nasi and opening of middle ethmoidal cells.
2. *m'* = angle between lowermost portion of limen nasi and opening of middle ethmoidal cells



Schematic Fig. 3: Measurement of *s, s'*

1. *s* = distance between lowermost portion of limen nasi and opening of maxillary sinus.
2. *s'* = *angle* between lowermost portion of limen nasi and opening of maxillary sinus.

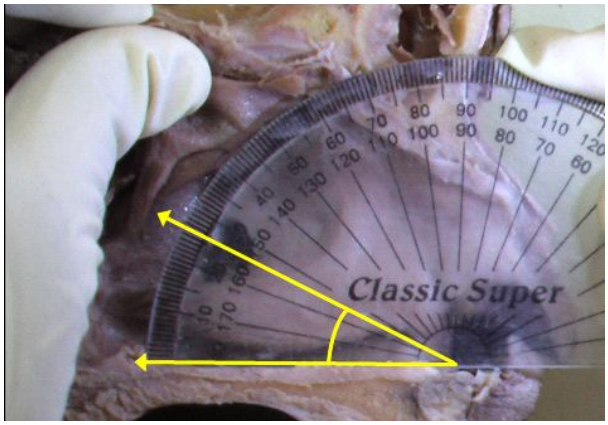


Fig. 1: Measurement of *s'*
(s' = Angle between lowermost portion of limen nasi and opening of maxillary sinus.)

Fig. 2*:* Measurement of *s*.
(s = Distance between lowermost portion of limen nasi and opening of maxillary sinus.)

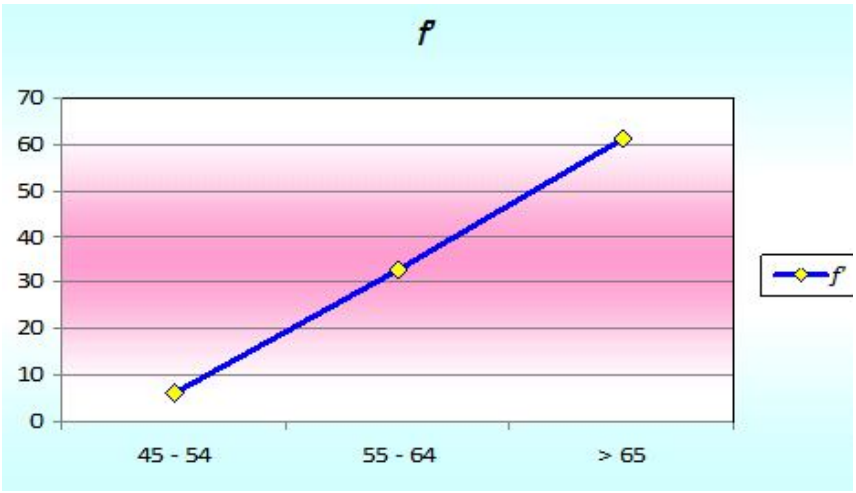


Fig. 3: Frequency distribution chart for *f'*
Along X axis is *f'* (in degree), Y axis indicates percentage distribution.
f' = Angle between lowermost portion of limen nasi and opening of frontal sinus.

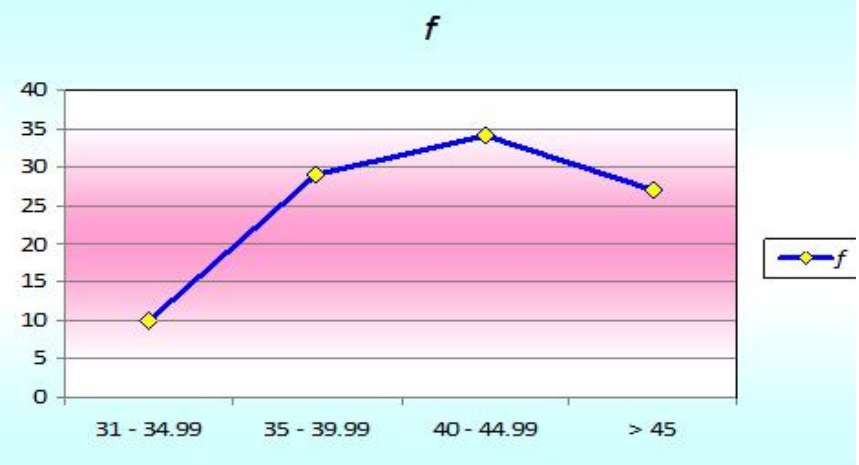


Fig. 4: Frequency distribution chart for *f*
Along X axis is *f* (in mm), Y axis indicates percentage distribution
f = Distance between lowermost portion of limen nasi & opening of frontal sinus.

Fig. 5: Two middle ethmoidal sinus openings

Fig. 6: Large maxillary sinus opening, middle ethmoidal sinus opening beneath bull ethmoidalis

Table 1: Mean, mode, median etc. values for *f', m', s'*

Angles	*f'*(in degree)	*m'*(in degree)	*s'*(in degree)
Mean	64.8	46.71	38.59
Standard Error	0.56	0.56	0.86
Median	65	45	38
Mode	68	45	38
Standard Deviation	5.58	5.52	8.24
Minimum	47	33	20
Maximum	72	62	66
Count	100	97	91

The mean, mode and median are approximately close and so the readings are normally distributed for all the three angles

Table 2: Comparison of the angles on left and right side for *f', m', s'*

	Angle *f'* (in degree)		Angle *m'* (in degree)		Angle *s'* (in degree)	
	Left	Right	Left	Right	Left	Right
Mean	65.40	64.25	46.90	46.53	38.89	38.30
Variance	26.12	35.68	34.18	27.50	67.65	69.59
Observations	48	52	48	49	45	46
Df	98		95		89	
t Stat	1.03		0.32		0.34	
P value	0.31		0.75		0.74	

f' = Angle between lowermost portion of limen nasi & opening of frontal sinus.
m' = Angle between lowermost portion of limen nasi & opening of middle ethmoidal cells.
s' = Angle between lowermost portion of limen nasi & opening of maxillary sinus.
df = Degree of freedom

Table 3: Mean, mode, median etc. values for *f, m, s*

Distances	*f* (mm)	*m* (mm)	*s* (mm)
Mean	41.07	43.56	36.84
Standard Error	0.49	0.39	0.42
Median	41.17	43.38	36.82
Mode	32.06	42.32	38.34
Standard Deviation	4.86	3.80	3.96
Minimum	31.48	35.82	26.08
Maximum	50	54.14	46.68
Count	100	97	91

Note:
1. Only 97 readings for the ethmoidal cells are considered as three specimens showed two openings for the middle ethmoidal cells.?
2. Similarly, for the maxillary sinus of the 100 readings, 9 readings showed variations as four specimens showed complete absence of maxillary sinus openings, and rest five showed dual openings for the maxillary sinus

Table 4: Comparison of the distances on left and right sides for *f, m, s*

	Distance f (mm)		*Distance m (mm)*		*Distance s (mm)*	
	Left	Right	Left	Right	Left	Right
Mean	41.15	41.00	43.35	43.76	36.21	37.47
Variance	22.32	25.19	13.08	15.93	12.27	18.56
Observations	48	52	48	49	45	46
Df	98		95		89	
t Stat	0.16		-0.53		-1.53	
P value	0.88		0.60		0.13	

f = Distance between lowermost portion of limen nasi & opening of frontal sinus.
m = Distance between lowermost portion of limen nasi & opening of middle ethmoidal cells.
s = Distance between lowermost portion of limen nasi & opening of maxillary sinus.
df = Degree of freedom

Table 5: Readings in three specimens with two openings for the middle ethmoidal cells

Sr.No	*m'* 1*(in degree)*	*m'*2*(in degree)*	*m*1 *(mm)*	*m*2 *(mm)*
1	38	42	47.61	48.24
2	47	44	40.04	40.08
3	45	36	40.02	41.32

Table 6: Readings in five specimens with dual openings for the maxillary sinus

Sr. No	*s'* 1 (degree)	*s'*2 (degree)	*s*1 *(mm)*	*s*2 *(mm)*
1	45	32	33.24	42.64
2	40	40	34.08	38.12
3	30	40	38.84	32.78
4	40	18	40.12	31.16
5	40	25	31.24	37.26

Discussion

Development of Paranasal Sinuses [4]

Some paranasal sinuses begin to develop during the late fetal life, such as the maxillary sinuses; the reminder of them, develop after birth. They form from outgrowths or diverticula of the walls of the nasal cavities and become pneumatic (air filled) extensions of the nasal cavities in the adjacent bones, such as the maxillary sinuses in the maxillae and the frontal sinuses in the frontal bones. The original openings of the diverticula persist as the orifices of the adult sinuses.

Postnatal Development of the Paranasal Sinuses [4]

Most of the paranasal sinuses are rudimentary or absent in the newborn infants. The maxillary sinuses are small at birth (3-4 mm in diameter). These sinuses grow slowly until puberty and are not fully developed until all the permanent teeth have erupted in early adulthood [4].

No frontal or sphenoidal sinuses are present at birth. The ethmoidal cells are small before the age of two years and they do not begin to grow rapidly until six to eight years of age. Around the age of two years, the two most anterior ethmoidal cells grow into the frontal bone, forming a frontal sinus on each side [4].

Usually the frontal sinuses are visible in the radiographs by the seventh year. The two most posterior cells grow into the sphenoid bone at about the age of two years, forming two sphenoidal sinuses. Growth of the paranasal sinuses is important in altering the size and shape of face during infancy and childhood, and in adding resonance to voice during adolescence [4].

In 1929 Mosher wrote, "If (the ethmoid) were placed in any other part of the body it would be an insignificant and harmless collection of bony cells. In the place where nature has put it, it has major relationships as that diseases and surgery of the labyrinth often lead to tragedy. Any surgery in this region should be simple but it has proven one of the easiest ways to kill a patient" [5].

Van Alyea advocating conservative surgery of the sinuses in 1951 wrote, "The early rhinologists were not concerned about the preservation of functioning structures"[6].

Then during the period of rigid intranasal endoscopy, the nasal endsoscopists were described as "Nasal Astronomers.", for proposing new ideas and new techniques to a community accustomed to headlight and open surgical techniques [7].

In 1978 the first systematic and detailed work documenting endoscopic findings was published in English by Messerklinger.

Messerklinger noted that the interruption of normal mucociliary clearance the middle meatus and ethmoid air cell system causes both persistence of local inflammation and affected the drainage of the frontal and maxillary sinuses, leading to the potential for recurrent infection [8]. Thus the importance of the middle meatus – anterior ethmoid complex in thepathogenesis of frontal and maxillary sinus disease led Naumann [9] to describe the area as the osteomeatal unit. Also in recognition of the importance of this area for the maxillary sinus, Prott [10] termed the maxillary ostium canalis maxillo–ethmoideo-nasalis. There is therefore increasing recognition of the impact of this area in inflammatory disease of the major sinuses.

The area of the anterior ethmoid is poorly visualized on routine sinus roentgenograms where only gross opacification is usually evident. Similarly anterior rhinoscopy reveals little information with regard to middle meatal cleft and no information regarding the infundibular opening and maxillary sinus orifice. Computed tomography is used to reveal mucosal changes deeper in the osteomeatal complex that are not visible endoscopically and to identify the extent of disease. The diagnostic evaluation for functional endoscopic sinus surgery (FESS) therefore consists of a combination of systematic nasal endoscopy and CT, the two modalities being adjunctive [8].

Thus the detailed position of these apertures (of the paranasal sinuses) and the precise form and the sizes vary enormously between the individuals. Since there is absence of similar previous studies ; we hope that this study sets standard for similar studies to be conducted in different regions , which may provide data regarding similarities or ethinic differences.

Conclusion

1. The mean angles between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f'*,

middle ethmoidal cells i.e. *m'*, maxillary sinus i.e. *s'* were 64.8°, 46.71°, 38.59° respectively.

2. The mean distance between the lowermost portion of limen nasi and openings of frontal sinus i.e. *f*, middle ethmoidal cells i.e. *m*, maxillary sinus i.e.*s*.are 41.07 ± 4.86 mm, 43.56 ± 3.8 mm, 36.84 ± 3.96 mm.The difference observed in the readings for the two sides is not statistically significant.
3. Three percent cases showed two middle ethmoidal cell openings. Fivepercent cases showed dual maxillary sinus openings. Fourpercent cases showed absence of maxillary sinus openings.
4. From the above findings it can be concluded that the detailed position of the apertures in the middle meatus vary enormously between individuals.

In conclusion this study documents the anatomical variation of the middle turbinate and osteomeatal complex, an important landmark of lateral nasal wall during endoscopy and partial turbinectomies. The documentation of these variations and their frequencies would be useful for the otorhinologists while performing endoscopy and be ready with optional interventions as and when required.

References

1. Lee HY, Kim CH, Kim JY, et al. Surgical Anatomy of Middle Turbinate. Clin Anat. 2006; 19: 493:496.
2. Sinnatamby Chummy S. Last's Anatomy: Regional and Applied. 10th Edition.1999: p.364 - 369.
3. Zhonghua Er Bi Yan Hou Ke Za Zhi.Anatomic variations of the osteomeatal complex and their correlation with chronic sinusitis: CT evaluation. Jun 34(3) 1999: 143 -146.
4. Keith Moore, Persaud TVN. The Developing Human: Clinically oriented embryology.Saunders, 7th Edition. 2003: p. 227- 231.
5. Mosher H: The symposium of the ethmoid - a surgical anatomy of the ethmoidal labyrinth. Trans Am Acad Ophthalmol Otolaryngol. 1929; 34: 376-410.
6. Van Alyea O. Nasal Sinuses: An Anatomic and Clinical Consideration. Baltimore Hopkins, 1951.
7. Friedman W: Letter to editor. Laryngosope. 1986; 96: 1171.
8. Kennedy DW, Zinreich SJ, Rasenbaum AE, Johns ME. Functional Endoscopic Sinus Surgery. Arch Otolaryngol. 1985, 111: 576-582.
9. Naumann H: Pathologische Anatomie der chronischen Rhinitis and Sinusitis. In Proceedings VIII International Congress of Otorhinolaryngology. Amsterdam, Excerpta Medica. 1965; p. 80.
10. Prott W: quoted by Draf W: Endoscopy of the Paranasal Sinuses. New York, Springer Verlag Inc. 1983; p 30.