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Morphological and morphometric study of jugular foramen in Telangana population

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Abstract:
The anatomy of jugular foramen is complex. The jugular foramen (JF) lies between the occipital bone and the petrosal portion of the temporal bone, and it allows for the passage of important nervous and vascular elements, such as the glossopharyngeal vagus and accessory nerves, and the internal jugular vein. Glomic tumors, schwannomas, metastatic lesions and infiltrating inflammatory processes are associated with this foramen, which can account for injuries of related structures. The jugular foramen (JF) varies in shape and size from side to side in the same cranium, and in different crania, racial groups and sexes. Side dominance is also said to be common. The foramen's irregular shape, its formation by two bones and the numerous nerves and venous channels that pass through it further compound its anatomy. An anatomical Study was undertaken in order to investigate the size and separation of jugular foramen in human adult skulls. A total of 110 human skulls were examined to determine the diameter, separation and side predominance of the foramen

Key words: Jugular foramen (JF), Separation, Skull, standard deviation (SD).

Introduction:

Jugular foramen of human skull is one of the most fascinating foramina. The jugular foramen (JF), sometimes referred to as the posterior foramen lacerum, is situated in the floor of the posterior fossa posterolateral to the carotid canal, between the petrous temporal bone (anterolaterally) and the occipital bone (posteromedially). The term foramen is not strictly accurate because the JF resembles a canal with endocranial and exocranial openings. This canal is triangular in shape with its apex pointing anteromedially. The JF is a complex crossroad of neurovascular structures in the skull base. Anatomical variation in the course of the nerves and vessels adds to the complexity of this area. The contents of the JF are conventionally divided into the smaller pars nervosa, situated anteromedially, and the larger pars vascularis that is posterolateral, although this terminology is misleading as both contain vascular and neural structures. The pars nervosa contains the glossopharyngeal (IX) and Jacobsen's nerve together with the inferior petrosal sinus, whereas the pars vascularis contains the internal jugular vein, vagus (X), spinal accessory (XI), and Arnold's nerve. The IX nerve is situated anterosuperomedially to the X and XI nerves. The IX, X, and XI nerves run through the JF in a connective tissue layer that attaches the Dura matter intracranially to the pericranium extracranially. This "guide plate" is usually situated between the area of the JF and the inferior petrosal sinus and has an opening for the inferior petrosal sinus, usually between the IX nerve and the X nerve. The IX nerve and/or the inferior petrosal sinus may take course through separate foramina.

Tekdemir et al[1] reported the presence of a Dural septum separating the IX from the X and XI cranial nerves. The posterior meningeal artery also traverses the JF. This artery is usually a branch of the ascending pharyngeal artery.

Rhoton and Buza have found that it is derived from the anterior inferior cerebellar artery in 8% of cases [2].

The relationship and significance of the JF to the deep fascial planes of the neck are extremely important because both infections and tumors in these spaces are often responsible for the radiographic changes.

The neural and vascular compartments are usually divided by a bone projection called the intra jugular process Hatiboglu and Anil, 1992; Prades, Martin, Veyretch et al., 1994; Williams,

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Warwick, Dyson et al., 1995[3].

The foramen presents variations regarding shape, size and laterality for the same skull, besides differences related to sex and race. Laterality dominance was also reported Wysocki, Chmielik and Gacek, 1999; Berge and Bergman, 2001; Idowu, 2004. [4]

The anomalies of the jugular bulb are associated with the JF, as the glomic tumors, which are often in direct contact with structures that cross it, as the internal jugular vein, the internal carotid artery, and the cranial nerves. Besides, schwannomas, metastatic lesions and infiltrating inflammatory processes can also occur. Microsurgical techniques improvement, such as the lateral sub occipital access, have allowed for the removal of these lesions, previously regarded as not passible to undergo surgery Guido and Zorzetto, 1997;[5] Idowu, 2004 [6].

Therefore, the detailed study and the acknowledgement of the characteristics related to this foramen are indispensable.

This study wants to analyse the size, presence of septa and side predominance of the JF in dry adult skulls of Telangana region.

Materials and methods:

A total of 220 JF were examined from 110 adult dry skulls. The skulls were obtained from the osteological collection of the Department of anatomy, kamineni academy of medical sciences and research center ,Hyderabad. Skulls showing pathological changes were excluded.

The lengths, widths and separation and predominance of side of the jugular foramina were determined. Metric measurements (anteroposterior and mediolateral diameters) were taken using with a montstar MS -5808-6 vernier caliper, precision of 0.1 mm.fig(2).

The measurements were taken in millimeters and all the measurements were taken bilaterally. The data collected was checked for errors prior to analysis. Data analysis was performed with "R version 3.1.0(2014-04-10)"[7] . The mean standard deviation (SD) and ranges of each dimension and derived index were computed. Right and left differences were analyzed. A comparison was made of the means of the dimensions using the Stu- dent's t-test. The association between continuous variables was investigated by means of Pearson's correlation coefficient. A probability (p) of less than 0.05 was considered statistically significant.

Observations and results:

Morphology of JF:

The jugular foramen is located between the temporal bone and the occipital bone. Its intracranial orifice is below the internal auditory meatus and superolateral to the intracranial orifice of the hypoglossal canal. It is situated with its long axis oriented from anteromedial to postero- lateral parallel to the petroclival fissure, being configured around the sigmoid and inferior petrosal sinuses. One cannot see through the foramen when viewing the skull directly from above or below be- cause of its roof, formed by the lower surface of the petrous temporal bone. It has a large oval lateral component, the sigmoid part, which receives the drainage of the sigmoid sinus, and a small medial part, the petrosal part, which receives the drainage of the inferior petrosal sinus. The view of the JF from below reveals the part of the temporal bone forming the dome of the jugular bulb rather than a clear opening. The intrajug- ular process partly divides the foramen into an anteromedial par nervosa and a larger postero lateral pars vascularis.

Dimensions of JF:

The mean mediolateral diameter on the right and left were 14.60 (13.6–19.80mm) and 12.69 (9.80- 17.8mm), while their antero posterior diameter measured on right and left were 9.61 (5.80-14.00mm) and 8.24(12.80-6.40mm) respectively(Table 1). There was no statistically significant difference between the two sides in the anteroposterior and mediolateral diameters of the JF, but there was a statistical difference in the mediolateral and anteroposterior diameters on each side. There was a positive correlation between lengths on both sides but no correlation between length and width on each side (Table2).

Predominance of mediolateral diameter of jugular foramen on right and left skulls are 69.09% &20%. And Anteroposterior diameter of right and left foramen are 64.35% and 22.73% respectively. The mediolateral and anteroposterior diameters on right and left side was12.73% and 10.91% of skulls showing no dominance, in most of skulls the right mediolateral and anteroposterior diameters were more than left anteroposterior and left mediolateral diameters. In present study the right predominance was observed [Chart2].

Out of 110 skulls , complete division of the JF by a bony septum(intra jugular process) was present on the right in 22%(Fig 3,5,,8,) and on the left in 27.5% (fig:7& 9).

The bony septation was sometimes partial. In life it was probably completed by cartilage or a fibrous structure. This type of incomplete bony septation was found on the right in 33% and left in 30% of skulls(fig.3,4,10,11). Absence of separation on right was 16.70% and left was 18.70% [Chart1],(fig12).

Discussion:

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The shape and size of the jugular foramen is obviously related to the size of the internal jugular vein and the presence or absence of a prominent superior bulb. It might be expected that the right foramen would usually be larger than the left, since the textbooks classically describe the superior sagittal sinus as draining into the right transverse sinus, but there is a very wide variation in the anatomy of the intracranial venous sinuses Wood hall, 1939[8], Browder & Kaplan, 1976[9] which accounts for variation in size and shape of jugular foramina.

The difference in size of the two internal jugular veins, when present, is already visible in the human embryo at the 23mm stage (8weekspost-conception) and probably results from differences in the pattern of development of the right and left brachiocephalic veins Pad get, 1957 [10].

It is of historical interest that out of 3 illustrations of the base of the skull in De Humani Corporis Fabrica (Versalius1543),[11] 2 are identical apart from the labeling, and the left jugular foramen is much larger than the right. The 3rd illustration is that of a skull held by a skeleton and the details of the base are indistinct, but the right jugular foramen appears to be larger than the left.

In Sturrock's (1988)[12] investigation on Nigerian skulls, the right foramen was larger in 69% and the left in 23%. In the remaining 8% they were almost the same size on both sides.

Predominance of JF appeared in 83% of cases in Wysocki's[4] series and the predominance of the left and the right side were equally possible.

Navsa and Kramer (1998) [13] found a larger volume for the jugular foramen on the right side of female skulls both for the white and the black race.

Schelling (1978) [14] reported a significantly larger volume of the jugular foramen on the right side of female skulls. Findings do not make it evident a difference between the right side and the left side regarding width and length measurements; although the analysis of the latero-medial measurement for genus regardless of laterality showed the largest measurement in male skulls.

Hatiboglu and Anil [3] studied 300 Anatolian skulls from the 17th and 18th centuries and observed that in 61.6% the foramen was larger on the right side and in 26% it was larger on the left side and in the reminder of equal size.

Patel and Singel [15] studied 91 Indian skulls (Saurashtra region) and observed in 60.4% cases larger right foramen, in 15.4% larger left foramen and in 24.2% equal on both sides.

According to Wysocki, Reymond and Skarzyński (2006) [22], results variation can be explained by racial and individual factors. As to the individual factors, these authors mention the significant correlation between the size of the JF and also the hypoglossal channel with skull volume, thus pointing to the significance of cranial capacity for brain venous drainage.

In present study Predominance of mediolateral diameter of jugular foramen on right and left skulls are 69.09% &20%. And Anteroposterior diameter of right and left foramen are 64.35% and 22.73% respectively. The mediolateral and anteroposterior diameters on right and left side was12.73% and 10.91% of skulls showing no dominance, in most of skulls the right mediolateral and anteroposterior diameters were more than left anteroposterior and left mediolateral diameters. So the right foramen is larger than the left.

Thus there is difference between our study and the studies by patel and single [15] and Anil & Hatiboglu[3]. But the findings are nearer to the Sturrock's (1988).

In our study mean mediolateral diameter of jugular foramen on the right and left were 14.61(13.6–19.80mm) and 12.69 (9.80-17.8mm), while their antero posterior diameter measured on right and left were 9.61 (5.80-14.00mm) and 8.24(12.80-6.40mm) respectively The statistically significant difference was observed between the two sides in transverse and sagittal diameter ($p<0.05$). Both diameters are more on right side.

In the study done by O.E.idowu (2004)[6]. on Nigerian skull, he found mean transverse diameter of jugular foramen on the right and left were 13.90 mm (11.6–17.0 mm) and 14.11 mm (9.2–20.2 mm), while their sagittal diameter measured 10.22 mm (6.8–14.4 mm) and 9.57 mm (7.4–12.8 mm) on the right and left respectively. Although the Jugular Foramen was larger on the right, it was not statistically significant. There is statistically significant between our study and O.E.idowu's study ($p<0.05$)[6].

Roma Patel & CD Mehta [18] observe in their study mean transverse diameter of jugular foramen on the right and left were 12.17mm (range: 4.5–16.5 mm and 11mm (range: 5-16mm) respectively, while their sagittal diameter measured 7.9mm (range:3– 12.5 mm) and 6.2 mm (range:3–12.5mm) on the right and left respectively. These findings are very nearer to our study.

According to study done on Turk's skull by Ekinci and Unur [16], the sagittal and transverse diameters of the left jugular foramen were 7.6 and 15.5 mm, respectively, and on the right 8.4 and 16 mm, respectively.

Pereira, GAM [17]. Studied total 111 skulls (of southern Brazil) and it was noticed that mean transverse diameter was 15.82mm on right side and 15.86mm on left side; mean sagittal diameter was 9.21mm on right side and 8.65mm on left side.

In our study the both diameters were more on the right side. So the mean values of right and left were statistically significant and

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the values are nearer to the values of O.E.idowu's [6].

Regarding the separation of compartments Sturrock R.R [12] observed complete separation on right side in 3.2%, left side in 3.2% and partial separation on the right side in 1.3%, on left side in 10.9%. Hatiboglu and Anil [3] observed complete separation on the right side in 5.6%, on the left side in 4.3% and partial separation on the right side in 2.6%, on the left side in 19.6%.

Patel and Singel [15] observed complete separation on the right side in 23.1%, on the left side in 17.6% and partial separation on the right side in 49.5%, on the left side in 59.3%.

Anjali et.al (2012)[23] observed complete bilateral and unilateral septation was observed in 8&4% of skulls.

The present study differs a lot from the study of sturrock, hatiboglu and anil and Anjali et.al. And our values are related to patel and single.(chart1)

Hussain Saheb S.[19] observed complete separation was present in 20.8%on the right side and 16.8% on the left side. Partial septation was present in 45.6% on the right side and in 58.4%on the left side. Non separation was present in 33.6% on the right side and in 24.8%on the left side.

These findings are close to our study.

Pereira, GAM[17]. Noticed in their study that in 0.9% of them (one skull) there was a completed bone septum on both sides; 0.9% (one skull) showed uncompleted bone septum on both sides, and 83.8% (93 skulls) did not show bone septum on both sides at all.

Shifan.k, Ramesh Kumar [21] observed that complete septation of jugular foramen was present on Right side in 13% and Left side in 4%. Partial or incomplete septation on Right side in 24% and on Left side in 7%.

The morphogenesis of foraminal anamolies at the base of skull, Shapiro & robonson stated that three major fenestrations are observed in early human fetal skull- foramen lacerum anterior hiatus between greater and lesser wing of sphenoid; foramen lacerum medius opening between basisphenoid and periotic capsule; foramen lacerum postrius –hiatus between basiocciput and the auditory bullae.

These openings have their counter part in the primitive mammalian skull. These large fenestrations become subdivided by the ingrowth of bony spicules, leading to the formation of the multiple foramina. The foramen lacerum posterior persist as jugular foramen.

Saphiro [20] attributed the variation in the jugular foramen compartmentalization to variability in bone formation around primitive foramen lacerum posterior.

It appears that compartmentalization of JF might be a part of on going evolutionary process. It may be also due to racial and genetic factors. This study provides detailed anatomy of jugular foramen. Knowledge of morphology, compartments and morphometry is important for neurosurgeons dealing with space occupying lesions in jugular foramen.

Conclusion:

Variations in the size ,shapes and compartments of jugular foramen might a part of the ongoing evolutionary process and also due to constitutional racial and /or genetic factor.

This study provides detailed anatomy of JF and it supports reported morphometric and morphological variations. Knowledge of morphology compartments ,side predominance and morphometry is important for neurosurgeons dealing with space occupying lesions in JF.

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Table 1:The Jugular Foramen dimensions

	Rt AP	Lt AP	Rt ML	Lt ML
Mean	9.61	8.24	14.60	12.69
SD	3.019	3.24	3.94	3.51
maximum	14.00	12.80	19.80	17.8
minimum	5.80	6.40	13.06	9.80
percentiles				
0th	5	3	5	5
3rd	5.27	5	7	6
25th	7	6	13	10
50th	9	7	15	14
75th	11.0	9.0	17.5	15.0
97th	16	15.73	20	17.37
100th	19	20	24	20

RtAP-right anterioposterior,LtAP-left anterioposterior, RtML-right mediolateral,LtML-left mediolateral, SD-standard deviation, All measurements in mm.

Table 2:Student's t test and Pearson correlation of the various variables

variables	Student's t	P-value	r -value
Rt – Lt AP	-3.249	0.0013	0.746
Rt – Lt ML	-3.789	0.0019	0.740

Rt-Lt AP-right –left anterioposterior; Rt-Lt-ML-right – left mediolateral; r-pearson correlation coefficient ; p<0.05.

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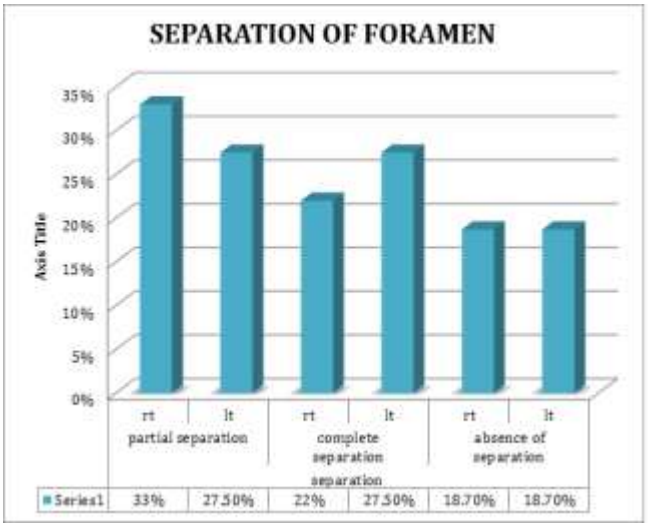


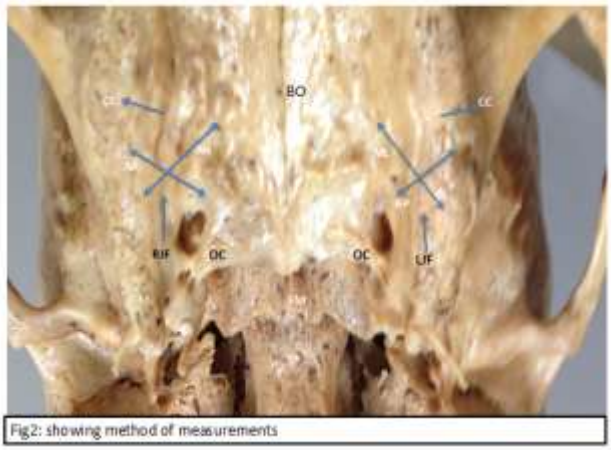
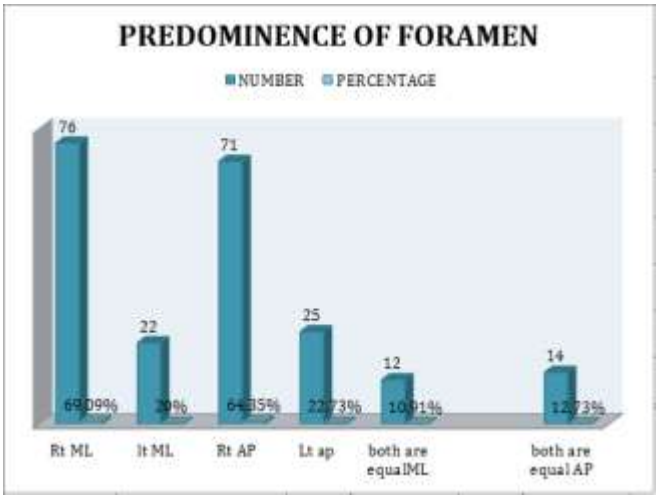


Fig2: showing method of measurements



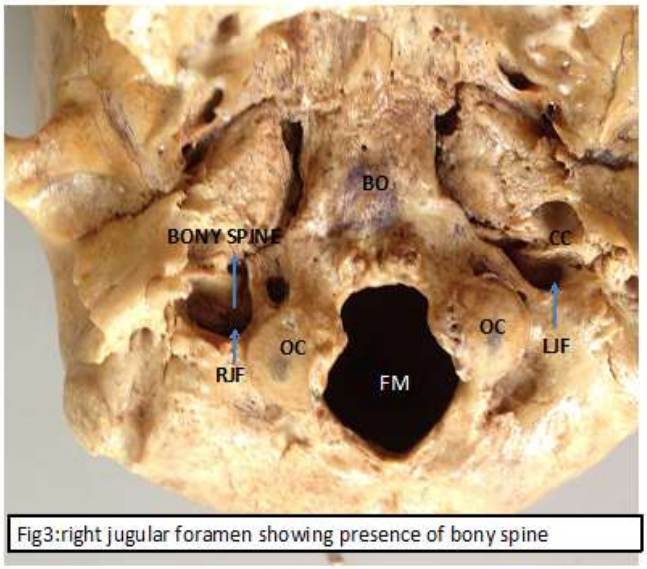


Fig3:right jugular foramen showing presence of bony spine

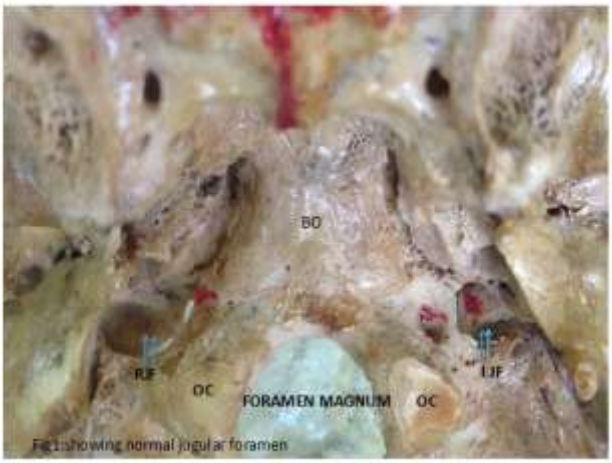


Fig1:showing normal jugular foramen

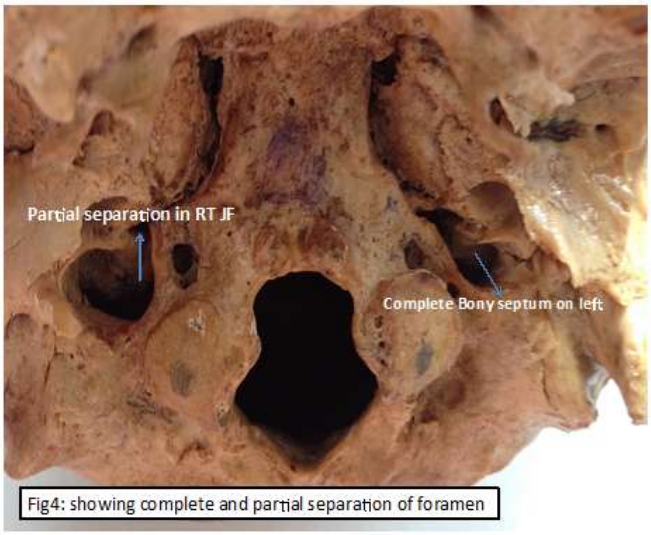


Fig4: showing complete and partial separation of foramen

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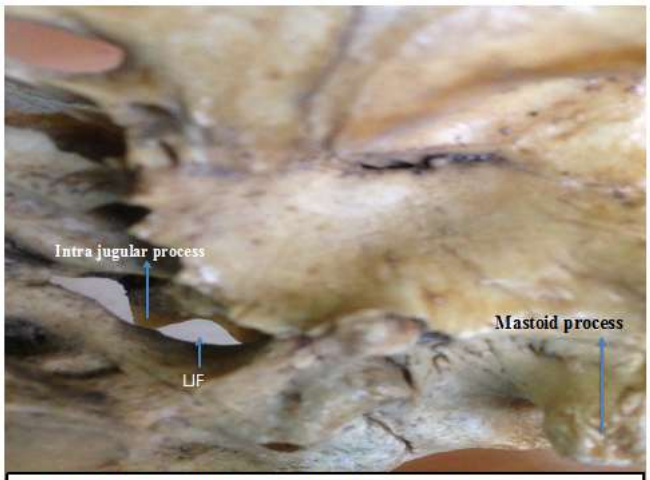

Fig5:left JF showing complete separation by intra jugular process

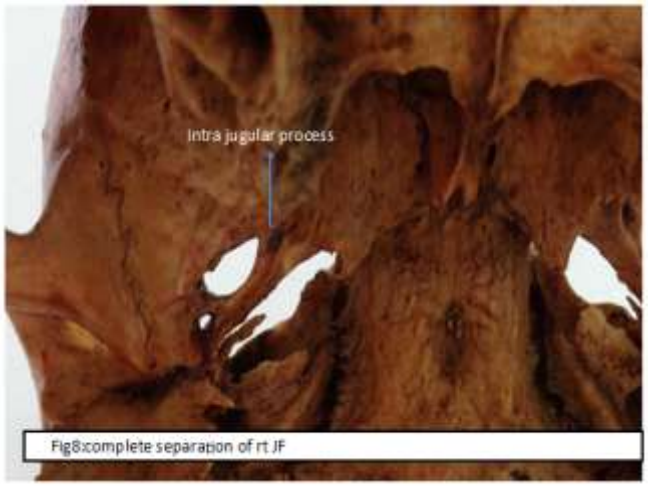

Fig8:complete separation of rt JF

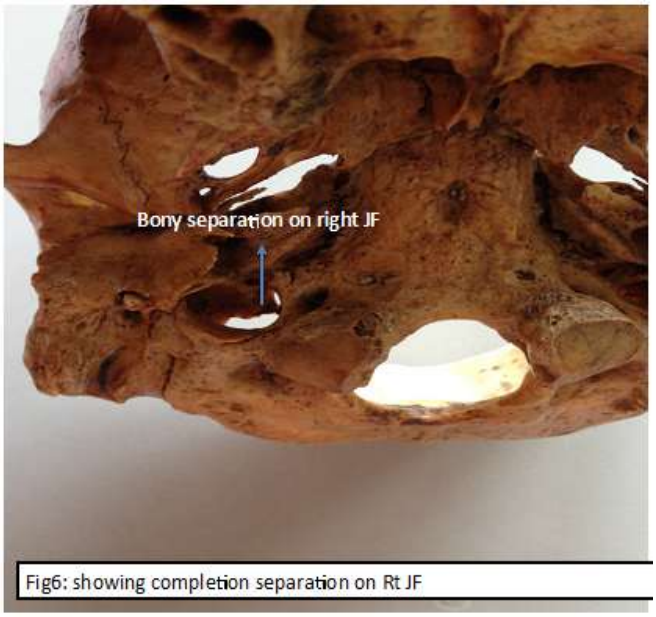

Fig6: showing completion separation on Rt JF

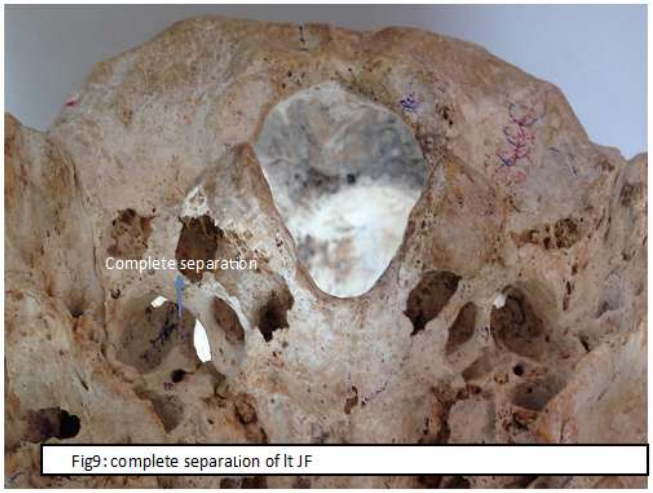

Fig9: complete separation of lt JF

Fig7: showing complete separation of LT JF

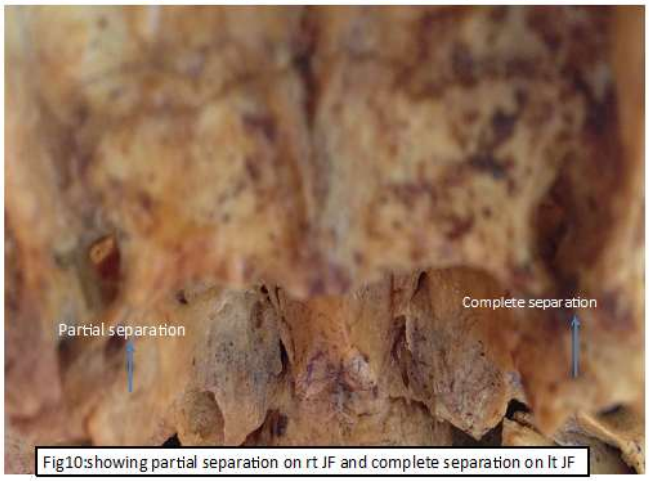

Fig10:showing partial separation on rt JF and complete separation on lt JF

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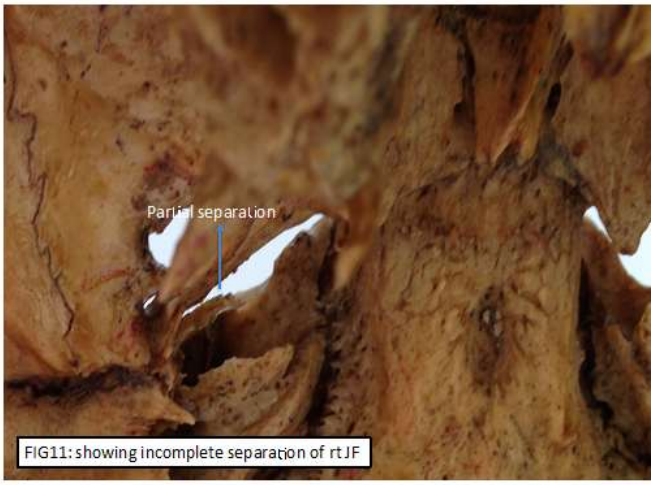

FIG11: showing incomplete separation of rt JF

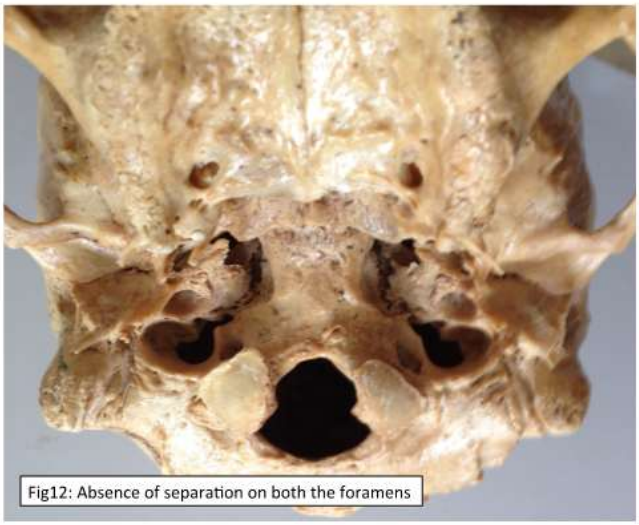
Fig12: Absence of separation on both the foramens

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