ORIGINAL ARTICLE

An Analysis of Configuration of Lateral Lamella of Cribriform Plate of Ethmoid: A Computed Tomographic Study

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Abstract:

Background: Ethmoid Skull Base (ESB) is an articulation of ethmoid roof with Lateral Lamella of Cribriform plate (LLCP). An increased LLCP height was observed to increase the vulnerability of ESB to surgical injuries. *Aim and Objectives*: The present study was undertaken to analyze the configuration of the lateral lamella of cribriform plate, the ethmoid roof with respect to Keros type of olfactory fossa. *Material and Methods*: A retrospective Computed Tomographic (CT) study was done with 60 Coronal Paranasal Sinuses (PNS) scans and LLCP height was determined by subtracting Medial Ethmoid Roof Point (MERP) from CP heights and classified according to Keros. The difference between Medial Ethmoid Roof Point (MERP) and Lateral Ethmoid Roof Point (LERP) heights in both anterior and posterior planes indicates the direction of ethmoid roof slope. *Results*: The average height of the LLCP was between 1.53 to 8.55 mm with a mean (SD) of 3.77 mm ± 1.66 and majority belonged to Keros type I. Overall mean difference between LERP and MERP was 5.43 ± 0.74 mm in anterior and 4.43 ± 0.63 mm in posterior planes. In both the planes irrespective of the sides the height of the LERP was higher in relation to medial side. *Conclusion*: Keros type I was the most common type and the slope of anterior ethmoid roof is steeper compared to posterior. This preoperative knowledge about the configuration of LLCP as well as the ethmoid roof contour is vital during endonasal ethmoidal surgeries.

Keywords: Ethmoid Skull Base, Ethmoid Roof, Lateral Lamella of Cribriform Plate, Keros Classification

Introduction:

The Sino-nasal region is an epicenter of anatomical variations, the knowledge of which is important for a Functional Endoscopic Sinus Surgery (FESS). In this region, the ethmoid roof and the Lateral Lamella of the Cribriform Plate (LLCP) are of paramount interest during FESS [1]. The fovea ethmoidalis of orbital plate of frontal bone forms the ethmoid roof. The ethmoid roof articulates medially with the thinnest portion of the skull base, the LLCP and together they constitute the Ethmoid Skull Base (ESB) [2-4]. In ESB, LLCP is more prone for injuries during complex maneuvering in FESS and can result in serious complications like CSF leakage, intracranial injuries or hemorrhages [5-7].

Even though the cadaveric anatomy of the ethmoid roof has been studied previously by various authors, a CT study by Keros proposed a clinically relevant classification of depth of olfactory fossa [8]. According to this classification, height of LLCP was considered in classifying olfactory fossa into three types. In type I, the height of LLCP ranges from 1 to 3.99 mm, type II - 4 to 6.99 mm, and type III - 7 to 16 mm (Fig. 1) [8]. The height of LLCP was considered as the critical point based on reported findings. They observed that an increase in height of LLCP is directly proportional to increased weakness of the ESB, which ultimately makes ESB vulnerable for injuries [4, 9-10]. This

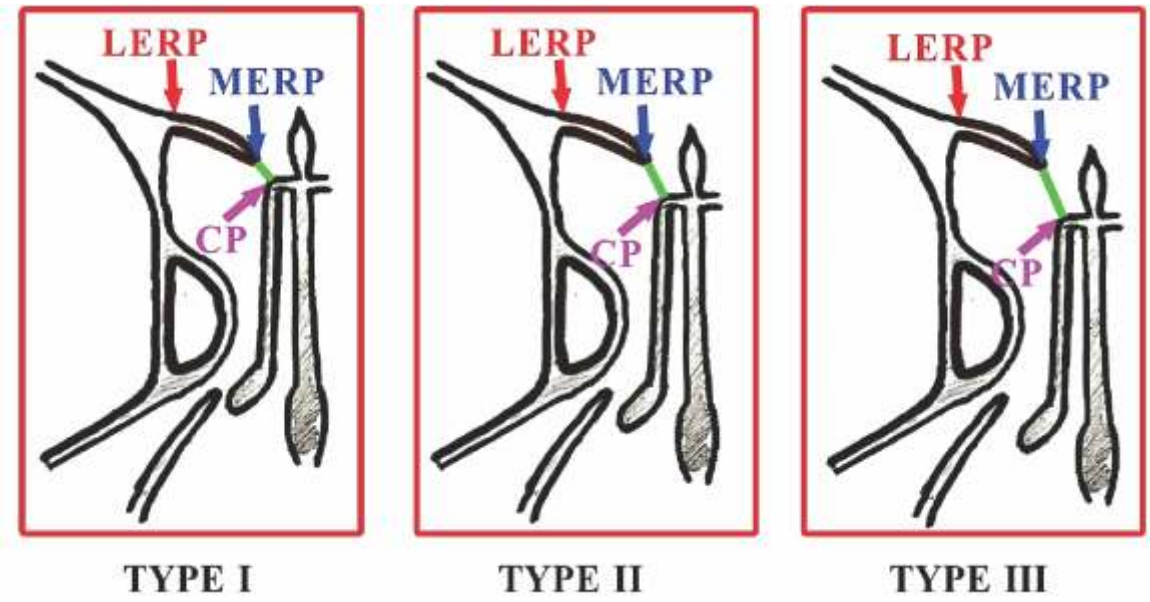

Fig. 1: Showing Three Types of Keros Classification.
LERP – Lateral ethmoid roof point, MERP – Medial ethmoid roof point, CP – cribriform plate point, Green line indicates – Lateral lamella of cribriform plate (LLCP)

present CT study was undertaken with an aim to analyze the configuration of the lateral lamella of cribriform plate and the ethmoid roof and provide a preoperative data for the surgeons in planning their anatomico-surgical approach.

Material and Methods:

A retrospective CT study was carried out utilizing 60 Coronal Computed Tomography (CT) Paranasal Sinuses (PNS) scan image sets from the Archives of Department of Radiology, Chennai Medical College Hospital and Research Centre, Trichy, Tamilnadu, a tertiary care medical college hospital. The CT image sections were of 3 mm thickness and captured using GE Healthcare VCT multi slice scanner. The CT images of patients above 18 years of both genders were included whereas patients with previous sinonasal trauma or pathologies, congenital abnormalities were excluded from the study. A convenient sampling method was adapted and after applying inclusion and exclusion criteria a total of 60 coronal CT scan image sets were finalized for analysis. RadiAnt Dicom viewer software designed and created by Medixant Company was used for analyzing the CT images.

Coronal CT paranasal sinus scan images at the level of visualization of infraorbital foramen, were taken for studying the morphology of LLCP on both sides. In each image, bony reference points in relation to the skull base were determined. The Medial Ethmoid Roof Point (MERP), marks the junction between the ethmoid roof and LLCP. The Lateral Ethmoid Roof Point (LERP), refers to the point of intersection of a vertical tangent with the ethmoid roof drawn along the medial wall of orbit. The lowest point was marked on Cribriform Plate (CP) at the junction of horizontal plate and lateral lamella of cribriform plate.

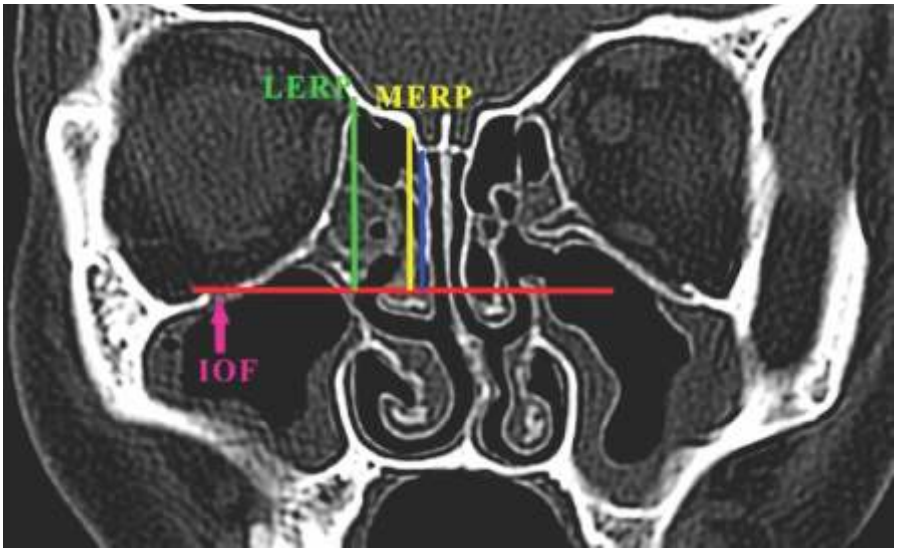

Fig. 2: Showing Measurements of CP, MERP and LERP Heights in Anterior Plane at the Visualization of Infraorbital Foramen (IOF)

The measurements were taken in the anterior plane at the first coronal cut and the posterior plane at the last coronal cut with a clearly visible CP. The vertical distances from the reference points MERP, LERP and CP to the horizontal line drawn at the level of infraorbital foramen were measured and termed as MERP height, LERP height and CP height (Fig. 2) [4]. The height of the LLCP was determined in both the planes by noting the difference between MERP height and CP height. The LLCP was classified in to three types based on Keros classification with reference to the average height of LLCP between the two planes [8]. The direction of the ethmoid roof slope was determined by calculating the difference between MERP and LERP heights in both anterior and posterior planes [4].

The IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA) was utilized for analysis of recorded data. The chi square test was applied to relate the side distribution of Keros classification and independent t-test for comparing the LERP and MERP mean values in two planes and between sides. The P value of $\leq$ 0.05 was defined as statistically significant. Approval from Institutional Ethics Committee, Chennai Medical College Hospital and Research Centre, Trichy, Tamilnadu was obtained before undertaking the study.

Results:

The present study was done in 60 coronal CT PNS scan (120 sides) that fulfilled our inclusion, exclusion criteria. Among them 31(52%) belonged to male and 29 (48%) to females. The age of the patients ranged from 18 to 80 years, with majority belonged to 20 – 40 years.

The height of the LLCP was between the range of 1.53 to 8.55 mm with a mean (SD) of 3.77 ± 1.66 mm. In analysis of LLCP height by Keros classification, majority belonged to Keros type I as against type II or III (Table 1). The mean (SD) height of LLCP in type I, II and II were 2.62 ± 0.67, 5.19 ± 0.78 and 8.3 ± 0.35 respectively. On applying Chi-square test between the sides of

Table 1: Showing Side Distribution of Keros Classification

Keros type	Right	Left	Total
Type I	46 (43.00) [0.21]	40 (43.00) [0.21]	86
Type II	13 (16.00) [0.56]	19 (16.00) [0.56]	32
Type III	1 (1.00) [0.00]	1 (1.00) [0.00]	2
Total	**60**	**60**	**120**

distribution, it was observed to be statistically not significant with value of 1.5436 (P = 0.46).

The configuration of ethmoid roof was assessed by knowing the mean difference between LERP and MERP in anterior and posterior planes. Overall mean (SD) difference was 5.43 ± 0.74 mm in anterior plane and 4.43 ± 0.63 mm in posterior plane. On right side, the mean (SD) difference was 5.33 ± 0.71 mm and 4.52 ± 0.63 mm in anterior and posterior plane respectively. On left side, it was 5.52 ± 0.77 mm and 4.44 ± 0.64 mm. On applying Independent sample t-test to compare the mean difference between LERP and MERP in right anterior and posterior plane, it was statistically significant with P value <0.001. The P value of <0.001 was also noted between left anterior and posterior planes. On applying independent sample t-test for comparing mean difference values between LERP and MERP in right and left anterior and left anterior and posterior, showed statistically insignificant values. In both the planes irrespective of the sides the height of the lateral ethmoid roof point (anterolateral) was higher in relation to medial side, indicating symmetrical sloping of ethmoid roof contour from lateral to medial and was steeper in anterior plane as compared to posterior plane (Figs. 3 and 4).

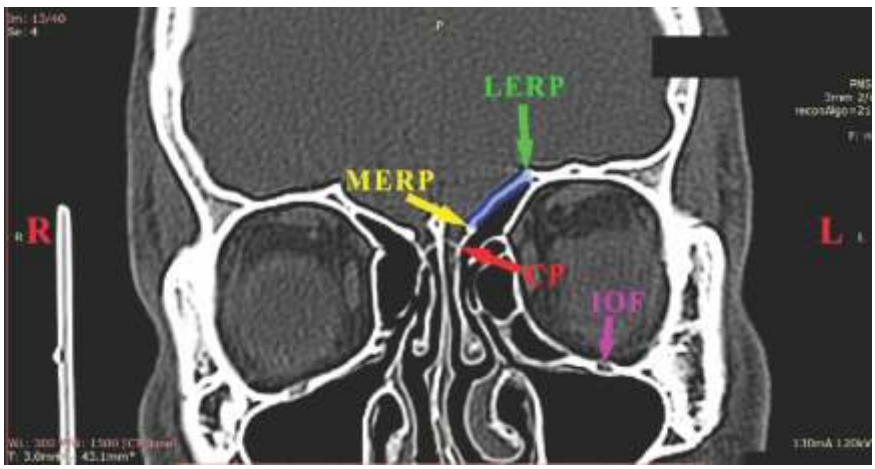

Fig. 3: Showing Ethmoid Roof (Blue Shaded Line) with Steeper Slope from Lateral to Medial in Anterior Plane

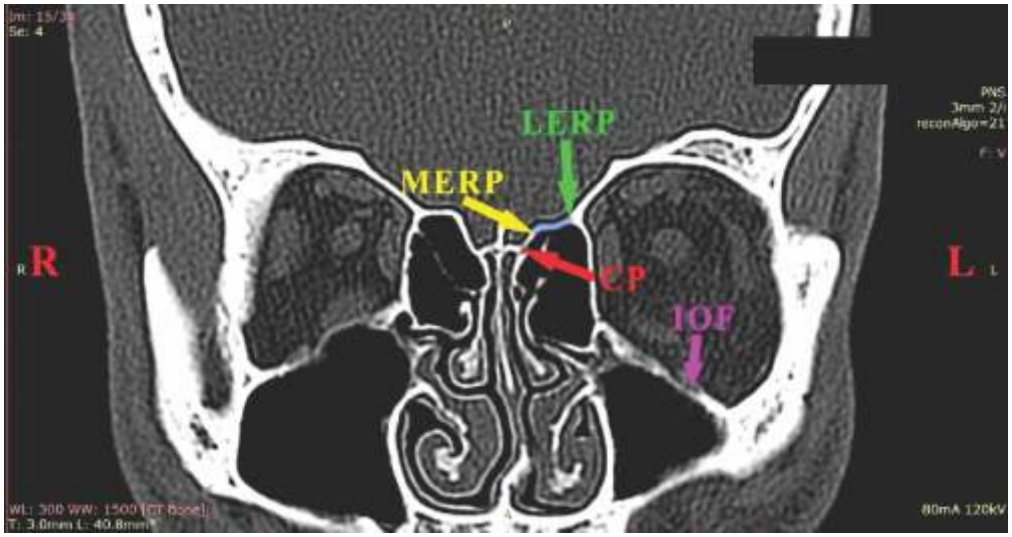

Fig. 4: Showing Ethmoid Roof (Blue Shaded Line) with Flat Slope from Lateral to Medial in Posterior Plane

Discussion:

The ethmoidal labyrinth develops as an extension of lateral nasal wall during 3rd fetal month and lies medial to orbital cavity in the superior aspect of nasal cavity forming an important component of Anterior Skull Base (ASB) [11]. The anatomy of ASB plays a significant role in endoscopic anterior skull base surgeries including FESS. The ASB is formed medially by crista galli and cribriform plate of ethmoid bone, laterally by the orbital plate of frontal bone, and posteriorly by the jugum sphenoidale and lesser wing of the sphenoid bone. The ESB is a component of ASB which includes LLCP and fovea ethmoidalis of orbital plate (ethmoid roof) [2]. In comparison to routine cadaveric study, the present study was done using coronal CT images taking in the vital role these CT images play in intricate evaluation of anatomical structure and configuration of ESB as well as create an anatomical map for the operating surgeons [12].

The height of LLCP reported by various researchers in different ethnic groups showed variations as tabulated (Table 2). The categorization of LLCP by Keros method in literature showed type I to be the most prevalent when compared to other two types of classification (Chart 1).

The LLCP having thickness from 0.05 mm to 0.2 mm, is considered as the weakest and vulnerable portion of ESB [2-4, 9]. The length of the LLCP was claimed to directly relate to the depth of the cribriform plate as well as to the incidence of its dehiscence. Type III Keros shows maximum length and thus it was observed to be more prone to iatrogenic injuries and complications compared to less likely injured type I group [4, 9]. On comparison of LLCP on both sides, many studies had reported asymmetry between sides with right side having lower height than left side [2, 8, 14, 19, 21]. The reasons for this asymmetry had been

Table 2: Mean Height of LLCP (mm) among Different Populations

Study population	Mean height of LLCP (mm)
Ohio, USA [4]	2.5 ± 1.5
Italian [13]	5.9 (range of 1.3-17mm)
Malaysian [14]	2.64
Turkish [9,15]	4.92 ± 1.70, 6.1 ± 2.3 (range 1 - 15 mm)
Philippine [16]	2.21 ± 1.59 mm (range 0 to 10 mm)
Indian [17]	2.57
Present study	3.77 mm ± 1.66 (range 1.53 to 8.55mm)

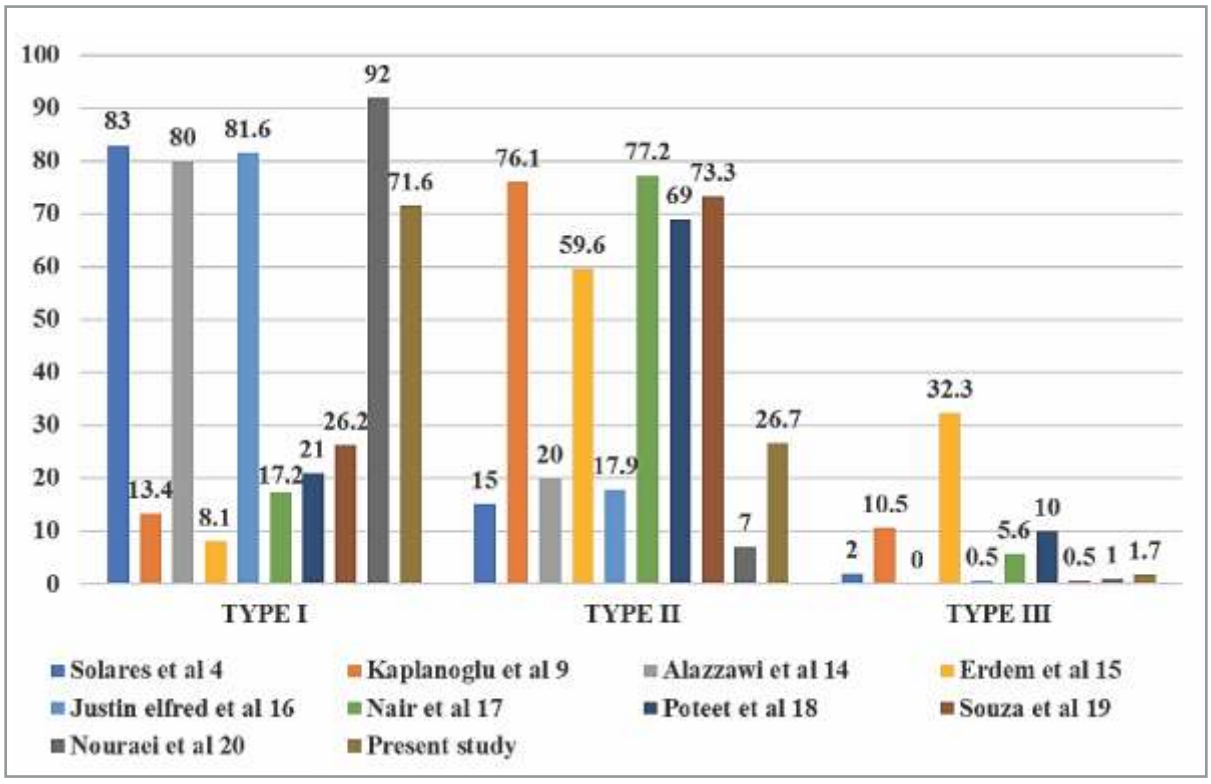

Chart 1: Showing Comparison of Incidence of Types of Keros Classification (in Percentage)

postulated to be ethnic difference and hormonal factors [4, 9, 13, 14-17, 22]. However, another study reported no such asymmetry in height of LLCP between both sides in an individual [16] which is similar to the finding of present study.

The statistically significant mean difference between LERP and MERP in anterior and posterior planes without side to side variation observed in this study indicates the symmetrical sloping ethmoid roof contour from lateral to medial and the slope was steeper in anterior plane as compared to posterior plane (Figs. 3 and 4). Two studies documented on contouring of EBS. When one of the studies found lateromedial slope contouring in 94% cases studied, the other observed as flattening of ESB contouring in 48% cases studied [4, 21].

This study attributes the variations in the height of LLCP and the slope of ethmoidal roof as causes for diverse configuration of ASB. These measurements and the data reported might act as anatomico- radiological guide map for the surgeons before or during endoscopic surgeries performed in anterior skull base or FESS on paranasal air sinuses.

Conclusion:

The preoperative knowledge about the height and configuration of lateral lamella of cribriform plate as well as the contour of ethmoid roof are vital during endonasal ethmoidal surgeries, so as to avoid iatrogenic injury to the ethmoidal skull base. We conclude that Keros type I was the most common type in our study population, pointing towards less chances of injury to lateral lamella during endoscopic surgeries. But, even though the other two types are less common the surgeon should acknowledge them as they have a major impact on the outcome of surgeries and their complications. We also conclude that the slope of anterior ethmoid roof is steeper as compared to posterior which can make surgeries relatively safer in anterior plane than in posterior.

Limitations:

1. More sample size can increase the statistical power of data.
2. The side to side variation between ABS might show significance with increased sample size.

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