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The Relationship between Ethmoid Roof, Cribriform Plate Dimensions and Degree of Septal Deviation Angle

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ABSTRACT

Background: endoscopic sinus surgery (ESS) is a common operation for the management of sinonasal pathologies, the surgeons dealing with endoscopic sinus surgery should understand the crucial complex anatomy of the anterior cranial base to avoid the intracranial violation during ESS.

Objective: the aim of this work is to investigate the relationship between degree of septal deviation angle and the dimensions of cribriform plate and ethmoid roof by radiological paranasal CT evaluation.

Patients and methods: forty patients, 20 females and 20 males, were selectively collected according to inclusion and exclusion criteria from the out-patient E.N.T clinics of El-Hussein and Bab-El-She'reya Hospitals from November 2017 to January 2019 with their age ranged from 18 – 60 years old.

Results: the severity of deviation didn't have impact on the dimensions of the ethmoid roof and cribriform plate in terms of depth and width except right ethmoid roof width (direct proportion) and the left cribriform width (inverse proportion). There was a significant direct relationship between ipsilateral and contralateral ER width and between ipsilateral and contralateral ER depth. This study showed no significant relation between ipsilateral and contralateral CP width. High rate of asymmetry between CP and ethmoid roof in our study (100 %) was noted.

Conclusion: in cases of deviated nasal septum, this study suggests that the increase in the severity of septum deviation rises the possibility of the increasing right ethmoid roof width and of decreasing the left cribriform width and this possibility should be taken into consideration to avoid iatrogenic injury during ESS.

Keywords: Ethmoid Roof, Cribriform Plate Dimensions, Degree of Septal Deviation Angle.

INTRODUCTION

Radiological evaluation of the ethmoid roof is important in preventing the endoscopic sinus surgery complications. Iatrogenic lesions of the anterior skull base can occur in the ethmoid roof and the cribriform plate **[1]**.

The relationship between cribriform plate (CP) dimensions (height or width) and other paranasal structures such as frontal sinus pneumatization, pneumatized middle turbinate, and nasal septum deviation was investigated by several researchers in the relevant literature **[2]**.

However, the relationship between septal deviation (SD) and CP dimensions has not been evaluated so far. Among studies, a study was done by **Saylisoy *et al.*** **[3]**. They observed that when septal deviation angle is increased, ipsilateral and contralateral CP width and depth is increased.

Understanding the complex anatomy of the paranasal sinuses is crucial to surgeons to avoid the intracranial violation during endoscopic sinus surgery (ESS) **[4]**.

Inadvertent violation of the cribriform plate (CP) or the ethmoid roof may result in an intracranial injury, cerebrospinal fluid rhinorrhea, and a consequent increased risk of developing meningitis **[5]**.

Between the two CPs there are two central vertically disposed midline processes of ethmoid bone the superior is the crista galli, and the inferior is the perpendicular plate that makes a substantial contribution to the nasal septum which divides the nasal cavity into two separate chambers **[2]**.

The septal deviation is defined as convexities of the nasal septum on one side with accompanying deformities of midline structures **[6]**.

The development and refinement of computerized tomography (CT) imaging has allowed detailed assessment of not only the sinonasal diseases, but also the characterization of the paranasal sinuses anatomy. It is important for the surgeon to look at the CT scan preoperatively to get an idea of the anatomy and to relate the changes revealed on the CT scan to the patient's clinical condition **[7]**.

AIM OF THE WORK

The aim of this work is to investigate the relationship between degree of septal deviation angle and the dimensions of cribriform plate and ethmoid roof by radiological paranasal computed tomography (CT) evaluation.

PATIENTS AND METHODS

This prospective study was carried out at the Otorhinolaryngology Department with assistance of the Radiology Department of Al-Azhar University Hospitals.

Forty patients, 20 females and 20 males, were selectively collected according to inclusion and exclusion criteria from the out-patient E.N.T Clinics of El-Hussein and Bab El-She'reya Hospitals from

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November 2017 to January 2019. Their age ranged from 18 – 60 years old.

Inclusion criteria as follows:

- Age: Patients were between 18 and 60 years old.
- Sex: Both genders (males and females) were included.
- Race and ethnicity: To overcome the racial and ethnic problem and its effect on the skull configurations, we confined our work to the adult Egyptian population.
- Nasal septum deviation with or without symptoms.
- Paranasal sinuses with intact olfactory fossa and ethmoid roof.

Exclusion criteria as follows:

- Patients younger than 18 years old and older than 60 years old.
- Previous sinus surgery, rhinoplasty or sleep apnea surgery.
- Septoplasty performed with concurrent sinus surgery, rhinoplasty or sleep apnea surgery.
- Prior rhinoplasty or turbinoplasty.
- Septal perforation.
- Craniofacial syndrome.
- Systemic diseases e.g. sarcoidosis and Wegener's granulomatosis.
- Pregnancy.
- Previous facial trauma.
- Marked facial deformity
- Sinonasal polyposis.
- Rhinosinusitis.
- CSF leak.
- Sinonasal tumor.
- Head and neck tumors.
- Radiation therapy to the head and neck.

Written informed consent:

An approval of the study was obtained from Al- Azhar University academic and ethical committee. Every patient signed an informed written consent for acceptance of the operation.

Procedure:

all patients were subjected to the following protocols:

1-Careful history taking from the patients: personal history, complaint and history of the present illness and past history.

2- Routine physical ear-nose-throat examination: Focusing on detailed nasal examination: Nasal examination including ear, larynx and oral cavity.

3. Radiological examination of the nose: Imaging CT scans of nasal and paranasal sinuses.

Methods:

All patients were evaluated by clinical examination, nasal endoscopy and CT imaging.

Nasal septum assessment by endoscopy:

0° and 30° 4 mm rigid nasal endoscopes were used to:

*Assess the anatomy in the neutral position and it also allows inspection of the elements that are not visible in anterior rhinoscopy; this at times can reveal adenoid tissue, mucosal abnormalities, nasal polyps or choanal pathology which can affect the study.

*Exclude inferior turbinate hypertrophy, presence of nasal secretions, and nasal mass such as polyp.

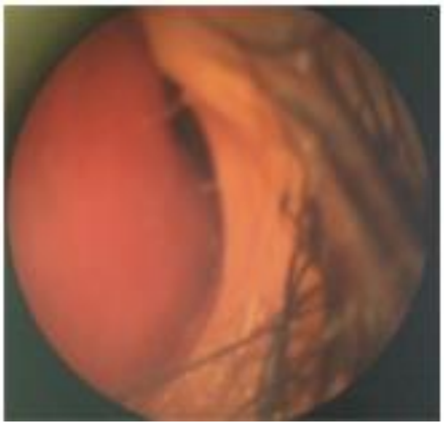


Figure (1): Endoscopic nasal examination shows septal deviation to Lt side.

- ***CT imaging :***

CT examinations were performed by Activion 16 CT Scanner (Toshiba Medical Systems, 2008 Japan) (kVp = 150, mAs = 150, slice thickness = 3 mm).

For more accurate measurement film workstations (Vitrea 5.2.487.4267 at Bab El-She'reya Hospital and Paxera ultimate 360 at El-Hussein Hospitals) were used.

The film workstations are a diagnostic image and a manipulation tools for medical imaging that are able to measure with a precision of 0.01.

Three points were chosen as reference points at the skull base:

1. The lateral ethmoid roof point (LERP): which is identified by the intersection of a vertical line tangent to the medial orbital wall with the ethmoid roof.
2. The medial ethmoid roof point (MERP): which corresponded to the articulation of horizontal/slope part of anterior skull base with the lamina lateralis of the cribriform plate.
3. Cribriform plate (CP).

- The distance between these two roof points (LERP and MERP) is defined as ''width of anterior ethmoid roof''.
- The distance between crista galli and MERP is defined as ''width of cribriform plate''(figure 2, 3 and 4)

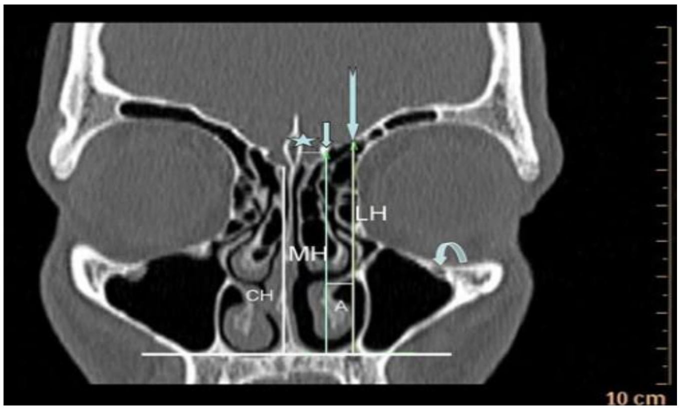
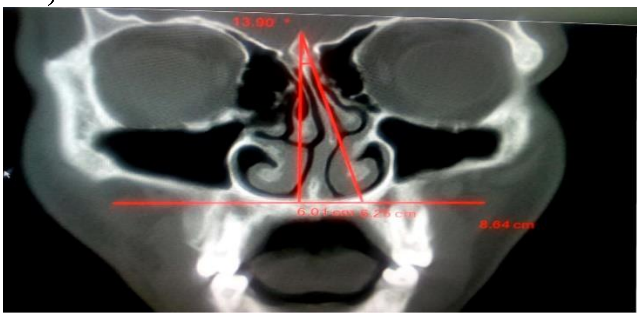
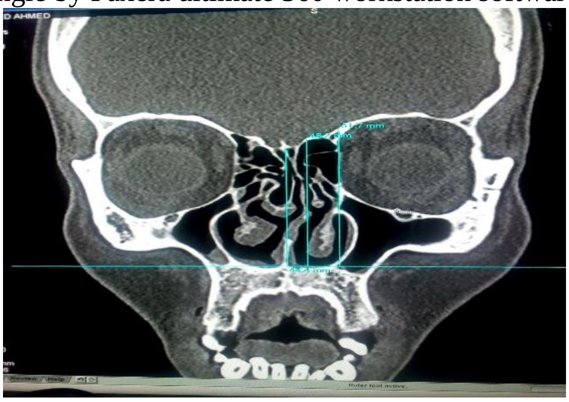


Figure (2): Coronal computed tomographic scan demonstrating the LERP (long arrow), MERP (short arrow), the distance of these landmarks to the horizontal plane of nasal cavity (LH: LERP height, MH: MERP height and CH: CP height), the width of cribriform plate (CP) (asterisk) and the width of anterior ethmoidal roof (A) at the first coronal section of which is infraorbital nerve determined (curved arrow) [8].



(Fig. 3): Measurement of septal deviation angle by Paxera ultimate 360 workstation software.



(Fig. 4): Measurement of dimensions of ethmoid roof and cribriform plate by Vitrea workstation software.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:
- P-value <0.05 was considered significant.
- P-value <0.001 was considered as highly significant.
- P-value >0.05 was considered insignificant.

RESULTS

This study included 40 patients suffered from deviated nasal septum; 20 females (50 %) and 20 males (50 %) with age range from 18 to 60 years (mean 31.9 ± 12.88 years).

Twenty patients (50%) were deviated to the right side and the other twenty patients (50%) were deviated to the left side.

According to the side of deviation, mean age of deviated septum to the right side was 30.1 and to the left side was 33.7.

Septal deviation to the right side was more in females 60% *"12 cases"* while in males was 40% *"8 cases"* and septal deviation to the left was more in males 70% *"14 cases "* while in females was 30% *" 6 cases "* (Table 1).

Table 1 shows no significant statistical influence **(p-value > 0.05)** of age and sex as regard side of deviation.

Table (1): Comparison of age and sex as regard side of deviation

Variables		Right (N = 20)	Left (N = 20)	P-value
Age	**Mean**	30.1	33.7	0.4
	±SD	13.7	12.04	
Sex	**Male**	8 (40%)	14 (70%)	0.06
	Female	12 (60%)	6 (30%)	

Table (2): Comparison between ipsilateral and contralateral sides as regard cribriform plate and ethmoid roof dimensions

Variables		Ipsilateral (N = 20)	Contralateral (N = 20)	P-value
Ethmoid roof width	**Mean**	8.1	7.4	0.2
	±SD	1.7	1.6	
Ethmoid roof depth	**Mean**	4.3	3.9	0.6
	±SD	2.1	1.7	
Cribriform plate width	**Mean**	5.5	5.5	0.9
	±SD	0.8	1.1	
Cribriform plate depth	**Mean**	6.1	5.7	0.5
	±SD	1.9	1.8	

Table 2 shows no significant statistical difference between ipsilateral and contralateral sides as regard cribriform plate and ethmoid roof dimensions.

Table (3): Comparison between right and left sides as regard cribriform plate and ethmoid roof dimensions.

Variables		Right (N = 20)	Left (N = 20)	P-value
Ethmoid roof width	Mean	7.6	7.9	0.5
	±SD	1.3	1.9	
Ethmoid roof depth	Mean	3.7	4.5	0.2
	±SD	1.9	1.9	
Cribriform plate width	Mean	5.7	5.6	0.7
	±SD	0.8	1.2	
Cribriform plate depth	Mean	5.8	5.8	0.9
	±SD	2.05	1.8	

Table 3 shows no significant statistical difference between right and left sides as regard cribriform plate and ethmoid roof dimensions.

Pearson correlation coefficient (r) test results:

a. Between septal deviation angle degree and ethmoid roof dimensions:

- There was positive correlation between the degree of septal deviation angle and right ethmoid roof width and this means if the angle increases, the right ER width increase.
- There was no significant statistical correlation between the degree of septal deviation angle and other ethmoid roof dimensions in studied patients (Table 4).

Table (4): Correlation study septal deviation angle degree and ethmoid roof dimensions in studied patients

Variables	(r)	value
Septal deviation angle vs. Rt. ethmoid roof width	**0.3**	**0.04***
Septal deviation angle vs. Rt. ethmoid roof depth	**- 0.2**	**0.2**
Septal deviation angle vs. Lt. ethmoid roof width	**- 0.02**	**0.9**
Septal deviation angle vs. Lt. ethmoid roof depth	**- 0.3**	**0.06**
Septal deviation angle vs. Ipsi. ethmoid roof width	**0.2**	**0.2**
Septal deviation angle vs. Ipsi. ethmoid roof depth	**- 0.2**	**0.08**
Septal deviation angle vs. Cont. ethmoid roof width	**- 0.03**	**0.8**
Septal deviation angle vs. Cont. ethmoid roof depth	**- 0.2**	**0.2**

(r): Pearson correlation coefficient.
*: p-value < 0.05 is considered significant.

b **- <u>Between septal deviation angle degree and cribriform plate dimensions:</u>**

There was a negative correlation between the degree of septal deviation angle and the left cribriform plate width, this means if the angle of deviation increases the left CP width decreased.

There was no significant statistical correlation between the degree of septal deviation angle and other CP dimensions in studied patients (Table 5).

Table (5): Correlation study septal deviation angle and cribriform plate dimensions in studied patients

Variables	(r)	p-value
Septal deviation angle vs. Rt. cribriform plate width	0.3	0.09
Septal deviation angle vs. Rt. cribriform plate depth	0.08	0.6
Septal deviation angle vs. Lt. cribriform plate width	**-** 0.3	**0.03***
Septal deviation angle vs. Lt. cribriform plate depth	- 0.2	0.2
Septal deviation angle vs. Ipsi. cribriform plate width	0.07	0.7
Septal deviation angle vs. Ipsi. cribriform plate depth	0.2	0.3
Septal deviation angle vs. Cont. cribriform plate width	- 0.2	0.2
Septal deviation angle vs. Cont. cribriform plate depth	- 0.2	0.2

(r): Pearson correlation coefficient.
*: p-value < 0.05 is considered significant.

c. Between the same ethmoid roof dimension in both sides :

There was a high significant statistical positive correlation between rt. ethmoid roof width vs. lt.

There was a statistically significant positive correlation between rt. ethmoid roof depth vs. lt. ethmoid roof depth.There was a statistically significant positive correlation between ipsilateral ethmoid roof (deviated side) width and contralateral ethmoid roof width. There was a statistically significant positive correlation between ipsilateral ethmoid roof (deviated side) depth and contralateral ethmoid roof depth (Table 6).

Table (6): Correlation study the same ethmoid roof dimension in both sides.

Variables	(r)	p-value
Rt. ethmoid roof width vs. Lt. ethmoid roof width	0.5	**< 0.001***
Rt. ethmoid roof depth vs. Lt. ethmoid roof depth	0.4	**0.001****
Ipsi. ethmoid roof width vs. Contra. ethmoid roof width	0.4	**0.002****
Ipsi. ethmoid roof depth vs. Contra. ethmoid roof depth	0.4	**0.005****

(r): Pearson correlation coefficient.
*: p-value < 0.001 is considered highly significant.
**: p-value < 0.05 is considered significant.

d. ***Between the same cribriform plate dimension in both sides :***

There was insignificant positive correlation between right cribriform plate width vs. left cribriform plate width.

There was a high statistical significant positive correlation between right cribriform plate depth vs. left cribriform plate depth.

There was insignificant positive correlation between ipsilateral cribriform plate (deviated side) width and contralateral cribriform plate width.

There was a statistically significant positive correlation between ipsilateral cribriform plate (deviated side) depth and contralateral cribriform plate depth (Table 7).

Table (7): Correlation study the same cribriform plate dimension in both sides.

Variables	(r)	p-value
Rt. cribriform plate width vs Lt. cribriform plate width	0.08	0.6
Rt. cribriform plate depth vs Lt. cribriform plate depth	0.5	**< 0.001***
Ipsi. cribriform plate width vs Contra. cribriform plate width	0.2	0.3
Ipsi. cribriform plate depth vs Contra. cribriform plate depth	0.4	**0.02****

(r): Pearson correlation coefficient.
*: p-value < 0.001 is considered highly significant.
**: p-value < 0.05 is considered significant.

DISCUSSION

This study included 40 patients suffered from deviated nasal septum, which was with equal incidence in male and female (50% and 50 % respectively). It is consistent with the study done on 284 patients by **Ibrahim *et al.*** [(9)] who found an equal incidence in male and female (50.4% and 49.6% respectively).

Ozkurt *et al.* [(10)] found 65% of deviated nasal septum with relatively more male predominance in his study on two hundred and twelve patients but this predominance has no significant differences between men and women [(11)].

In this study, the age range was 18-60 years with a mean age of 31.9 years and the selection of this age group indicates that deviated nasal septum is common in adults. **Gray** [(12)] found that deviated nasal septum was 30% in children and 80% in adults. **Van der Veken *et al*.** [(13)] found that deviated nasal septum incidence is up to 70% with increasing incidence with age.

The nasal septum may be deviated to the right or to the left side, **Cumberworth**[(5)] proposed that the nasal septum deviates to the right side but **Buyukertan *et al.*** [(14)] stated that the nasal septum is usually deviated to one side or the other most often without definition which side is more. **Saylisoy *et al.*** [(3)] observed that right septal deviation was more (58 % of the patients). In this study, the septal deviation was equally deviated to both sides "50 % to the right side and 50 % to the left one".

The measured angles of nasal septal deviation were found to range between 6.13 and 20 degree (mean10.57± 3.76). Deviation angles were 11.7 ± 4.3 for right deviations and 9.9 ± 2.9 for the left deviations and no significant statistical difference (p-value > 0.05) of septal deviation angle degree as regard side of deviation. These results are compared with studies reported by **Saylisoy *et al.*** [(3)] who found the deviation angles were 6.85 ± 1.47 for right deviations and 7.11 ± 1.63 for the left deviations.

The present study found that the mean width of CP was 5.7 ± 0.8 mm at the right side and 5.6 ± 1.2 mm at the left side (p- value = 0.7) and the mean depth of CP was 5.8 ± 2.05 at the right side and 5.8 ± 1.8 at the left side (p – value = 0.9) while the results – according to side of deviation – showed that the mean width of CP was 5.5 ± 0.8 mm at the ipsilateral side and 5.5 ± 1.1 at the contralateral side (p – value = 0.9) and the mean depth of CP was 6.1 ± 1.9 mm at the ipsilateral side and 5.7 ± 1.8 at the contralateral side (p value = 0.05). By student t test there was no statistically significant difference between the opposite sides.

These results in our study were similar to the studies done by **Erdem *et al.*** [(4)] who found that the mean CP depths were 6.1 ± 2.3 mm on the right side and 6.1 ± 2.2 mm on the left side, and there was no statistically significant difference between the opposite sides. **Saylisoy *et al.*** [(3)] detected that the mean depth of CP was 5.08 ± 1.57 mm on the right side and 5.06 ± 1.59 mm on the left side and there was no statistically significant difference between the opposite sides. **Oakley *et al.*** [(15)] found the mean depth of CP according to the ‘‘septal deviation side,’’ was 5.9 ± 2.19 mm at the ipsilateral side (deviated side), at the contralateral side, the mean depth of CP was 6.04 ± 2.1 mm in three groups of the study and there was no statistically significant difference between the opposite sides.

The results in our study weren't similar to the studies done by **Erdem *et al.*** [4] and **Saylisoy *et al.*** [3]. They reported that the mean depth of CP according to ''septal deviation side'' was 4.9 ± 1.56 mm at the ipsilateral side (deviated side), and 5.22 ± 1.58 mm at the contralateral side. They found that CP depth at the contralateral side was significantly higher than that of the ipsilateral side.

The variability of percentage of Keros classification system was found in the study done by **Damar *et al.*** [1]**, who** observed that type I was 18.2% on the right side and 18.2% on left side and type II occurred in 64.2% on the right side and 58.8% on the left side and type III occurred in 17.6% on the right side and 23% on the left side.

Correlation tests showed a positive correlation between the degree of septal deviation angle and right ethmoid roof width. There was a negative correlation between the degree of septal deviation angle and the left cribriform plate width, but **Saylisoy *et al.*** [3] reported in his study that as deviation angle increased, ipsilateral and contralateral CP width, right and left CP width increased.

Our study revealed that ipsilateral and contralateral ER width, also ipsilateral and contralateral ER depth increased together. In other words, right and left ER width; and ER depth increased simultaneously. The tests also showed a positive correlation between right and left ethmoid roof width and right and left ethmoid roof depth, contralateral and ipsilateral ethmoid roof (deviated side) width and contralateral and ipsilateral ethmoid roof (deviated side) depth .

Also our study revealed that right and left CP depth increased together and additionally ipsilateral and contralateral CP depth increased together.

These results were, to some extent, like those of **Saylisoy *et al.*** [3] except in his study he reported that ipsilateral and contralateral CP width increased together and the CP width of the right and left sides also increased.

The asymmetry of CP and ethmoid roof have been investigated by several authors. **Adeel *et al.*** [16] found asymmetry was found in 94.8% of the patients. **Souza *et al*.**[17] in a review of 200 CT studies, observed asymmetry between the left and right LLCP in 12% of the cases. **Dessi *et al***. [18] analyze***d*** the height of the ethmoid roof in 150 CT studies; asymmetry was observed in 15 (10%) patients. **Lebowitz *et al***. [19] reviewed 200 CT scans and noted asymmetry in 19 cases (9.5%). **Alazzawi *et al.*** [20] reported asymmetry in 93% of cases, and **Solares *et al.*** [21] and **Oakley *et al***. [15] reported asymmetry of the ethmoid roof in all subjects.

High rate of asymmetry of CP and ethmoid roof was noted in our study compared with the studies above. This is mostly due to the accurate measurements that are collected by using the computer software, which is able to measure with a precision of 0.01 mm.

The relationship of the ethmoid roof and its cribriform plate to other structures has been reviewed by other studies.

CONCLUSION

Iatrogenic intracranial penetration through the weakest and thinnest ethmoid roof, predominantly in the lateral lamella of the CP during FESS causes serious complication so several studies reviewed the relationship of this potential area to other structures of the nasal cavity.

Radiological evaluation of the ethmoid roof is important in preventing endoscopic sinus surgery complications.

The presented study showed the impact of septal deviation and its severity on the ethmoid roof and cribriform plate dimensions in terms of width and depth.

The findings showed that the severity of deviation didn't have impact on the dimensions of ethmoid roof and cribriform plate in terms of depth and width in ipsilateral and contralateral sides and right and left sides except right ethmoid roof width (direct proportion) and the left cribriform width (inverse proportion).

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