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A RETROSPECTIVE OBSERVATIONAL STUDY ON THE SIGNIFICANCE OF RADIOLOGICAL ASSESSMENT OF CRIBRIFORM LATERAL LAMELLA LENGTH AND ANGLE IN COMPARISON WITH KEROS CLASSIFICATION

Otorhinolaryngology

Nagaraj Kirupananthan* Department of ENT, Sri MuthuKumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, South India. *Corresponding Author

Sunitha M Department of ENT, Sri MuthuKumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, South India.

Asokan L Department of ENT, Sri MuthuKumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, South India.

Gokul Kannaiyan Department of ENT, Sri MuthuKumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, South India.

ABSTRACT

Introduction: The depth of anterior cranial fossa was described by Keros in the year 1962. It is used for traumatic risk assessment during endoscopic surgery involving anterior skull base by ENT Surgeons. The purpose of this study is to measure the length of the lateral lamella, the angle formed by the lateral lamella and the horizontal plane passing through the cribriform plate on CT PNS and to correlate it with Keros Classification.

Material and Methods: A retrospective observational study was carried out by review of CT-Scan of Paranasal sinus of patients above 18 years from November 2019 to October 2021. The lateral lamella (LL) length, the angle formed by the lateral lamella and the horizontal plane passing through the cribriform plate and the depth of the olfactory fossa was measured by viewing the DICOM images of the CT scan.

Results: A total of 102 CT Scan of Paranasal sinuses of patients were assessed. The length of lateral lamella was greater in males compared to females. There were no significant differences in the lateral lamella length between each side. The most common type of angle was Class II (88.7%), followed by Class III (6.9 %) and Class I (4.4%). When the depth of the cribriform fossa was assessed by Keros classification, type I (63.7%) was the commonest presentation followed by Keros type II (36.3%). A strong correlation was found between types of Keros and lateral lamella length (Pearson coefficient = 0.679), which was found to be statistically significant [p-value - 0.0005]. In this study, we noted that there were gender and sidewise variations on Keros classification.

Conclusion: Lateral lamella length and angle formed by the lateral lamella and the horizontal plane passing through the cribriform plate is as important as the depth of olfactory fossa. An acute angle increases the risk of injury to skull base during endoscopic sinus surgery.

KEYWORDS

Computed tomography of Paranasal sinuses (CT-PNS), Functional Endoscopic sinus surgery, Keros classification, Lateral lamella.

INTRODUCTION

Sinonasal diseases management by endoscopic sinus surgery is a well known approach.While accessing the skull base, the lateral lamella (LL) of the olfactory fossa, the posterior surface of the frontal recess and the anterior ethmoidal canal are the most commonly injured regions in ESS.[1] These injuries are mainly because of the anatomical variations that are expected between each patient. To avoid such injuries, a risk-based assessment approach is ideal to predict the high-risk individual.

The depth of anterior cranial fossa was described by Keros in the year 1962 and he classified it into 3 category. It is used for traumatic risk assessment during endoscopic surgery involving anterior skull base by ENT Surgeons. The Keros classification based on the depth of the olfactory fossa as determined by the height of the lateral lamella of the cribriform plate has three types (i) Type I (1-3mm depth) (ii) Type II (4-7mm) and (iii) Type III (8-16mm).[2]

Pre-operative anatomical assessment by Computer tomography (CT) is the gold standard technique to visualize and measure the paranasal sinuses and neighboring structures.[3] The cribriform plate and the fovea ethmoidalis form a part of anterior skull base. They converge together at the lateral lamella of the cribriform plate (LLCP) which marks a common point of iatrogenic skull-base injuries.

Since it is a weak area, direct penetration or fracture during surgery is common if done without anatomical orientation. The fact that there are differences in olfactory fossa depth among each individual and the complication arising out of it stresses the importance of assessing the angulation and length of the lateral lamella by radiological methods. Understanding the variations in the anatomical structures in everyone is crucial to avoid postoperative complications.

Based on the above fact, we aimed to measure the length of the lateral lamella, the angle formed by the lateral lamella and the horizontal plane passing through the cribriform plate on CT PNS and to correlate it with Keros Classification. Although few studies have been published looking at the anatomical variations and Keros classification, this analysis is done among patients attending a tertiary care teaching hospital in South India.

MATERIALS AND METHODS

A retrospective observational study was conducted by review of CT-Scan of Paranasal sinus from November 2019 to October 2021. This study was approved by the institutional ethics committee. Patients who were above the age of 18 years who underwent non-contrast CT scan for various reasons were included as the study sample. Those CT scans of the patients who have a history of endoscopic nasal surgeries or skull-based surgeries and any other history which causes anatomical distortion were excluded from the assessment. The basic demographic characteristics (age and gender) of the study population have been captured from the medical records department. The lateral lamella length, the angle formed by the lateral lamella and the horizontal plane passing through the cribriform plate and the depth of the olfactory fossa was measured by viewing the DICOM images of the CT scan of Paranasal sinuses.

Lateral Lamella is the thinnest bony structure connecting the cribriform plate to the ethmoidal roof.The length of the lateral lamella is measured from the lateral end of the LL to the point where the middle turbinate is attached to the cribriform plate (Figure 1).

The angle that is formed by the LL and the continuation of the horizontal plane passing through the cribriform plate is depicted in figure 2. The angle is classified into class I as low risk (>80 degrees), Class II as medium risk (45-80 degrees), and class III as high risk (<45 degrees). The angle that is formed by the LL cribriform plate and the continuation of the horizontal plane passing through the cribriform plate is called as Gera angle.[4] The coronal scans taken for measurements

Two vertical lines were drawn

(X) - From lateral end of lateral lamella to palate

(Y) - From the point of attachment of middle turbinate to palate

Depth of cribriform fossa - (X- Y) (Figure 3).

Statistical analyses were performed by using SPSS software.

Descriptive statistics were performed to study the basic demographics of the study population. The significance of association between the angle formed by LL and the depth of the olfactory fossa with the Keros classification was tested using the Pearson Chi-square test. Differences at the level of p value <0.05 were accepted to be statistically significant.

RESULTS

Demographics: During the above study period, a total of 102 CT reports of patients were assessed. Among them, 52.9% (54) were males and 47.1% (48) were females. The mean age of patients included in the study was 43.65 ± 17 years (Range 18–80). Among the study population, 46% belonged to the age group of 18-40 years, 35% to 41-60 years and 19% were elderly population (>60 years).

Length of lateral lamella: The mean length of lateral lamella was 3.84 ± 1.09 mm. There were no significant differences in the lateral lamella length between right (3.77 ± 1.18 mm) and left side (3.90 ± 1.14 mm). When gender wise comparison was made, it was found that the LL length was greater in males (4.35 ± 0.96 mm) compared to females (3.26 ± 0.95 mm) (p-value 0.0005) as seen in figure 5.

Angle distribution: The most common type of angle was Class II (88.7%), followed by Class III (6.9 %) and Class I (4.4%). The mean angle was 58.94° (SD ± 8.19), which was more in males (60.61° ± 8.81°) compared to females (57.08° ± 8.19°) (p = 0 0.005). There were no significant differences in the angle between the left (58.99° ± 9.96°) and right side (58.89° ± 10.10°) (p-value 0.924). We found positive correlation between lamella angle and Keros which was statistically significant (p-value 0.005). Positive correlation was found between lamella angle and lateral lamella length (p-value 0 0.005). The angle distribution is shown in table 1 and figure 4.

Keros distribution: The mean depth of cribriform fossa was 3.59 (SD ± 1.10 mm). When gender wise comparison was made, an increased mean depth was seen in males 4.12 ± 1.04 mm (range 1.6 - 7.53 mm) as compared to females 2.99 ± 0.83 mm (range 1.38 - 4.7 mm) [p-value - 0.005]. When the depth of the cribriform fossa was assessed by Keros classification, type I (63.7%) was the commonest presentation followed by Keros type II (36.3%) as seen in figure 6. Type III was not seen among our study population., There were statistically significant differences in the depth between the right (3.42 ± 1.13 mm) and the left side (3.77 ± 1.16 mm) [p-value - 0.0005] as seen in figure 7. A strong correlation was found between types of Keros and lateral lamella length (Pearson coefficient = 0.679), which was found to be statistically significant [p-value - 0.0005] as seen in figure 8.

DISCUSSION

Computed Tomography scan of the paranasal sinuses is not just used as diagnostic tool but also guide way during endoscopic sinus surgery. In this study, we measured the depth of anterior cranial fossa with reference to hard palate and found Keros type I (63.7%) commonest followed by Keros type II (36.3%) and Keros type III (0%). The depth of olfactory fossa was found to be more in males & greater depth over left side when compared to right. The mean LL length is greater in males compared to females & no significant difference between left and right LL in our study as seen in figure 8.

In a study by Solares *et al.,* they have shown that when the height of the lateral lamella increases, then the possibility of penetrating the skull bases is higher.[5] In our study, we found that the mean cribriform lamella length and depth of the cribriform of fossa is more in males as compared to the females as comparable to other studies.[6-7] Lamella angle is an important aspect of anterior cranial fossa as an acute angle would be more prone to injury than obtusely angled during surgery. So far only few studies have analyzed this angle.

The frontal bone is thick in the ethmoidal roof area but when it goes down laterally, there lies a thinner region of ethmoid named as lateral lamella. Lateral lamella is defined as the lateral region of cribriform plate of ethmoidal bone which needs to be assessed before any endoscopic sinus or skull surgeries.[8] If the LL is inferiorly positioned, then there is a greater risk of intraoperative injury. Lateral lamella (LL) was referred as the 'medial cranial wall' by Takahashi (1994) since it's the thinnest portion of skull base**.** During sinus surgery mostly we tend to remain lateral to the middle turbinate, so the lateral lamella region is as important as the cribriform plate. In the anterior skull base, the lateral lamella, fovea ethmoidalis and cribriform plate are the common areas at risk during surgery.

Endoscopic sinus surgeries can cause complications in around 0.5% of the cases leading to cerebrospinal fluid leak, orbital injury, hemorrhage and toxic shock syndrome.[9] There are various classification systems available to predict the individuals who are prone to these complications based on the anatomical features seen by radiological methods. One such classification is Keros which is most used but has limitations in assessing the risk of intracranial entry due to the sloping nature of the skull. In a study conducted by Skorek *et al.,* it is shown that the Keros classification is not enough to assess the high-risk area at the base of the skull and the ethmoidal region.[10]

Keros classification was the most reliable method to assess the anatomical structure earlier. In our study, the most common type of angle was Class I (88.7%), followed by class III (6.9 %) and class II (4.4%). We found the angulation is more among males. In this study, type I Keros (63.7%) was the commonest presentation followed by Keros type II (36.3%). Type III was not seen among our study population. Among the patients classified as Class III angle, 100% demonstrated Keros type I. A significant positive correlation between the depth of the cribriform fossa, the length of LLCP and the degree of the angle between the LLCP and the cribriform plate was found in our study. We postulate that a significant percentage of patients classified as low risk according to Keros classification, may have at high risk during surgery due to pronounced slope of the anterior skull base.

In studies conducted across the world, type II and type I are commoner than type III Keros. A study conducted in Ohio by Solares *et al.,* had shown that 83%, 15% and 2% were belonging to type I, II and III respectively among 50 study samples.[5] Even though Keros is still followed by many surgeons, CT PNS gives a more accurate imaging, and this has been shown in the above study that a significant percentage of patients classified as low risk according to Keros' classification, may have at high risk during surgery due to pronounced slope of the anterior skull base. This shows that the length of LL and angulation are important predictors of trauma to anterior skull base. Nowadays, CT PNS is available widely and helps in diagnosing the disease condition and to understand the anatomical landmarks and variations in the skull base accurately by using three dimensions contemporary technology. Imaging highlights the importance of angulation, depth of lateral lamella, and anatomical variations thereby pointing out the limitations in the Keros classification.[11]

In this study, we highlighted the importance of differences among gender, right and left side and variations between CT image-based assessment and Keros classification. The evaluation of the angle formed by the LL and the continuation of the horizontal plane passing through the ethmoidal plate could provide information regarding the anterior skull base. A significant percentage of patients classified as low risk according to Keros' classification are actually high risk as per our study findings. Hence the length of the LL and angulation of LL need to be assessed by CT imaging before and during endoscopic sinus surgery to prevent complications.

CONCLUSION

this study, we highlight the importance of the evaluation of the angle formed by the lateral lamella of Cribriform plate and the continuation of the horizontal plane passing through the ethmoidal plate that could provide information regarding the anterior skull base. Hence the length and angulation of lateral lamella are important during endoscopic sinus surgery to prevent complication.

Table 1: Distribution Of Angle Based On The Gender

Angle distribution	Right side		Left side		Total	
	Male n (%)	Female n (%)	Male n (%)	Female n (%)	Male n (%)	Female n (%)
Class I	4 (7.4%)	1 (2.1%)	3 (5.6%)	1 (2.1%)	7 (6.5%)	2 (2.1%)
Class II	46 (85.2%)	44 (91.7%)	49 (90.7%)	43 (89.6%)	95 (88%)	87 (90.6%)
Class III	4 (7.4%)	3 (6.2%)	2 (3.7%)	4 (8.3%)	6 (5.5%)	7 (7.3%)
Total	53 (100%)	48 (100%)	54 (100%)	48 (100%)	108 (100%)	96 (100%)

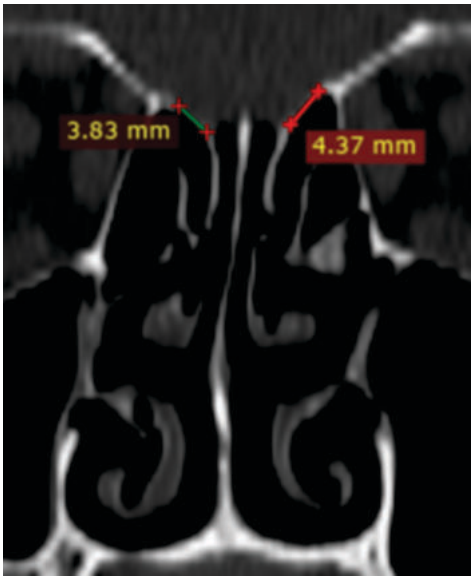

Figure 1: Measurement Of Length Of Lateral Lamella

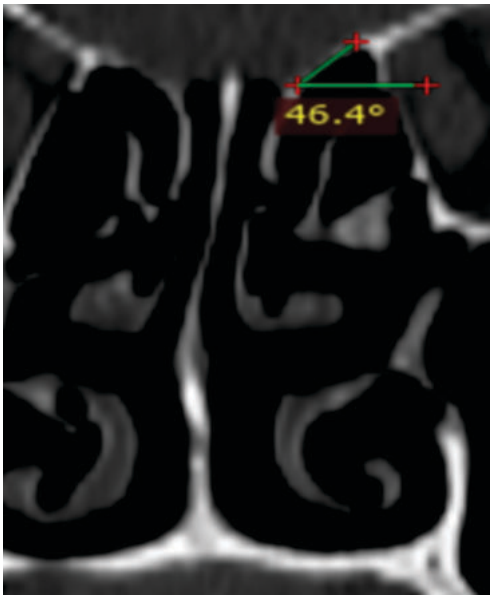

Figure 2: Angle Formed By The Lateral Lamella

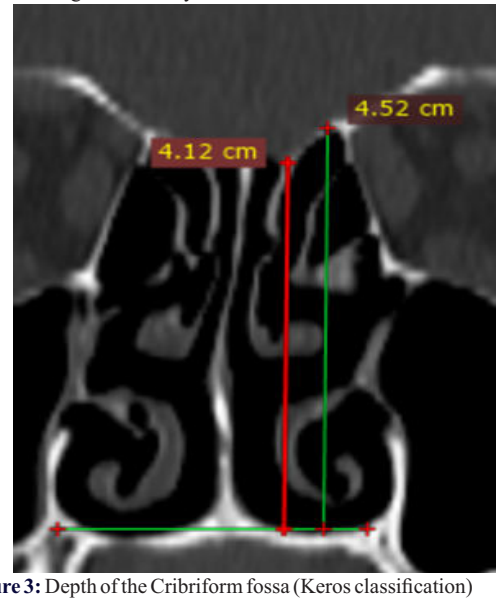

Figure 3: Depth of the Cribriform fossa (Keros classification)

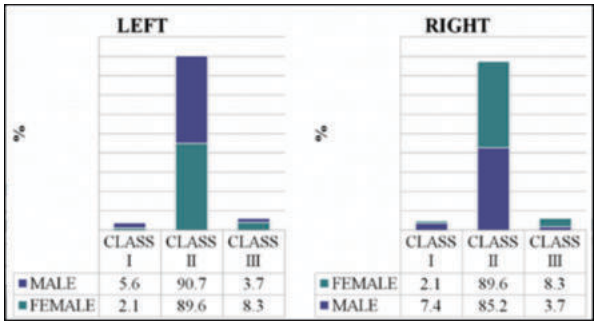

Figure 4: Distribution Of Angle Among The Study Participants

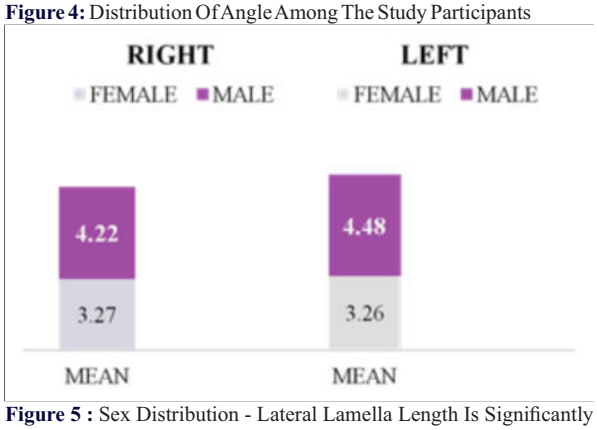

Figure 5 : Sex Distribution - Lateral Lamella Length Is Significantly Greater In Male

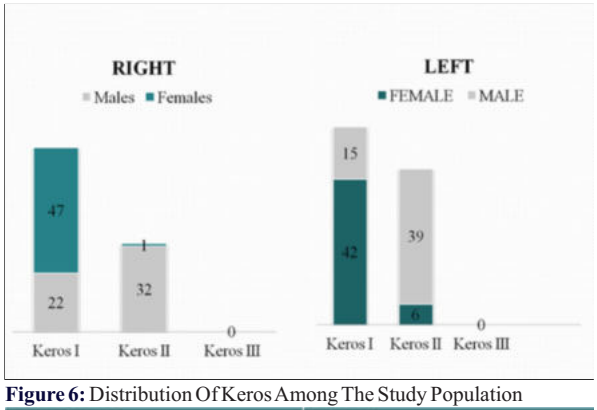

Figure 6: Distribution Of Keros Among The Study Population

OF DEPTH	MEAN
RIGHT	3.42
LEFT	3.76
TOTAL	3.59

Figure 7: Overall Keros Distribution Based On Sides

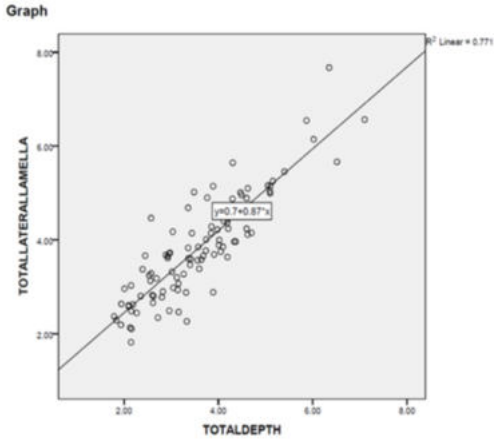

Figure 8: Correlation Between Lateral Lamella Length And Keros Classification

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