Important anatomical landmarks in the lateral nasal wall

Baris O. Donmez, *MSc,* ***Bulent V. Agirdir,*** *MD,* ***Muzaffer M. Sindel,*** *PhD.*

ABSTRACT

Objectives: The study aimed to investigate the anatomy of the lateral nasal wall to provide a set of measurements among some important anatomical landmarks and to reveal the relationship between them.

Methods: Fifty half heads were dissected to determine the distances between important landmarks in the lateral nasal wall for endoscopic sinus surgery. Landmarks were measured with an electronic caliper. This study was carried out between December 2002 and February 2003 at the Anatomy Research Laboratory, Faculty of Medicine, Akdeniz University, Antalya, Turkey.

Results: Results were provided as mean ± standard deviation. In our study, some of the critical distances as in the lateral nasal wall were measured and results showed consistency to the data found in the literature.

Conclusion: Our results are useful to achieve safe endoscopic sinus surgery.

Saudi Med J 2005; Vol. 26 (9): 1403-1408

Functional endoscopic sinus surgery (FESS) is a frequently used technique in the treatment of patients with chronic and acute recurrent sinusitis, sinonasal polyposis[1] and has many advantages for the intranasal endoscopic examination and surgical applications.[2] Rigid nasal endoscope permits a better surgical view of the lateral nasal wall. This technique improves the ability to visualize specific anatomical details of sinonasal structures by the surgeons. Anatomy is important to differentiate pathological conditions from normal variants.[1] The individual anatomy of the paranasal sinuses and the floor of the anterior cranial fossa can vary considerably. Systematic orientation based on anatomical landmarks and their empirical relationships provide a limited degree of certainty during endoscopic procedures.[3]

Variations in intranasal and sinus anatomy have been implicated in the etiology of chronic and acute recurrent sinusitis.[4] Also, these variations can cause catastrophic results during surgery. Trauma to the ethmoidal arteries may cause vessel retraction into the orbit and visual loss can occur secondary to intraorbital hematoma. Expanding orbital hematoma will result in compression of the optic nerve in the optic canal. Double vision can be permanent. Diplopia secondary to medial rectus injury may result in irreparable damage. In order to perform safe superior dissection within the ethmoidal sinuses, the skull base should be carefully identified. Direct brain trauma is most likely to occur where the skull base is thinnest. When using endoscopes, the surgeon must have an intimate knowledge of anatomy. Death may be related to massive intranasal bleeding, intracranial bleeding or meningitis. The development of functional intranasal sinus surgery has progressed since 1903.[5] The research on this subject has revealed new and important developments. Today, the advancing development of instrumentation, suction irrigation, video-endoscopes and modern minimal invasive operation techniques; in addition to chronic

From the Department of Anatomy (Donmez, Sindel) and the Department of Ears (Agirdir), Nose and Throat, Akdeniz University, Faculty of Medicine, Antalya, *Turkey.*

Received 1st March 2005. Accepted for publication in final form 21st June 2005.

Address correspondence and reprint request to: Prof. Dr. Muzaffer Sindel, Department of Anatomy, Akdeniz University, Faculty of Medicine, Antalya 07070, *Turkey.* Tel. +90 (242) 2274485. Fax. +90 (242) 2274495. E-mail: sindelm@akdeniz.edu.tr

sinusitis, a wide range of pathologic processes in the paranasal sinuses and floor of the anterior cranial fossa can be treated successfully by the purely endoscopic approaches.[3] The recent popularization of FESS, however, has resulted in many of these standard surgical techniques being considered radical by proponents of FESS.[2] Successful endoscopically guided intranasal surgery of the paranasal sinuses requires accurate knowledge of the anatomy of the lateral nasal wall. Nasal endoscope has become important tools for endoscopic visualization of lateral nasal wall surgery.[2,4-7] The anatomy of the lateral nasal wall area is a highly complicated.[8] Additionally, there are some specific anatomic structures on the lateral nasal wall. These structures are important particularly for endoscopic sinus surgery and other standard nasal surgical techniques. There are many studies for anatomical landmarks in the lateral nasal wall and many of which measure the distances of the anatomical structures.[5,9-15]

Many Ears, Nose, Throat surgeons may need support in anatomical orientation during the endoscopic nasal surgery. Anatomic variations and limitations imposed by endoscopic visualization demands a good understanding of anatomy and familiarity with endoscopic surgery.[2]

We aimed to investigate the anatomy of the lateral nasal wall to provide a set of measurements among some important landmarks and to reveal the relationships between them. Anatomical structures, which are chosen as landmarks in our study, are very important for both surgeons and anatomists. Moreover, we think that the distances, which are measured in our present study, can be used safely in FESS or help develop new surgical techniques.

Methods. Fifty embalmed cadaver half heads were used in our study. No specimen showed any evidence of previous surgery or any other gross anatomical anomaly. Mucosa on the lateral nasal wall was carefully removed under operation microscope. Later, anatomic structures on the lateral nasal wall were carefully dissected. During the dissection, anterior nasal spine (ANS), inferior turbinate (inferior nasal concha) (INC), middle turbinate (middle nasal concha) (MNC), uncinate process (UP), natural ostium of the maxillary sinus (NOMS), opening of the nasolacrimal duct (OND), sphenopalatine foramen (SF), natural ostium of the sphenoidal sinus (NOSS), anterior ethmoidal artery (AEA), posterior ethmoidal artery (PEA), pharyngeal opening of the auditory tube (POAT), posterior nasal spine (PNS), natural ostium of the frontal sinus (NOFS) and nasal base (NB) were exposed. To expose the UP, the sagittal portion of MNC was cut and was carefully removed (**Figures 1-5**). The persistent landmarks were then identified,

Table 1 - Measurements obtained from anterior nasal spine (N=50).

Distances	MD (cm)	SD
ANS - INC	1	0.1
ANS - MNC	2.6	0.2
ANS - UP	3.4	0.3
ANS - NOMS	3.9	0.5
ANS - OND	3	0.4
ANS - SF	5.6	0.2
ANS - NOSS	5.5	0.4
ANS - AEA	5.5	0.3
ANS - PEA	5.8	0.4
ANS - POAT	6.2	0.3
ANS - PNS	5.6	0.3

INC - anterior border of the inferior turbinate, MNC - anterior border of the middle turbinate, UP - mid-uncinate process, NOMS - natural ostium of the maxillary sinus, OND - opening of the nasolacrimal duct, SF - exit point of the sphenopalatine artery, NOSS - natural ostium of the sphenoidal sinus, AEA - exit point of the anterior ethmoidal artery, PEA - exit point of the posterior ethmoidal artery, POAT - pharyngeal opening of the auditory tube, PNS - posterior nasal spine.

Table 2 - Distances from middle nasal concha (MNS) (N=50).

Distances	MD (cm)	SD
MNS-UP	1.4	0.3
MNS-NOMS	1.8	0.3
MNS-AEA	2.2	0.4
MNS-PEA	2.7	0.2

UP -uncinate process, NOMS - Natural ostium of the maxillary sinus, AEA - exit point of the anterior ethmoidal artery, PEA - exit point of the posterior ethmoidal artery.

Table 3 - Distances of the other anatomical landmark on lateral nasal wall (N=50).

Distances	MD (cm)	SD
NOMS-OND	1.8	0.3
OND-UP	1.8	0.5
NOSS-NB	3.4	0.6
NOFS-AEA	0.9	0.3
UP-AEA	2.5	0.6
NOMS-INC	1.5	0.3

NOMS-OND - anterior border of the natural ostium of the maxillary sinus- opening nasolacrimal duct, OND-UP - opening nasolacrimal duct - uncinate process, NOSS-NB - natural ostium of the sphenoidal sinus - nasal base, NOFS-AEA - natural ostium frontal sinus - exit point of anterior ethmoidal artery, UP-AEA - uncinate process - exit point of the anterior ethmoidal artery, NOMS-INC - anterior border of the natural ostium maxillary sinus - anterior attachment point of the inferior nasal concha to the lateral nasal wall.

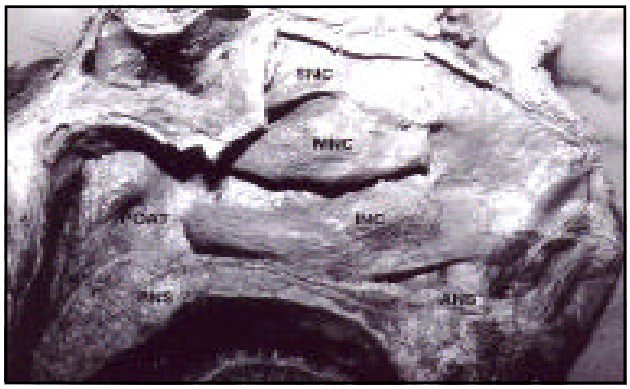

Figure 1 - Anatomical landmarks on the lateral nasal wall; anterior nasal spine (ANS), posterior nasal spine (PNS), inferior nasal concha (INC), middle nasal concha (MNC), superior nasal concha (SNC), pharyngeal opening of the auditory tube (POAT).

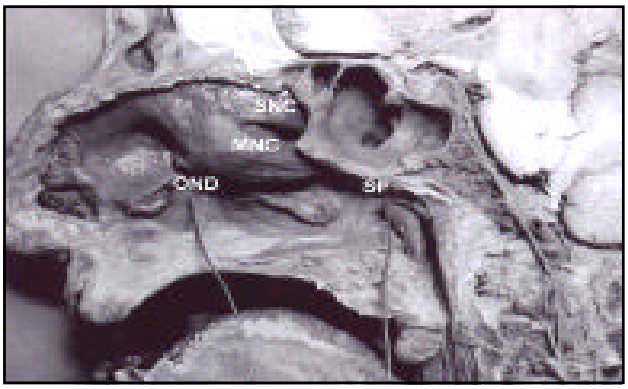

Figure 3 - Representative picture for exit point of the sphenopalatine artery (SF), superior nasal concha (SNC), middle nasal concha (MNC), opening of nasolacrimal duct (OND).

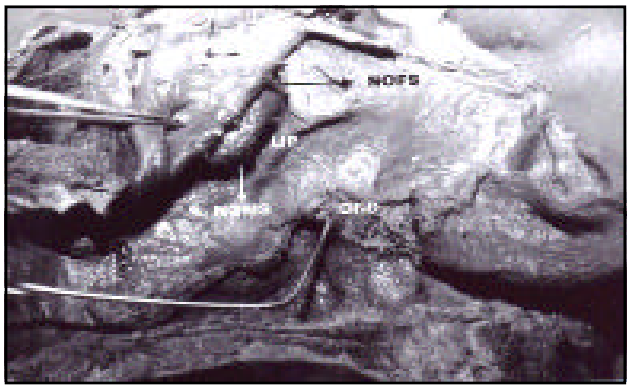

Figure 2 - Lateral nasal wall with the inferior nasal concha (INC) and middle nasal concha (MNC) removed and demonstrated opening of nasolacrimal duct (OND), uncinate process (UP), natural ostium of the maxillary sinus (NOMS) and natural ostium frontal sinus (NOFS).

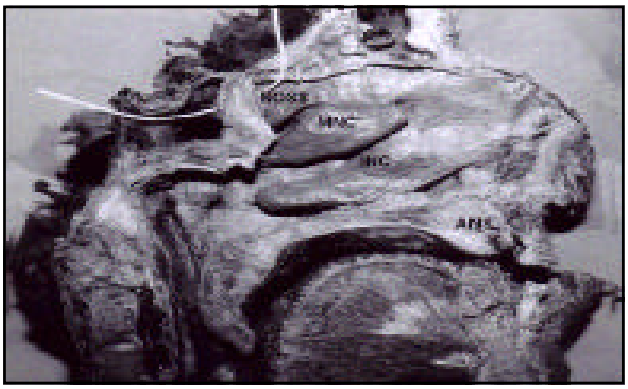

Figure 4 - Representative pictures for natural ostium of the sphenoidal sinus (NOSS) middle nasal concha (MNC), inferior nasal concha (INC), and anterior nasal spine (ANS).

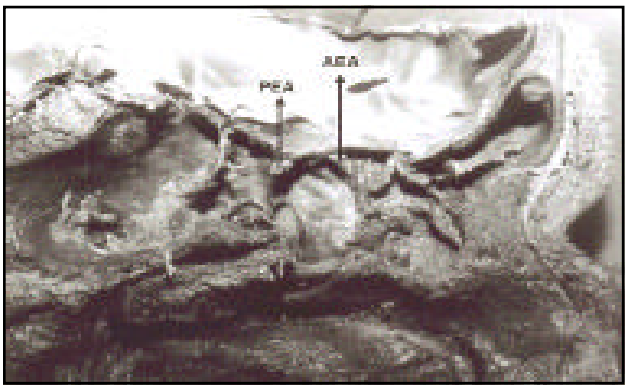

Figure 5 - Representative picture for exit point of the anterior ethmoidal artery (AEA) and exit point of the posterior ethmoidal artery (PEA).

some of which required limited dissection. Anterior nasal spine was chosen as a main landmark. Distances were measured with electronic caliper under operating microscope. Measurements were recorded from ANS to the designated structures (anterior-inferior border of the inferior turbinate, anterior-inferior border of the middle turbinate, mid-uncinate process, natural ostium of the maxillary sinus, opening of the nasolacrimal duct, sphenopalatine foramen, natural ostium of the sphenoidal sinus, exit point of the anterior ethmoidal artery, exit point of the posterior ethmoidal artery, pharyngeal opening of the auditory tube, posterior nasal spine) and the distances were rounded to the nearest millimeter.

Results. Measurements obtained from ANS were presented as mean distance (cm) and standard deviation in **Table 1**. Measurements were obtained from anterior attachment point of the middle nasal concha to the lateral nasal wall designated structures (uncinate process, natural ostium of the maxillary sinus, exit point of the anterior ethmoidal artery, exit point of the posterior ethmoidal artery) and the distances were rounded to the nearest millimeter in **Table 2**. Results of the measurements between anterior border of the natural ostium of the maxillary sinus and opening nasolacrimal duct, opening nasolacrimal duct and uncinate process, natural ostium of the sphenoidal sinus and nasal base, anterior border of the natural ostium frontal sinus and exit point of anterior ethmoidal artery, uncinate process and exit point of the anterior ethmoidal artery, anterior border of the natural ostium maxillary sinus and anterior attachment point of the inferior nasal concha to the lateral nasal wall are given in **Table 3**.

Discussion. Successful endoscopically guided intranasal surgery of the paranasal sinuses requires accurate knowledge of the anatomy of the lateral nasal wall. There have been many descriptions of the anatomic landmarks and their variations. Distances and angles between these structures are seldom stated.[5]

In this study, we have measured distances between the major lateral nasal wall landmarks in 50 half heads. We chose the posterior nasal spine and the anterior nasal spine as reference points. These locations are constant and measurements from these points are easily performed. These measurements can be used an intraoperative guidelines during transnasal endoscopic surgery. The results of this study suggest that, during lateral nasal wall surgery, a surgeon should pay attention to the sphenopalatine artery, anterior ethmoidal arteries and posterior ethmoidal arteries. These arteries may be damaged in endoscopic approaches. Moreover, we also measured the distance between anterior nasal spine and exit point of anterior ethmoid artery and posterior ethmoid artery on the lateral nasal wall. According to our findings, those arteries in the lateral nasal wall must be observed during endoscopic sinus surgery. Ethmoidal artery is an important anatomical structure to be recognized during endoscopic sinus surgery. Since, the anterior ethmoidal artery is the best landmark for the roof of the ethmoid sinus or the anterior base of the skull.[11,14,16] In our study, distance of AEA and PEA were measured (ANS-AEA 5.5 ± 0.3, ANS-PEA 5.8 ± 0.4, MNC-AEA 2.2 ± 0.4, MNC-PEA 2.7 ± 0.2, NOFS-AEA 0.9 ± 0.3, UP-AEA 2.5 ± 0.6). Another study reported that the distance of ANS and AEA was measured as 5.3 cm.[13] However, we found that this distance was 5.5 cm. The sphenopalatine artery, a major blood vessel of the nasal mucosa, exits from the sphenopalatine foramen and supplies the turbinates located on the lateral nasal wall and the nasal septum. Excessive hemorrhage can result to injury to the branches of sphenopalatine artery, which is very important for epistaxis, during endoscopic sinus surgery. Therefore, anatomical knowledge of the location of the sphenopalatine foramen is important.[12,17-22] Owing to the importance of sphenopalatine artery, the distance between SF (the exit point of the sphenopalatine artery) and ANS was measured (5.6 ± 0.2). With the role of the FESS, a thorough understanding of the anatomy of the sphenoid sinus has become increasingly important. The sphenoid sinus is adjacent to many important structures, and its relationship to them is subject to considerable variations.[9] Other distances found in our study are consistent with the results of Calhoun et al[5] Additionally, previous studies measured the distance between the ANS and NOSS as 5.6 cm.[5,10] In another study, the distance from the ANS to the NOSS was 7 cm.[23] On the other hand, Elwany et al[9] found that the distance was 6.44 cm but in our study this distance was measured as 5.5 cm. This distance is of importance as identification of the sphenoid sinus ostium is of great importance for safe and effective endoscopic surgery of the sphenoid sinus.[23]

Currently, 2 popular transnasal endoscopic approaches are used to locate the natural ostium of the maxillary sinus. The first technique is the traditional Messerklinger "anterior-to-posterior" infundibulotomy approach described by Stanberger and Posavetz.[24,25] The second approach is the "retrograde uncinectomy" technique advocated by Parsons et al.[24,26] Accurate identification of the natural ostium of the maxillary sinus is important in functional endoscopic maxillary sinus surgery.[15] The distance between the NOMS and OND was measured as 1.8 cm in our study, which differs from the results of Calhoun et al.[5] Interestingly, while Calhoun et al[5] found that the distance between the

OND and UP was 0.3 cm, the same distance was 1.8 cm in our study which is significantly higher. However, the measured distances were highly variable 0.5 - 2.8 cm in our study. This difference is likely due to many variations in positions of anatomical structures in this region. When compared to the result of Calhoun et al,[5] no differences were found.

The middle turbinate is a structure of great importance in nasal function and this structure is often carefully preserved at FESS.[25-30] Therefore, we considered this to be a very important distance between the anterior border of middle turbinate and anterior nasal spine during FESS. In our study, this distance was measured as 2.6 ± 0.2. The nasal cavity is a region where anatomical variations are not infrequently seen.[31] Anatomic variations imposed by endoscopic visualization demands a well known anatomy in endoscopic surgery.[6] Some of these variations are accepted to have no clinical significance.[31] Most nasal polyps arise from near the ostium of the maxillary sinus.[32] Nasal polyposis and allergic rhinitis are disease processes where the usefulness of nasal endoscopy is limited. Endoscopes could not be passed in these patients even after applying topical nasal decongestants.[4] The structure and landmarks are changed by nasal polyposis and this is another sign for the importance of the anatomical structure of this region.

There are 2 main ostiomeatal channels. The anterior ostiomeatal unit includes the frontal sinus ostium, frontal recess, maxillary sinus ostium, infundibulum and middle meatus. The posterior ostiomeatal unit consists of the sphenoid sinus ostium, sphenoethmoidal recess and the superior meatus. These channels provide communication between the ipsilateral frontal, anterior ethmoid and maxillary sinuses, posterior ethmoid and sphenoid sinuses. Understanding the anatomy of the lateral nasal wall and its relationship to adjacent structures is essential.[33] The FESS is based on the belief that the ostiomeatal complex is the key area in the pathogenesis of chronic sinus diseases.[2] Anatomic variations, infections, trauma, and tumors represent structural variations that predispose to narrowing of the ostiomeatal complex and the sinus drainage channels.[34] However, a review of the literature reveals a lack of consensus among investigators with regards to the prevalence, suspected pathogenicity, and clinical significance of these anatomic structures.[35] We did not encounter any significant anatomical variations in our cadavers. Rigid nasal endoscopes permit a better surgical view of the lateral nasal wall. Successful endoscopic intranasal surgery of the paranasal sinuses requires accurate knowledge of the anatomy of the lateral nasal wall.

In conclusion, our results may contribute to a better understanding of the anatomy of nasal-ethmoid complex and help to simplify the surgical technique and improve performance for safe endoscopic sinus surgery.

Acknowledgments. This research was supported by the Research Foundation of Akdeniz University, Antalya, Turkey. We thank Mr. Necati Sagıroglu, Mr. Huseyin Gezer and Mr. Hasan Savcili for their technical assistance.

References

1. Joe JK, Ho SY, Yanagisawa E. Documentation of variations in sinonasal anatomy by intraoperative nasal endoscopy. ***Laryngoscope*** 2000; 110: 229-235.
2. Mafee MF. Preoperative imaging anatomy of nasal-ethmoid complex for functional endoscopic sinus surgery. ***Radiol Clin North Am*** 1993; 31:1-20.
3. Gunkel AR, Freysinger W, Thumfart WF. 3D anatomo-radiological basis of endoscopic surgery of the paranasal sinuses. ***Surg Radiol Anat*** 1997; 19: 7-10.
4. Vining EM, Yanagisawa K, Yanagisawa E. The importance of preoperative nasal endoscopy in patients with sinonasal disease. ***Laryngoscope*** 1993; 103: 512-519.
5. Calhoun KH, Rotzler WH, Stiernberg CM. Surgical anatomy of the lateral nasal wall. ***Otolaryngol Head Neck Surg*** 1990; 102: 156-160.
6. Cheung DK, Attia EL, Kirkpatrick DA, Marcarian B, Wright B. An anatomic and CT scan study of the lateral wall of the sphenoid sinus as related to the transnasal transethmoid endoscopic approach. ***J Otolaryngol*** 1993; 22: 63-68.
7. Yoon JH, Kim KS, Jung DH, Kim SS, Koh KS, Oh CS et al. Fontanelle and uncinate process in the lateral wall of the human nasal cavity. ***Laryngoscope*** 2000; 110: 281-285.
8. Bingham B, Wang RG, Hawke M, Kwok P. The embryonic development of the lateral nasal wall from 8 to 24 weeks. ***Laryngoscope*** 1991; 101: 992-997.
9. Elwany S, Elsaeid I, Thabet H. Endoscopic anatomy of the sphenoid sinus. ***J Laryngol Otol*** 1999; 113: 122-126.
10. Kim HU, Kim SS, Kang SS, Chung IH, Lee JG, Yoon JH. Surgical anatomy of the natural ostium of the sphenoid sinus. ***Laryngoscope*** 2001; 111:1599-1602.
11. Kirchner JA, Yanagisawa E, Crelin ES, Jr. Surgical anatomy of the ethmoidal arteries. A laboratory study of 150 orbits. ***Arch Otolaryngol*** 1961; 74: 382-386.
12. Kumar S, Shetty A, Rockey J, Nilssen E. Contemporary surgical treatment of epistaxis. What is the evidence for sphenopalatine artery ligation? ***Clin Otolaryngol*** 2003; 28: 360-363.
13. Moon HJ, Kim HU, Lee JG, Chung IH, Yoon JH. Surgical anatomy of the anterior ethmoidal canal in ethmoid roof. ***Laryngoscope*** 2001; 111: 900-904.
14. Ohnishi T, Yanagisawa E. Endoscopic anatomy of the anterior ethmoidal artery. ***Ear Nose Throat J*** 1994; 73: 634-636.
15. Yanagisawa E, Joe JK, Christmas DA. Unusual appearance of the maxillary sinus ostium on transnasal endoscopy. ***Ear Nose Throat J*** 1999; 78: 80-81.
16. Lee WC, Ming Ku PK, van Hasselt CA. New guidelines for endoscopic localization of the anterior ethmoidal artery: a cadaveric study. ***Laryngoscope*** 2000; 110: 1173-1178.
17. Lee HY, Kim HU, Kim SS, Son EJ, Kim JW, Cho NH et al. Surgical anatomy of the sphenopalatine artery in lateral nasal wall. ***Laryngoscope*** 2002; 112: 1813-1818.

18. Duncan IC, Dos Santos C. Accessory meningeal arterial supply to the posterior nasal cavity: another reason for failed endovascular treatment of epistaxis. ***Cardiovasc Intervent Radiol*** 2003; 26: 488-491.
19. Holzmann D, Kaufmann T, Pedrini P, Valavanis A. Posterior epistaxis: endonasal exposure and occlusion of the branches of the sphenopalatine artery. ***Eur Arch Otorhinolaryngol*** 2003; 260: 425-428.
20. O'Flynn PE, Shadaba A. Management of posterior epistaxis by endoscopic clipping of the sphenopalatine artery. ***Clin Otolaryngol*** 2000; 25: 374-377.
21. Voegels RL, Thome DC, Iturralde PP, Butugan O. Endoscopic ligature of the sphenopalatine artery for severe posterior epistaxis. ***Otolaryngol Head Neck Surg*** 2001; 124: 464-467.
22. Wiorowski M, Schultz P, Perrot JB, Gentine A, Debry C. Indications and results of cauterization by endoscopic approach of the sphenopalatine artery in severe posterior epistaxis. ***Auris Nasus Larynx*** 2004; 31: 131-133.
23. Yanagisawa E, Yanagisawa K, Christmas DA. Endoscopic localization of the sphenoid sinus ostium. ***Ear Nose Throat J*** 1998; 77: 88-89.
24. Christmas DA, Yanagisawa E, Joe JK. Transnasal endoscopic identification of the natural ostium of the maxillary sinus: a retrograde approach. ***Ear Nose Throat J*** 1998; 77: 454-455.
25. Stanberger H, Posavetz W. Concepts, indications and results of the Messerklinger technique. ***Eur Arch Otolarhinolaryngol*** 1990; 247: 63-76.
26. Parsons DS, Setliff RC, Chambers D. Special considerations in pediatric functional endoscopic sinus surgery. Operative techniques in otolaryngology. ***Head Neck Surg*** 1994; 5: 40-42.
27. Banfield GK, McCombe A. Partial resection of the middle turbinate at functional endoscopic sinus surgery. ***J R Army Med Corps*** 1999; 145: 18-19.
28. Friedman M, Landsberg R, Tanyeri H. Middle turbinate medialization and preservation in endoscopic sinus surgery. ***Otolaryngol Head Neck Surg*** 2000; 123: 76-80.
29. Friedman M, Tanyeri H, Landsberg R, Caldarelli D. Effects of middle turbinate medialization on olfaction. ***Laryngoscope*** 1999; 109: 1442-1445.
30. Thornton RS. Middle turbinate stabilization technique in endoscopic sinus surgery. ***Arch Otolaryngol Head Neck Surg*** 1996; 122: 869-872.
31. Apaydin FD, Duce MN, Yildiz A, Egilmez H, Ozer C, Talas UD. Inferomedially projecting pneumatised secondary middle turbinate. ***Eur J Radiol*** 2002; 43: 42-44.
32. Ozgirgin ON, Kutluay L, Akkuzu G, Gungen Y. Choanal polyp originating from the nasal septum: a case report. ***Am J Otolaryngol*** 2003; 24: 261-264.
33. Cummings CW, Fredrickson JM, Harker LA, Krause CJ, Richardson MA, Sekuller DB. Osteomeatal unit and Sinus physiology. St Louis: Mosby; 1993. p. 1084.
34. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H. Paranasal sinuses: CT imaging requirements for endoscopic surgery. ***Radiology*** 1987; 163: 769-775.
35. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. ***Laryngoscope*** 1991; 101: 56-64.