

Importance of Ethmoidal Roof in Endoscopic Sinus Surgery

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Introduction

Rhinosinusitis is a common health problem that leads to frequent visits to primary care physicians and to ear, nose and throat specialists. The endoscope has revolutionized the diagnosis and treatment of diseases of the nose and paranasal sinuses. Endoscopic Sinus Surgery (ESS), like all minimally invasive surgery, is designed to combine an excellent outcome with minimal patient discomfort. Successful outcome with minimal complications can only be achieved with good knowledge of the endoscopic anatomy, appropriate training in the procedure and the understanding of the anatomical variations. The intraoperative complications of ESS are bleeding and injury to surrounding structures commonly the orbital structures and fovea ethmoidalis [1,2].

Computed Tomographic (CT) scan of nose and paranasal sinus plays a key role in pre-operative evaluation of patients undergoing endoscopic sinus surgery. The asymmetries of ethmoidal fovea, olfactory fossa, anatomical variations of lateral lamella and course of Anterior Ethmoid Artery (AEA) are critical in ESS as it may predispose to dangerous consequences like hemorrhage, CSF leak and intracranial complications.

The CT scan of paranasal sinus taken for various conditions were analysed with special attention to anatomical variations of anterior skull base. The endoscopic surgeon's awareness of these variations and its role in preventing complications are highlighted in the study.

Materials and Methods

A study of CT scans paranasal sinus of 180 patients taken for various conditions in our institute were analyzed. The inclusion criteria were patients above 16 years of age. All patients with previous history of nasal or paranasal trauma, surgeries, tumours or conditions involving bone destruction were excluded from the study.

The patients underwent true coronal CT scan paranasal sinus with CT Vision; CT Secura (Philips). A direct coronal positioning was done with the patient prone with the chin extended (neck hyper extended). The slice thickness was 3 mm. Bone algorithm was used for acquisition and the scans were interpreted in bone window. The CT scans were interpreted in detail with special emphasis on asymmetries of ethmoidal fovea, and olfactory fossa.

The asymmetries of the anterior skull base analysed included asymmetries of the 'height' and 'contour' of the ethmoid fovea on both sides and the depth of the cribriform plate. The 'height' of the ethmoidal fovea is the difference in the length of the lateral lamella and the 'contour' is the angle at which the lateral lamella articulates with the cribriform plate. The depth of the anterior cranial fossa was classified as per Keros classification.[3]

The data was tabulated in an excel spreadsheet which was then exported to SPSS Ver 20.0 for analysis. The various radiological features of anterior skull base structures were analyzed in detail and the frequency distributions were determined by descriptive statistics. The comparison of variations in ethmoidal fovea with respect to olfactory

fossa was performed using the student t-test. The statistical significance was set to $p < 0.05$.

Results

The CT scan paranasal sinus of 180 patients analysed for the various anatomical variations of the anterior skull base revealed interesting results. The patients were of the age group 16 to 62 (mean age of 32.2) with 112 female and 68 male patients.

Out of the 180 patients analysed 21 (11.7%) patients had asymmetry of height. Of the 21 patients with asymmetry of height, 15 (71.4%) showed low fovea on right side and 06 (28.6%) patients on the left side. The average difference in height was 2.57 mm with an average of 2.42 mm on the right side and 2.97 mm on the left side. Contour asymmetry between the two sides was observed in 49 (27.2%) patients who were due to flattening of ethmoidal fovea on one side. The flattening of ethmoidal fovea in patients of contour asymmetry was seen in 32 (68.1%) patients on the right side. The olfactory fossa was Keros type I in 31 (17.2%) patients, Keros type II in 139 (77.2%) patients and Keros type III in 10 (5.6%) patients.

	HEIGHT ASSYMETRY	CONTOUR ASSYMETRY
KEROS TYPE I (n = 31)	7 (22.6%)	14 (45.2%)
KEROS TYPE II (n = 139)	13 (9.3%)	32 (23.1%)
KEROS TYPE III (n = 10)	01 (10%)	03 (30%)

Table 1: Comparison of Keros classification with asymmetries of the ethmoidal fovea.

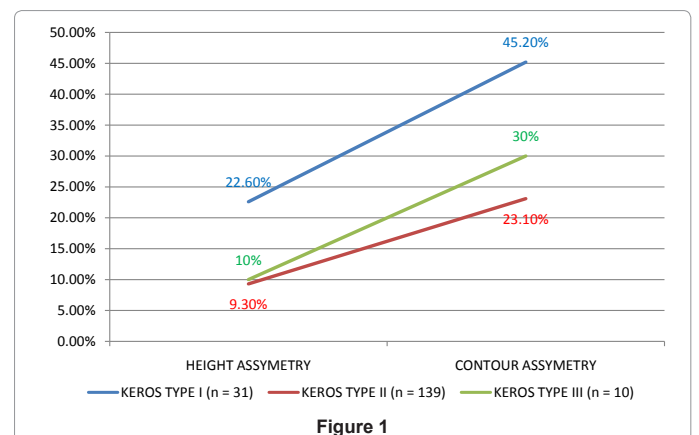


Figure 1

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The comparison of ethmoidal roof asymmetry with Keros classification is described in Table 1.

Discussion

ESS is a commonly performed surgery for refractory chronic rhinosinusitis. In spite of the advantage of ESS over traditional techniques of better visualization, being less invasive and minimal postoperative discomfort [4] it has its own risk of complications. [5] Mosher in 1912 stated that intranasal ethmoidectomy is "the blindest and most dangerous surgery". Over the years the incidence of complications has reduced due to improved surgical experience, knowledge of the endoscopic anatomy and better equipment and instruments.

The ethmoidal labyrinth appears during the third month of fetal development as evaginations of the lateral nasal wall. Anatomically, the ethmoids lie medial to the orbit in the superior nasal vault. There are vertical and horizontal plates, with the vertical plate known as the perpendicular plate of the ethmoid inferiorly and the crista galli superiorly. Horizontally, the lateral aspect is called the fovea ethmoidalis and the medial portion the lamina cribrosa (cribriform plate). Lateral to the lamina cribrosa and insertion of the middle turbinate, the ethmoid bone is open superiorly. This part is covered by the orbital plate of frontal bone and is called the ethmoid roof (fovea ethmoidalis) separating the ethmoidal cells from the anterior cranial fossa.[6,7] The fovea ethmoidalis and the lamina cribrosa can be at more or less the same level, or a height difference may exist. The very thin bone connecting the horizontal lamina cribrosa and fovea ethmoidalis is called the lateral lamella of the lamina cribrosa. The fovea ethmoidalis or ethmoid roof is lowest medially at its articulation with the lateral lamella and rises from medial to lateral in a "gull wing" configuration.

The ethmoid sinuses are one of the most complex anatomical structures of the body with vital structures such as the orbit, dura and optic nerve bordering it. The detailed knowledge of paranasal anatomy and the prevalence of asymmetry of ethmoidal fovea are important for the endoscopic surgeon to avoid complications. [7-15] A careful study of the CT scans is mandatory to familiarize the surgeon with the anatomical variations and pathology. [16,17] Injury to surrounding structures during endoscopic ethmoid surgery can lead to cerebrospinal fluid leak, damage to orbital structures and bleeding. In serious injuries, direct penetration trauma to the dura, serious intracranial and intracerebral complications can occur [10,18]. The commonest sites of injury in anterior cranial fossa is the cribriform plate and roof of the ethmoid sinus [19].

Asymmetry of ethmoidal fovea is an important finding to be noted in the CT scan analysis before endoscopic sinus surgery. [9,11,13] In the review of literature various studies have described the asymmetry in the height of ethmoidal roof in the range of 9% to 16%.[13,18,20,21] The height of the ethmoid roof on the right side is usually lower than the left which predisposes the surgery on the right side to lead to complications as compared to left.[13,18,20-22] Freedman et al attributed the cerebrospinal fluid leak during ethmoidectomy performed on the right side by right handed surgeon to awkward position of surgeon. [23] Our study results are in line with the literature with an incidence of asymmetry of height of ethmoidal roof in 21 (11.7%) patients, 15 (71.4%) of them with lower ethmoidal roof on right side and 06 (28.6%) on the left side.

Cribriform plate is usually more caudal than the ethmoid roof and Keros (1962) in his study of olfactory fossa in 450 skulls classified them

into three types as per the depth of the olfactory fossa. Type I: 1-3mm (11.59%), Type II 4-7mm (70.16%) and Type III 8-16mm (18.25%).[3] On review of studies describing depth of olfactory fossa it was seen that Keros type II is the commonest presentation followed by Keros type I. [10,20,21,24] The incidence of Keros type III was found to be variable in studies with Basak S et al and Anderhuber W et al [10,24] observing it in 38% and 15.2% respectively whereas Souza Sa et al and Ali et al [20,21] describing it as an uncommon presentation with incidence of 0.5% and 1.3% respectively. We observed type II (77.2%) as the commonest presentation followed by type I (17.2%) and type III (5.6%).

In our study we have analyzed the association of the olfactory fossa depth with the asymmetries as well as the contour of the ethmoidal roof with interesting inferences. No other study in the literature has been cited with similar analysis and results. The comparison of ethmoidal roof asymmetry with Keros classification revealed that the height and contour asymmetry were significantly higher in Keros type I with an incidence of 67.8% of patients as compared to 32.3% and 40% of patients of Keros type II and III. Hence the endoscopic surgeon needs to be careful in identifying these variations in patients of Keros type I to prevent complications due to asymmetric and low lying ethmoidal roof.

The Keros type III is considered as the most vulnerable for iatrogenic lesion during frontoethmoidal surgery due to its long length of the lateral lamella.[7,9,10,25] The area of the entry of AEA through the lateral lamella into the olfactory fossa is considered the thinnest and at risk of injury causing CSF leak. [7-9] In our study we have observed that low or flattened contour of ethmoidal fovea as well as asymmetries between the sides in respect to height and contour of ethmoidal fovea were most commonly associated with Keros type I. As the AEA traverses through the ethmoid sinus, there is increased risk of trauma while performing ethmoid surgery in cases of low angle or flattened contour. Damage to the AEA can lead to profuse hemorrhage with the formation of orbital hematoma due to retraction of the lacerated artery into the orbit. Hence in cases of Keros type I the endoscopic surgeon need to be wary of the increased chances of asymmetries as well as lower ethmoidal roof and AEA as compared to Keros type III which is a rare presentation.

The endoscope brings better vision and exposure with lesser bleeding - together leading to better results. An optimal preoperative evaluation including CT scan and a thorough knowledge of paranasal anatomy is paramount in a successful endoscopic sinus surgery. We found in our study that Keros type III is a rare presentation and that Keros type I is associated with lower and asymmetric ethmoidal fovea. These asymmetries in the anatomy of ethmoidal roof need to be kept in mind to prevent complications.

Conclusions

Asymmetry of the ethmoid roof is an important anatomic variation seen on CT scan that has the potential for disastrous complications in ESS. In our study in addition to the variations in ethmoidal roof and olfactory fossa, we have analyzed the association of the olfactory fossa depth with the asymmetries of height and contour of the ethmoidal roof. No other study in the literature has been cited with similar analysis and results. Keros type I olfactory fossa was found to have an increased association with asymmetries of fovea ethmoidalis. Though Keros type III is well known for complications during ethmoid surgery, we observe that it is relatively rare presentation. Hence the endoscopic surgeon should be aware of the Keros type I patients who have a higher

incidence of asymmetries. This study highlights the importance of careful preoperative and intraoperative review of paranasal sinus CT scans in patients undergoing ESS to prevent complications. Further studies to analyze the above findings in relation to the complications are mandatory to improve the safety of ESS.

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