

Original Article

Morphometry and Sexual Dimorphism of Olfactory Fossa in Relation To Crista Galli in North Karnataka Region – A Multidetector Computed Tomographic Study

Anandagouda V Naikanur¹, Balappa M Bannur², Sanjeev I Kolagi³, Naseema Begum⁴

¹Ph.D Scholar ²Professor, Department of Anatomy, Shri B M Patil Medical College, Vijayapura, ³Professor and Head, ⁴Associate Professor, Department of Anatomy, S Nijalingappa Medical College, Bagalkot

Abstract

Background: The aim of this study was to establish the morphometry and sexual dimorphism of olfactory fossa and its correlation with the types of crista galli in North Karnataka region.

Method: Two hundred and twenty Multidetector computed tomographic (MDCT) scans were collected from North Karnataka region and analyzed by using RadiAnt DICOM Viewer. The depth and width of olfactory fossa, their side symmetry, types of crista galli and correlation between the depth of olfactory fossa with types of base of crista galli were calculated in both genders. Statistical analysis was done by using Student unpaired 't' test.

Conclusion: Keros type II of olfactory fossa was most common in the present study. There was significant difference ($p < 0.05$) in olfactory fossa depth when compared between right (mean=4.64mm) and left sides (mean=4.07mm) in females. There was no statistically significant difference found between the gender and the sides of depth and width of olfactory fossa. There was no statistically significant correlation found between the types of olfactory fossa and types of crista galli. The morphometry of olfactory fossa and crista galli would help neurosurgeons to assess these vulnerable regions of ethmoidal skull base in surgeries.

Key-words: *Cribriiform plate, Crista galli, Keros classification, Olfactory fossa.*

Introduction

The Ethmoid bone lies in the anterior cranial fossa at the base of the cranial cavity. The cribriform plate, median perpendicular plate and two lateral labyrinths are the parts of the ethmoid bone. The orbital plate of the frontal bone and its roof joins with lateral lamellae of the cribriform plate (LLCP).^[1]

The olfactory fossa is a depression in the anterior cranial fossa whose floor is formed by the cribriform plate. It is the most vulnerable site in the whole anterior skull base. It is medially bounded by crista galli and laterally by lateral lamella of the cribriform plate.^[2] The depth of the olfactory fossa is determined by the height of the LLCP which is the thinnest area of the ethmoidal skull base. Thin LLCP and low ethmoidal skull base are the potential sites of injuries during endoscopic sinus surgeries.^[3] Keros has classified the depth of olfactory fossa into three types. Type I (1 to 3 mm), type II (4 to 7mm) and type III (8 to 16 mm).^[4]

Corresponding Author:

Dr. Sanjeev I Kolagi

MBBS, DLO, MD (Anatomy),

Professor and Head, Department of Anatomy,

S. Nijalingappa Medical College,

Bagalkot, Karnataka- 587102, India.

E-mail: sanjeevkolagi@gmail.com

Phone no: 9731798355.

Keros has also described the width and depth of olfactory fossa at different points and noted that type III Olfactory fossa exposes thin LLCP to injuries during

surgeries.^[2]

The width of olfactory fossa increases evenly from rostral to the occipital end. Measured below the wing of crista galli, the mean width is 3.8 mm on right side and 3.6 mm on left side. In the posterior one third, it is 5.2 mm on the right side and 5.1 mm on the left side at the rostral end.^[5]

The Crista galli (CG) is a triangular median process projecting upwards from the centre of the cribriform plate. It has a thin and slightly curved posterior border and a much thicker and shorter anterior border. It is a compact bone, but can also be pneumatized in some individuals.^[6] Thicker the crista galli, smaller the volume of olfactory fossa. Hajjiannou has classified the base position of crista galli into 3 types,

Type I= the base of the crista galli is located at the level of the cribriform plate.

Type II= less than 50% of the height of the crista galli is located below the level of the cribriform plate.

Type III= more than 50% of the height of the crista galli is located below the level of the cribriform plate.^[7]

Aim

The aim of this study was to establish the morphometry and sexual dimorphism of olfactory fossa and its correlation with the types of crista galli in North Karnataka region.

Objectives

a) To determine the gender differences in depth and width of olfactory fossa on both the sides.

b) To determine the dimensions of pneumatization of crista galli and Hajjiannou types of crista galli in both the genders.

c) To determine the correlation between olfactory fossa depth and Hajjiannou's classification of base of crista galli in both the genders.

Materials and Method

A prospective hospital based radiological study was done on two hundred and twenty Multidetector Computed Tomographic (MDCT) scans of the patients of all the districts of North Karnataka region of Karnataka state, India, after institutional ethics committee clearance. The study was carried out from April 2018 to September 2019.

Normal Paranasal MDCT scans of patients above the age of 16 years belonging to both genders were included in the study.

MDCT scans of Patients below the age of 16 years and MDCT scans of patients with nasal or paranasal trauma, congenital abnormalities of face, tumours or conditions involving bone destruction and surgeries were excluded from the study. While taking the MDCT of paranasal sinuses, patients were informed and instructed about the procedure before obtaining informed written consent. Axial MDCT images of 3mm thickness were taken from CT scanner (Siemens Somatom) by using bone window.

Direct coronal scan showing the maximum depth of the olfactory fossa at the centre of infraorbital foramen was taken as reference point. Depth of the olfactory fossa was determined by the length of the lateral lamella of cribriform plate (CP). The height of CP point was subtracted from the height of medial ethmoidal roof point (MERP) to measure the length of the LLCP on both sides in both genders. Figure 1 shows Line A which represents a direct horizontal line connecting the middle of the inferior orbital foramina on both sides. Line B represents direct vertical line connecting line A and to the site of communication of fovea ethmoidalis and the lateral lamella of the cribriform plate of the ethmoid bone (LLCP). Line C was drawn as a direct vertical line connecting line A to the most lateral bony boundary of the cribriform plate of the ethmoid bone at its communication with the lateral lamella which will be CP height. The height of the ethmoid roof (h) was considered as the depth of the olfactory fossa. "h" was calculated as the result of subtraction of length of line C

(“c”) from the length of line B (“b”) in millimeters ($h = b - c$). “h” will be representing the direct vertical height of the lateral lamella of the cribriform plate of the ethmoid bone.

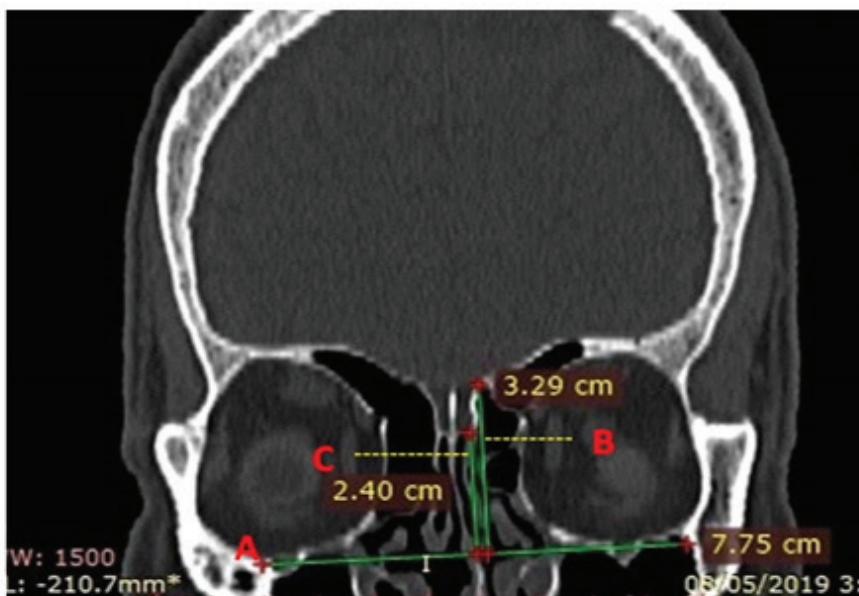


FIGURE 1: Showing coronal section of Multidetector computed tomographic scan of the patient at the level of infraorbital foramen.

A(77.5mm) -Line joining two infraorbital foramen,

B (32.9mm) -Line joining medial ethmoidal roof point to line A and

C (24mm) -Line joining cribriform plate to line A.

Olfactory fossa depth was classified according to Keros classification i.e, type I (0 to 3 mm), type II (4 to 7 mm), type III (8 to 16 mm) on both sides in males and females. The side symmetry of the types of depth of olfactory fossa was then compared in both genders as shown in figure 2.

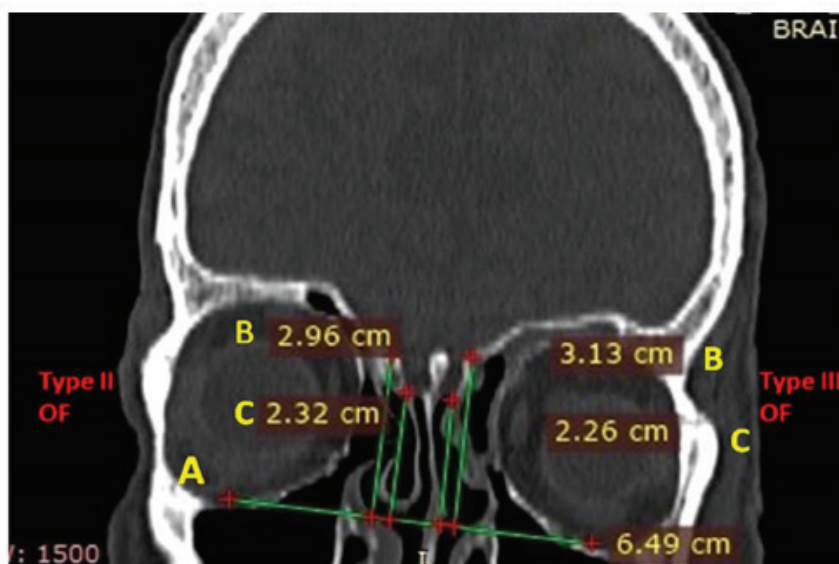


FIGURE 2: Types of depth of olfactory fossa in coronal section of MDCT scan on both the sides in the present study.

- A- Line joining two infraorbital foramen,
- B- Line joining medial ethmoidal roof point to line A and
- C- line joining cribriform plate to line A.

The width of the olfactory fossa was measured from fovea ethmoidalis (fe) to the lateral margin of the crista galli at the level of centre of infraorbital foramina as shown in figure 3.

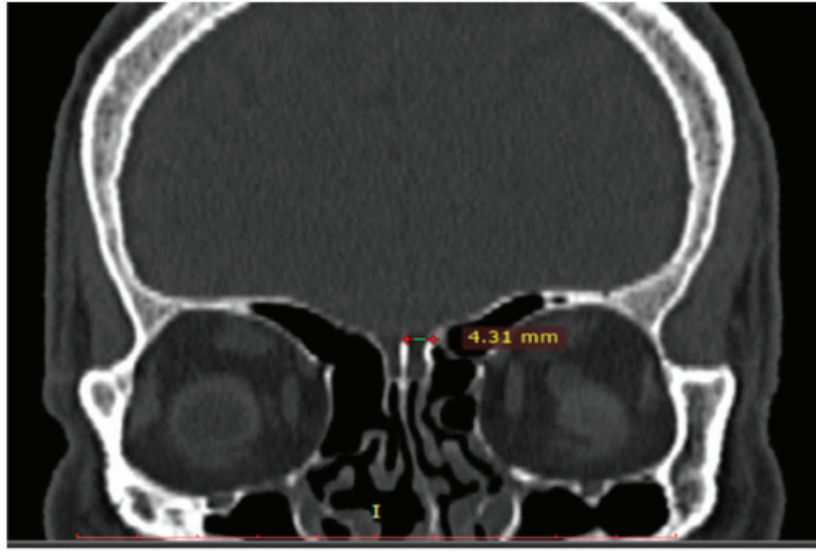


FIGURE 3: Measurement of width of left olfactory fossa in coronal section of MDCT scan of the patient.

The dimensions of the pneumatization of crista galli like anteroposterior and lateral to lateral diameter and types of base of crista galli according to Hajjioannous's classification (figure 4 & 5) were noted in both coronal and sagittal section of MDCT scans.



FIGURE 4: Sagittal section of MDCT scan of the patient with type I crista galli.

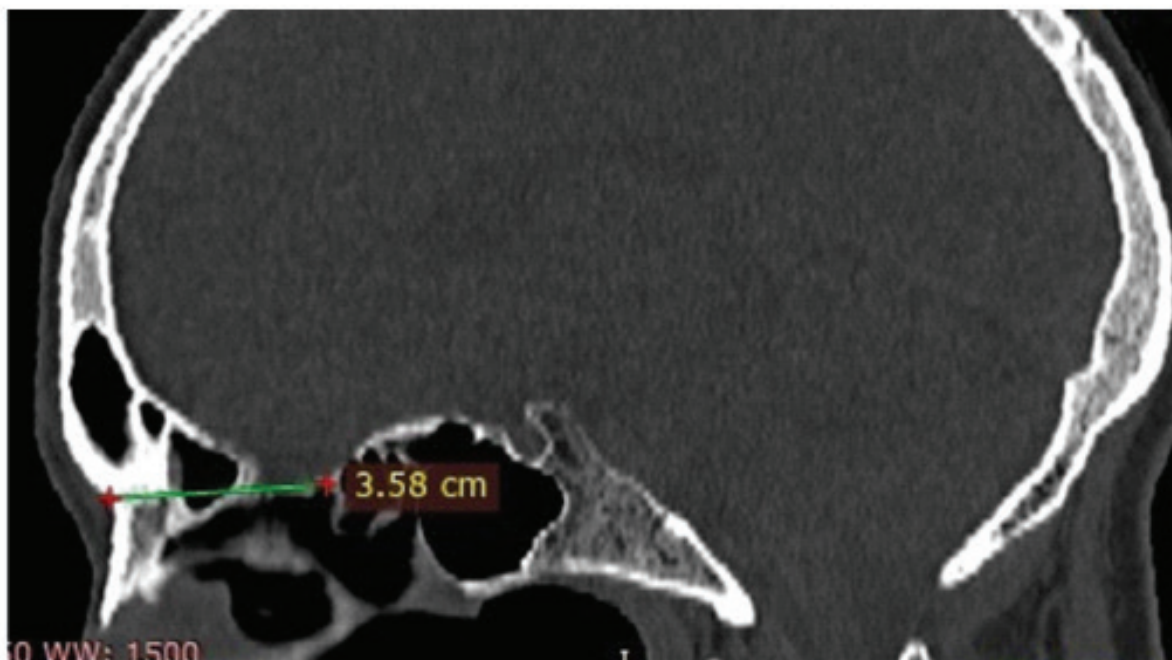


FIGURE 5: Sagittal section of MDCT scan of the patient with type II crista galli.

Results and Discussion

With regard to less data available in North Karnataka region, the present study was carried out to find out any correlation between the Keros types of olfactory fossa and types of crista galli.

Comparison of the mean±SD of MERP, CP, depth of OF, and width of OF, and their significance in the present study on both sides in both genders is shown in table 1,2 and 3.

Table 1: Comparison of MERP, Cribriform plate (CP), depth of OF, and width of OF and their significance on both sides in males in the present study.

Males n * =131	Right side Mean±SD†	Left side Mean±SD	P‡ value	Significance	95% CI§
MERP ht **	27.34±3.39	27.23±3.36	0.79	NS ††	-0.71-0.93
CP ht	22.4±3.12	22.79±3.02	0.3	NS	-1.13-0.35
OF depth	4.85±2.04	4.47±1.79	0.11	NS	-0.08-0.84
OF width	5.15±1.91	4.86±1.67	0.19	NS	-0.14-0.72

* (n)=number, † (SD)=standard deviation, ‡ (p)=significance, § (CI)=class interval, || (MERP)= medial ethmoidal roof point, ** (ht)=height and †† (NS)=not significant

Table 2: Comparison of MERP, Cribriform plate (CP), depth of OF and width of OF and their significance on both sides in females in the present study

Females n*=89	Right side Mean±SD†	Left side Mean±SD	P‡ value	Significance	95% CI§
MERP ht **	25.43±3.29	25.3±2.99	0.78	NS ††	-0.8-1.06
CP ht	20.83±3.14	21.28±2.78	0.31	NS	-1.32-0.42
OF depth	4.64±2.09	4.07±1.77	0.05	S ‡‡	0.002-1.14
OF width	5.16±1.6	4.84±1.43	0.16	NS	-0.13-0.77

* (n)=number, † (SD)=standard deviation, ‡ (p)=significance, § (CI)=class interval, || (MERP)= medial ethmoidal roof point, ** (ht)=height, †† (NS)=not significant and ‡‡ (S)= significant.

Table 3: Comparison of MERP, Cribriform plate (CP), depth of OF and width of OF and their significance on both sides in males and females in the present study

n*=220	Males (n=131) Mean±SD†	Females (n=89) Mean±SD	P‡value	Significance	95% CI§
MERP ht **	27.34±3.39	25.43±3.29	0.000	S ††	1.009-2.824
	27.23±3.36	25.3±2.99	0.000	S	1.054-2.797
CP ht	22.4± 3.12	20.83±3.14	0.000	S	0.725-2.42
	22.79±3.02	21.28±2.78	0.000	NS‡‡	0.72-2.3
OF depth	4.85±2.04	4.64±2.09	0.46	NS	-0.35-0.76
	4.47±1.79	4.07±1.77	0.09	NS	-0.07-0.88
OF width	5.15±1.91	5.16±1.6	0.96	NS	0.49-0.47
	4.86±1.67	4.84±1.43	0.92	NS	-0.4-0.44

* (n)=number, † (SD)=standard deviation, ‡ (p)=significance, § (CI)=class interval, ||(MERP)= medial ethmoidal roof point, ** (ht)=height, †† (S)= significant and ‡‡ (NS)=not significant

Among 220 MDCT scans, the mean MERP height was 26.57mm on the right side and 26.45mm on the left side. The cribriform plate height was 21.77mm on the right side and 21.28mm on the left side. The depth of the olfactory fossa was 4.76mm on the right side and 4.31 mm on the left side. The width of the olfactory fossa was 5.15mm on the right side and 4.85 mm on the left side.

Among 131 males, keros type I OF was found in 25 cases (19.08%) on the right side and 31 cases (23.66%) on the left side. Keros type II OF was found in 86 cases (65.64%) on the right side and 91 cases (69.46%) on the left side. Keros type III OF was found in 20 cases (15.26%) on the right side and 9 cases (6.87%) on the left side.

Among 89 females, keros type I OF was found in 23 cases (25.84%) on the right side and 31 cases (34.83%) on the left side. Keros type II OF was found in 54 cases (60.67%) on the right side and 51cases (57.3%) on the left side. Keros type III OF was found in 12 cases (13.48%) on the right side and 7 cases (7.86%) on the left side.

Keros type II of olfactory fossa was most common in the present study. There was significant difference ($p < 0.05$) in olfactory fossa depth when compared between right (mean=4.64mm) and left sides (mean=4.07mm) in

females. There was no statistically significant difference found between the gender and the sides of depth and width of olfactory fossa.

In the present study, symmetry of Olfactory Fossa depth was found in 94 cases (71.75%) in male patients and 54 cases (60.67%) in female patients. Asymmetry of Olfactory Fossa depth was found in 37 cases (28.24%) in male patients and 35 cases (39.32%) in female patients. There was no statistically significant difference found in the symmetry and asymmetry of olfactory fossa depth between the genders in the present study.

In the present study, type I Crista galli was found in 84 cases (64.12%) in male patients and 57 cases (64.02%) in female patients. Type II Crista galli was found in 47 cases (35.87%) in male patients and 32 cases (35.95%) in female patients. Type III Crista galli was not found in male and female patients. There was no statistically significant difference found between types of crista galli between the genders in the present study.

There was no correlation between the keros types of olfactory fossa and types of crista galli in the present study. Comparison of cases of keros type of olfactory fossa present in all types of crista galli in the present study on right side and left side in males and females is shown in chart 1 and chart 2 respectively.

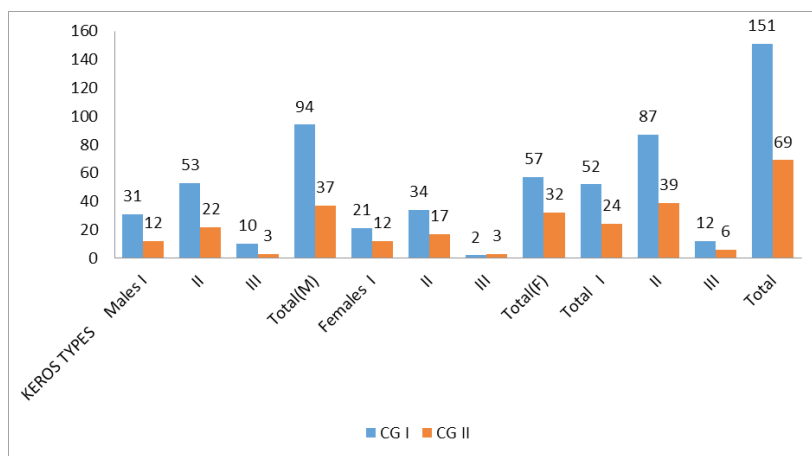


CHART 1 - Percentage of cases of keros types of olfactory fossa present in various types of crista galli in both genders on right side in the present study.

x axis = keros types I,II and III

Y axis= number of cases of Keros types I,II and III of OF in seen in CG types I,II and III

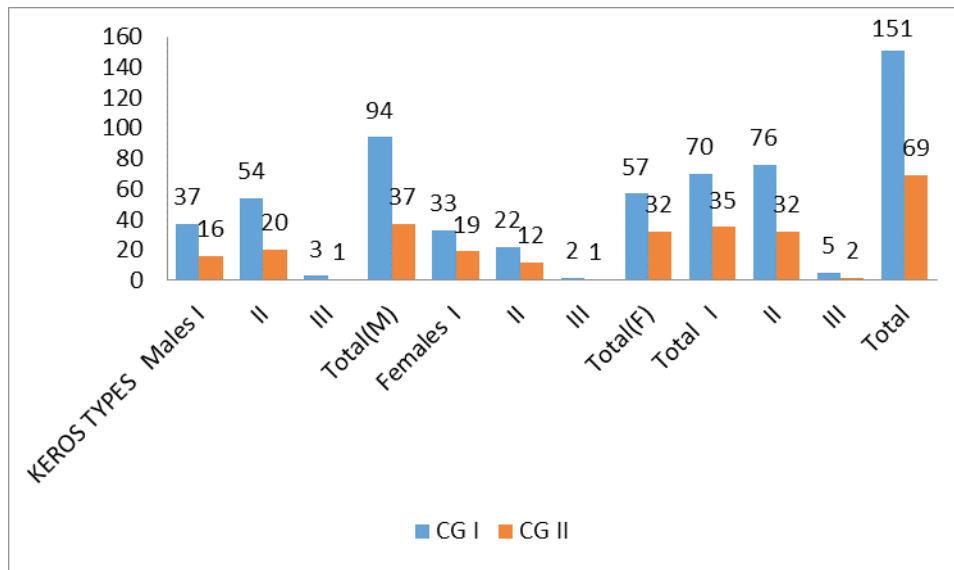


CHART 2 - Percentage of cases of keros types of olfactory fossa present in various types of crista galli in both genders on left side in the present study.

x axis = keros types I,II and III

Y axis= number of cases of Keros types I,II and III of OF in seen in CG types I,II and III.

There was statistically significant difference in olfactory fossa depth when compared between right and left sides in females as shown in table no 2 and chart 3. In males, there was no such difference as shown in table 1. Keros type II olfactory fossa was predominant (64%) among the cases and keros type III olfactory fossa was rare (10%) in the present study as shown in table no.4.

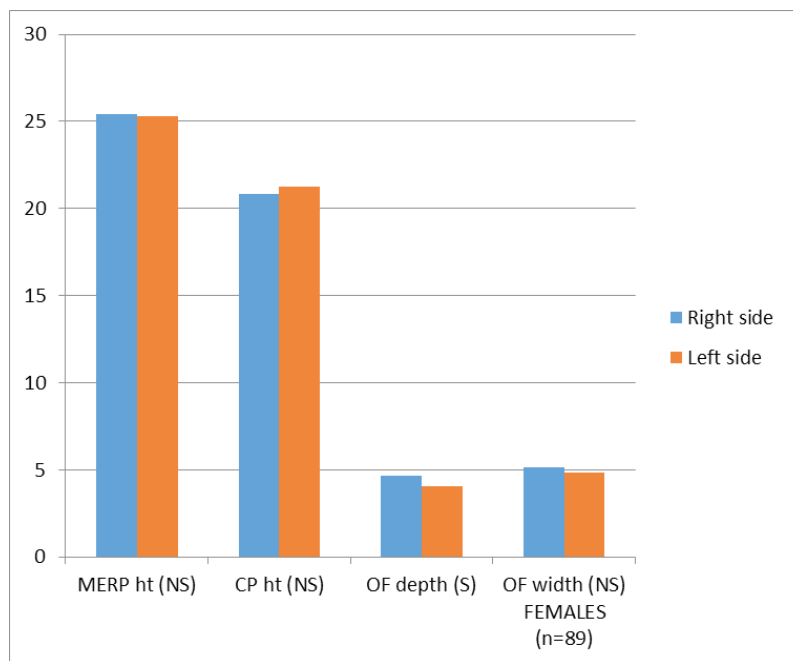


CHART 3- Comparison of MERP, CP, depth of OF and width of OF and their significance on both sides in females in the present study

n=number, CP= cribriform plate, MERP= medial ethmoidal roof point, NS=not significant and S= significant.

x axis=MERP,CP,OF

Y axis= number of cases

Comparison of keros types of depth of olfactory fossa in the present study and in various studies is shown in table 4.

Table 4: Keros classification of Olfactory fossa among different studies.

Author	Country	Keros I (%)	Keros II (%)	Keros III (%)
Present study	India	24.99	64.08	10.00
Original keros 4	Germany	26.3	73.3	0.5
Shama AM 2	Egypt	56.5	40.5	3.0
Kalpanoglu et al 8	Turkey	13.4	76.1	10.5
Solares et al 9	USA	83.1	15.0	2.0
Souza et al 10	Brazil	26.3	73.3	0.5
Paber et al 11	Philippine	81.08	17.7	0.5
Bista et al 4	Nepal	86.0	12.0	2.0

Among 220 patients, the mean width of the olfactory fossa was 5.15 mm on right side and 4.85mm on left side in the present study. There was no significant difference in the width of olfactory fossa between the sides in the present study. The study done by Daniel h. Coelho et al revealed that the mean width of OF was 4.57mm on the right side and 4.49mm on the left side by Digital photography.^[12]

In the present study, type I crista galli was found in 64.07% of cases, type II CG was found in 35.91% of cases and type III CG was not found. In the study done by Hajjiioannou, type I crista galli was found in 28.3% of cases, type II CG was found in 63.6% of cases and type III CG was found in 8.1% of cases.

In the present study, the width, height and length of pneumatized Crista galli was 3.95mm, 9.3mm and 7.02mm respectively. In the study done by Gorazd Poje,^[7] the width and length of pneumatized Crista galli was 5.1mm and 8.75mm respectively. In the study done by Ranko Mladina,^[6] the width, height and length of pneumatized Crista galli was 3.75mm, 10.35mm and 7.8mm respectively.

Strengths and limitations of the study:

With regard to less data available in North Karnataka region, this study will help neurosurgeons and endoscopic surgeons to assess olfactory fossa during various skull base and endoscopic sinus surgeries.

This study was carried out only in North Karnataka region and there were limited number of patients during the study period. Only adult patients were included in this study.

Conclusion

The dangerous keros type III olfactory fossa was rare in the present study when compared to the most common keros type II olfactory fossa. There was statistically significant difference in olfactory fossa depth when compared between right and left sides in females. In males, there was no such difference. The width of olfactory fossa was not significant when compared between two sides in males and females. There was no statistically significant correlation found between the keros types of olfactory fossa and types of crista galli. The knowledge regarding the keros types of

depth of olfactory fossa, width of olfactory fossa and types of crista galli will help the neurosurgeons to assess these vulnerable regions of ethmoidal skull base that are difficult to access during skull base surgeries.

Ethical Clearance - It was taken from Bde (deemed to be university) Shri B M Patil medical college, hospital and research centre, Vijayapura, Institutional ethical committee and SNMC-Institutional ethics committee on human Subjects research, Bagalkot.

Source of Funding - Self

Conflict of Interest - Nil

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