RADIOLOGICAL ANALYSIS OF OLFACTORY FOSSA DEPTH: A TERTIARY CARE HOSPITAL BASED STUDY

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ABSTRACT

Introduction

Computed tomogram (CT) of nose and paranasal sinuses provides the detailed knowledge of depth of olfactory fossa as per Keros' classification, which is important in endoscopic sinus surgery.

Objective

To analyze the types and frequency of depth of olfactory fossa in Nepalese population.

Methodology

This was a longitudinal study conducted from 1st May to 30th August 2018. Coronal CT scans of nose and paranasal sinuses were taken for analysis of olfactory fossa depth. The landmarks like infraorbital foramen, point of articulation of medial ethmoidal roof with lateral lamella of cribriform plate (MERP) and lowest point on the cribriform plate (CP) were taken. The lateral lamella of cribriform plate (LLCP) was calculated by subtracting CP height from MERP height (MERP-CP = LLCP).

Results

There were total 101 patients included. The distribution of age was 33.72 ± 15.15 years. The keros' type I was the most common (86.1%). Regarding the olfactory fossa depth, right side was deeper in male whereas in females, the left side was deeper, but overall right side was deeper in 52(51.5%) patients.

Conclusions

Type I Keros' was the most common whereas type III Keros' was the least common. A deep olfactory fossa is more common on right.

KEYWORDS

Cribriform plate, ethmoidal roof, lateral lamella of cribriform plate, olfactory fossa depth

INTRODUCTION

For the endoscopic sinus surgery the detailed anatomical knowledge of nose and paranasal sinus is important. The knowledge is mainly gained by the computed tomogram of nose and paranasal sinuses. Though there are several other important surgical landmarks, the landmark of olfactory fossa is very important during sinus surgeries to avoid iatrogenic injury to anterior skull base.

The olfactory fossa is occupied by the olfactory nerve and bulb. It lies in the most infero-medial portion of the anterior cranial fossa. The crista galli forms the longitudinal limb above the horizontal limb and the perpendicular plate lies below it.[1]

The fovea ethmoidalis (FE) is the major part in formation of the roof of the ethmoid bony labyrinth that separates the ethmoidal air cells from the anterior cranial fossa. It articulates medially with the lateral lamella of the cribriform plate (LLCP). The shape of the fovea is determined by the joining angle between FE and LLCP.[2]

The LLCP is the thinnest bone, so it is the most vulnerable site for iatrogenic injury during functional endoscopic sinus surgery (FESS).[3-6]

In 1962, Keros' had described the different heights of the horizontal level of the cribriform plate. As per Keros' classification, there are 3 types of olfactory fossa depth depending on the length of the LLCP. This thin (mainly vertical) plate of bone is connecting the lateral wall of cribriform plate with fovea ethmoidalis.[7]

The three types of olfactory fossa are: Type I is 1-3 mm deep in which the lateral lamella is short, and the ethmoid roof and cribriform plate are almost in the same plane. Type II (most common) is 4 to 7 mm deep, and the lateral lamella is longer. In type III, it is 8-16 mm deep, and the ethmoid roof lies significantly above the cribriform plate. According to Keros, the more the height of LLCP, the greater the risk of iatrogenic injury during endoscopic sinus surgery.[7] Therefore, the type III is at risk during endoscopic sinus surgery for iatrogenic injury.

Since, there are not many studies done in Nepal regarding olfactory fossa depth, this study explores the variations of olfactory fossa depth which will help during endoscopic sinus surgery. So, the main aim our study is to analyze the types and frequency of olfactory fossa depth.

METHODOLOGY

This was a prospective, longitudinal study conducted in the department of Otorhinolaryngology and Head and Neck surgery, Dhulikhel Hospital, Kathmandu University from 1st May 2018 to 30th August 2018. The ethical approval was taken from institutional review committee.

All patients >/=18 years of age who underwent CT Scans of the nose and paranasal sinuses were included in the study whereas patients with previous sinus surgery, age <18 years, maxillofacial trauma, sinonasal malignancy, congenital anomaly and CT images of low resolution were excluded.

The one hundred one consecutive patients who underwent CT scan of nose and paranasal sinuses and fitted in the inclusion criteria were taken for the study.

CT scans were performed in 128 slice Siemens somatom perspective machine. Patient was positioned in supine position and using the parameters-130 kV, 145 mAs, and scan time of 3.5 seconds, a volumetric axial CT scan was taken with 3 mm slices thickness from the frontal sinus to the floor of maxillary sinus. Multiplanar reconstruction was done using 1 mm thin slices with 0.5 mm interval and images were obtained in all planes. For the depth of olfactory fossa calculation, coronal images were used. All the observations were performed by one person to avoid observer bias.

The positions of cribriform plate and ethmoidal roof were calculated relative to orbital floor as shown by the infraorbital foramen (a plane passing through the two foramina was used (IOP)). Two reference points were chosen at the skull base. They were: point of articulation of medial ethmoidal roof with lateral lamella of cribriform plate (MERP) and lowest point on the cribriform plate (CP) as shown in figure 1.

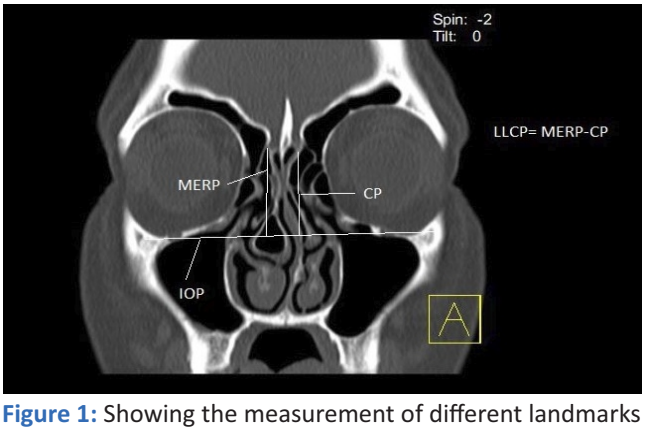

Figure 1: Showing the measurement of different landmarks in CT Scan.

Vertical height from MERP (MERP height) and vertical height from CP (CP height) to the horizontal plane through infraorbital foramen were measured on each side (IOP). The LLCP was calculated by subtracting CP height from MERP height (MERP-CP = LLCP).[8] The LLCP was classified according to Keros classification but with modification. In type I we included 0-3.99mm, in type II 4-7mm and in type III >7mm as there was deficit of 1 mm in type I to type II and type II to type III. The LLCP was compared on both sides in males and females.

For the statistical analysis, statistical package for social sciences version 23 (SPSS) was used. The frequency table was used to evaluate the different variables using the descriptive statistical methods (mean, standard deviation and percentage).

RESULTS

There were total 101 patients included in the study. The distribution of age was 33.72+/-15.15 years. Regarding the gender, there were 51 males and 50 females.

The Keros' variation type I was the most common in both right and left side as shown in table 1.

Table 1. Showing the Keros' variation.

Side	Type I	Type II	Type III
Right (n=101)	88(87.1%)	12(11.9%)	1(1%)
Left (n=101)	86(85.1%)	15(14.9%)	0(0%)
Total (n=202)	174(86.1%)	27(13.4%)	1(0.5%)

Regarding the gender distribution of Keros' variation, Type I was the commonest in both sides and both genders as shown in Table 2.

Table 2. Showing the gender related Keros' variation in right and left side.

	Side							
	Right				Left			
Gender	Type I	Type II	Type III	Total	Type I	Type II	Type III	Total
Male	42(41.7%)	8(7.9%)	1(0.9%)	51(50.5%)	45(44.6%)	6(5.9%)	0(0%)	51(50.5%)
Female	46(45.5%)	4(3.96%)	0(0%)	50(49.5%)	41(40.6%)	9(8.9%)	0(0%)	50(49.5%)

Regarding the depth of the olfactory fossa, right side was deeper in males whereas the left side was deeper in females, but overall right side was deeper 52(51.5%) as shown in table 3.

Table 3: Showing the depth of olfactory fossa in both gender.

Gender	Deeper right olfactory fossa deep	Deeper left olfactory fossa	Bilateral symmetrical
Male (n=51)	29(56.9%)	21(41.2%)	1(1.9%)
Female (n=50)	23(46%)	26(52%)	1(2%)
Total (n=101)	52(51.5%)	47(46.6%)	2(1.9%)

The height of the LLCP on right side was 3.331+/-5.010mm whereas on left side it was 2.845+/-1.084mm.

The figure 2 and 3 show the different variations of Keros' classification.

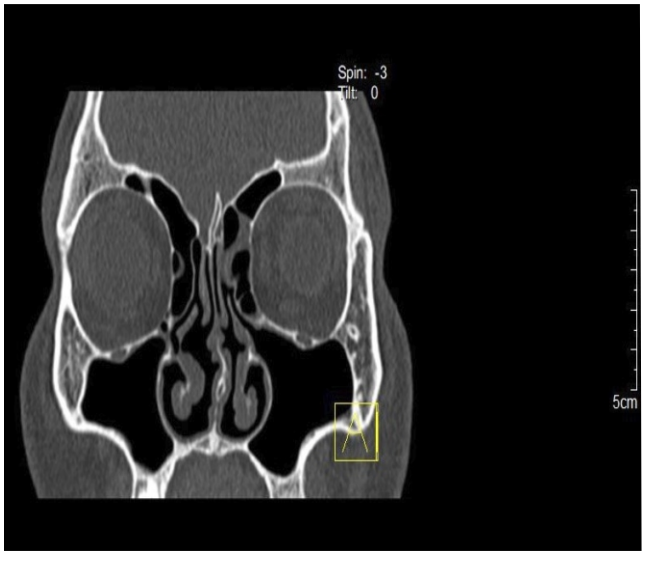

Figure 2 : Showing the Keros' variation I (left side) and II (right side)

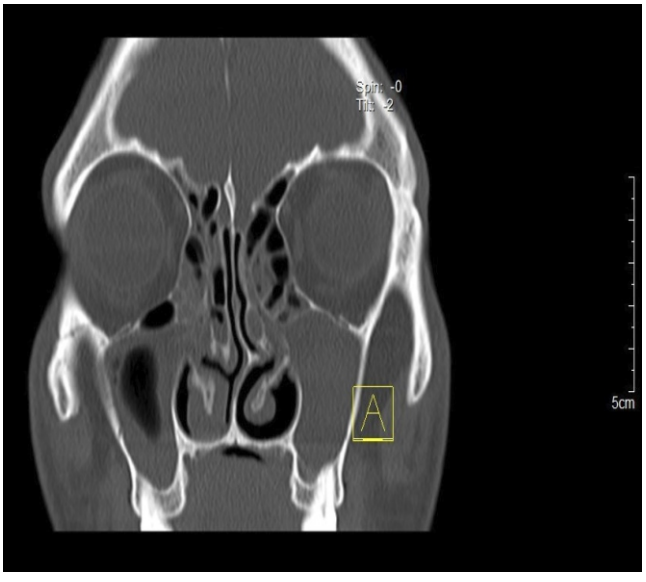

Figure 3: Showing the Keros' variation III (left side)

Table 4: Showing the variations of Keros' types in different studies.

Authors	Country	Keros' Type I (%)	Keros' Type II (%)	Keros'Type III(%)
Shama et al (1)	Egypt	56.5	40.5	3.0
Souza et al (2)	Brazil	26.3	73.3	0.5
Paber et al (4)	Philippine	81.8	17.7	0.5
Solares et al (5)	USA	83.0	15.0	2.0
Keros P (6)	Germany	26.3	73.3	0.5
Rathnakar et al (8)	India	28.0	70.5	1.5
Athamneh et al(10)	Jordan	70.5	22.0	7.5
Murthy et al (12)	India	19.5	71.5	9.0
Kaplanoglu et al (13)	Turkey	13.4	76.1	10.5
Sahin et al (14)	Turkey	10.0	61.0	29.0
Erdem et al (15)	Turkey	8.1	59.6	32.3
Bista et al (16)	Nepal	86.0	12.0	2.0
Elwany et al (17)	Egypt	42.5	56.8	0.7
Alazzawi et al (18)	Malaysia	80.0	20.0	0
Nitinavakarn et al (19)	Thailand	11.9	68.8	19.3
Ali et al (20)	India	20.0	78.7	1.3
Jang et al (21)	Korea	30.5	69.5	0
Adeel et al (9)	Pakistan	29.9	49.4	20.8
Erdogan et al (22)	Turkey	10.0	67.72	22.28
Our study	Nepal	86.1	13.4	0.5

DISCUSSION

The endoscopic sinus surgery is done mainly to remove the disease within the sinus and improve the ventilation.[9] This procedure is widely accepted for clearing the disease. The risk of iatrogenic injury to skull base area during surgery is always there and the most vulnerable area is LLCP, as it is the thinnest bone.[10] So, it is important to look for the LLCP and olfactory fossa depth by CT imaging of nose and paranasal sinuses. Coronal CT scan is the best to visualize the olfactory fossa depth. We have performed our study as per the variations formulated by Keros' on 1962.[6]

As per Keros' study in 450 skulls, type I has a depth of 1-3mm and is seen in 12% patients, type II has a depth of 4-7mm and is seen in 70% patients, whereas type III has a depth of 8-16mm and is seen in 18% patients.[6]

Our study showed that Keros' type I was the most common whereas type III was the least common with 86.1% patients falling in type I and only 0.5% in type III. So, it is somehow safe from the surgeon's point of view to do surgery in Keros' type I population. The distribution of Keros' variation in different studies in the literature and comparison with our study is shown in table 4. We have found 19 studies of Keros' variation in different countries and most of them had type II as the commonest variation (13 out of 19 studies) whereas 6 out of 19 studies had type I as the commonest variation as in our study. So, there is marked variation in Keros' types in the literature.

Regarding the gender distribution, in male and female both type I was more common both in right and left, whereas type III was only seen in right side in male. The reason behind large group falling under type I in our study could be because of taking up to 3.99mm in type I unlike up to 3mm in original Keros' classification and another may be because of developmental anatomical variation within the population and also due to difference in the extent of pneumatisation of the ethmoidal labyrinth and frontal sinus.[11]

Our study showed that the height of LLCP on right side was 3.331+/-5.010mm, whereas on left side, it was 2.845+/-1.084mm.This differs from other studies as most of the studies had LLCP of >4mm.[10,12-22] The difference in height could be because of variation in ethmoidal roof configuration between different population and another reason might be use of different measurement methods. In our study we had taken the infraorbital foramen as a reference point. Different literature has suggested this reference point as of relevant anatomic value during endoscopic middle meatal antrostomy as it helps in telling about the position of the ethmoidal roof.[14]

Our study also showed that the depth of the olfactory fossa was more on right in males whereas in females it was more on left side. We could not find any reason for it. However the possible explanation could be hormonal factors in development of craniofacial asymmetry. The literature has also shown variation in depth of olfactory fossa either on left or right with no consistency.[8,17,23-25]

But the overall depth of olfactory fossa was more on the right side (51.5%) in our study. The significance of our results showed that skull base injury with cerebrospinal fluid leaks occur more frequently when endoscopic sinus surgery is perform on right side as mentioned in literature.[23,26] So, we have to be very careful while performing surgery on right side.

In our study the type I Keros' variation was the most common. Therefore it is safer for the surgeon to perform endoscopic sinus surgery in type I population like ours as the iatrogenic risk of skull base injury is minimal.

CONCLUSION

1. The study on variation of Keros' classification is mainly to avoid injury in ethmoidal roof during sinus surgery.
2. In our study, type I is the most common Keros' type prevalent and the least prevalent is the type III.
3. A deep olfactory fossa is more common on right as compared to left in our population.
4. Careful and precise assessment of CT nose and PNS is a must prior to sinus surgery in order to avoid serious iatrogenic injury.

RECOMMENDATION

The type I Keros' variation is the most common and a deep olfactory fossa is more common on right as compared to left. However this study is single institutional, so we recommend the multi-institutional study in the different regions of Nepal which will give better idea regarding the distribution of Keros' variation of olfactory fossa.

LIMITATION OF THE STUDY

The main limitation of the study is sample size and short duration of study.

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None

CONFLICT OF INTEREST

None.

FINANCIAL DISCLOSURE

None.

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