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**D**ural venous sinuses are a complex of venous channels that lie between the two layers of dura mater, lined by endothelium, have no valves, and their walls are devoid of muscular tissue. They drain blood from the brain and cranial bones.<sup>12</sup>The cerebral veins

## Morphometric Relationship of the Transverse Sinus with Sigmoid Sinus Groove and Jugular Foramen

Cranial venous sinus anatomy is fundamental in neurosurgery and radiology, especially in surgical planning and treatment of neurological diseases. In this study, we aimed to study the morphometric relationship of the transverse sinus with sigmoid sinus groove and jugular foramen and imply if this relationship could aid in diagnosing the transverse sinus thrombosis. This is a retrospective analytical study conducted in our center among 30 patients who underwent Computed Tomography (CT) venogram during a period of 1 year. Diameter of transverse sinus and sigmoid groove at midpoint, and diameter of jugular foramen as it enters the skull base were collected. Relation of transverse sinus with sigmoid sinus groove and jugular foramen was analyzed. There were 60 transverse sinuses in the study with left and right being 50% (30 each). Mean age of patients collected was 53.20 years. There were 43.3% male and 56.7% female patients. Diameter of the Transverse sinus has statistically significantly linear relationship with the diameter of the sigmoid sinus groove and jugular foramen ( $p < 0.001$ ) and was positively correlated ( $r = 0.651$  and  $0.624$  respectively). Diameter of the transverse sinus has significant positive linear correlation with the sigmoid sinus groove and jugular foramen.

**Keywords:** jugular foramen, morphometry, sigmoid sinus groove, transverse sinus, venous sinus

Morphometric Relationship of the Transverse Sinus with Sigmoid Sinus Groove and Jugular Foramen

and venous sinuses have complex anatomy and marked variability. Normal variations of the venous sinuses include aplasia and/or hypoplasia of certain segments, duplication or fenestration, arachnoid granulations, and the presence of embryological remnants such as a persistent falcine or occipital sinus.<sup>9</sup>

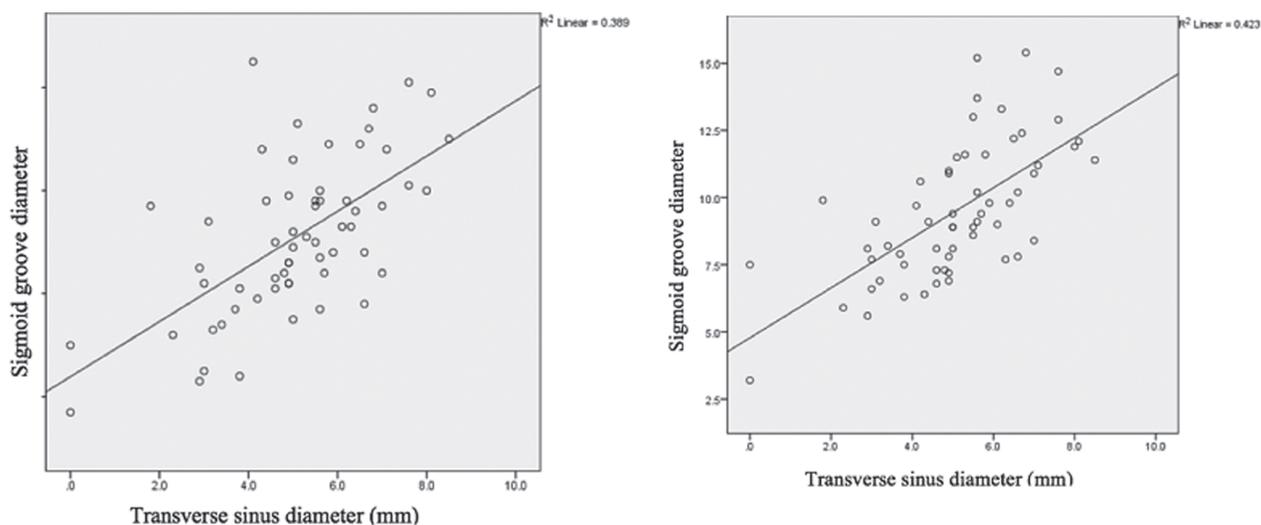


Figure 1: Linear relationship of transverse sinus with sigmoid sinus groove diameter (A) and jugular foramen diameter (B).

The understanding of the cranial venous sinus anatomy is fundamental in neurosurgery and radiology, especially in surgical planning and treatment of neurological diseases, and to avoid complications.<sup>2,4</sup>

In this study, we aimed to study the morphometric relationship of the transverse sinus with sigmoid sinus groove and jugular foramen and imply if this relationship could aid in diagnosing the transverse sinus thrombosis.

### Methods:

CT venogram of 36 patients was acquired. Six patients were excluded due to sinus venous thrombosis. A total of 30 venous phase of Computed Tomographic Angiogram (CTA) were retrospectively analyzed. All examinations were performed by single consultant radiologist (K.R). Approval for study was made by the Ethics Committee of Upendra Devkota Memorial National Institute of Neurological and Allied Sciences. Epidemiological variables and radiological variables were recorded in Performa. Patient demography was recorded. Source images of CT venogram were used for all measurement. Diameter of transverse sinus was measured at midpoint and sigmoid groove diameter was measured at its midpoint. Diameter of jugular foramen was measured at it enters the skull base were collected. The measurement ratio right/left of the sinuses (or IJV) were stratified according to dominance. A venous sinus was classified as dominant when the measurement ratio was more than 1.5 (more than 50% than the contralateral side) and venous sinus was classified as non-dominant when the measurement ratio was less than 0.67. A venous sinus was classified as co-dominant when the measurement ratio was between 0.67

and 1.5 (sinuses measuring between the upper and lower limit of 50%). Data entry done in SPSS ver 20. P value of <0.05 was considered significant. Relation of transverse sinus with sigmoid sinus groove and jugular foramen was analyzed with correlation test.

### Results:

30 patients were included in this study. Mean age of the patients was  $53.20 \pm 15.64$  years ranged 15 to 78 years. Most of them were female (56.7%) with female to male ratio of 1.3. Mean diameter of transverse sinus was  $5.04 \pm 1.76$  mm, sigmoid groove was  $9.48 \pm 5.09$  mm and jugular foramen was  $5.09 \pm 1.51$  mm. Moreover, mean diameter of right transverse sinus was  $6.16 \pm 1.11$  mm, right sigmoid groove was  $10.71 \pm 5.87$  mm and right jugular foramen was  $5.87 \pm 1.32$  mm while mean diameter of left transverse sinus was  $3.93 \pm 1.57$  mm, left sigmoid groove was  $8.25 \pm 2.29$  mm and left jugular foramen was  $4.31 \pm 1.26$  mm. Left transverse sinus was aplastic in one case (Table 1).

Right sided predominance was seen in 56.6% of transverse sinus, 53.3.6% of sigmoid sinus and 60% of jugular foramen. While left sided predominance was seen in 3.4% of transverse sinus only. Equal size of transverse sinus was seen in 40%, sigmoid sinus in 46.7% and jugular foramen in 40% cases (Table 2).

Mean diameter of transverse sinus has statistically significantly linear relationship with the diameter of the sigmoid sinus groove and jugular foramen ( $p < 0.001$ ) and was positively correlated ( $r = 0.651$  and  $0.624$  respectively) (Figure 1).

## Morphometry of transverse sinus

		<b>Total N=60</b>	<b>Right N=30</b>	<b>Left N=30</b>	<b>P value</b>
<b>Transverse sinus</b>	Minimum	0	4.1	0	0.00040
	Maximum	8.5	8.5	6.6	
	Mean	5.04	6.16	3.93	
	SD	1.76	1.11	1.57	
<b>Sigmoid groove</b>	Minimum	3.2	7.3	3.2	0.000064
	Maximum	15.4	15.4	15.2	
	Mean	9.48	10.71	8.25	
	SD	5.09	5.87	2.29	
<b>Jugular foramen</b>	Minimum	1.7	3.5	1.7	0.000018
	Maximum	8.5	8.5	6.8	
	Mean	5.09	5.87	4.31	
	SD	1.51	1.32	1.26	

Table 1: Diameter of variables

	<b>Transverse sinus</b>		<b>Sigmoid sinus groove</b>		<b>Jugular foramen</b>	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
<b>Right dominance</b>	17	56.6	16	53.3	18	60
<b>Equal</b>	12	40	13	46.7	12	40
<b>Left dominance</b>	1	3.4	0	0	0	0

Table 2: Comparison of measurement in respect to laterality.

### Discussion:

Venous sinuses of brain lie between the two layers of dura mater, lined by endothelium, have no valves, and their walls are devoid of muscular tissue. They drain blood from the brain and cranial bones.<sup>1</sup> The transverse sinuses drain from the confluence of sinuses to the sigmoid sinuses, which ultimately connect to the internal jugular vein. Sigmoid sinus continues as internal jugular vein in posterolateral part of the jugular foramen (pars vascularis).<sup>5</sup> The jugular foramen is hiatus located between lateral part of the occipital bone and petrous part of the temporal bone and is the main route of venous outflow from the skull and is characterized by laterality based on the predominance of one of the sides.

This study analyzed the size of jugular foramen, sigmoid sinus groove and transverse sinus in 30 individuals among Nepali population. The anatomy of these structures should be considered during dealing with pathological processes affecting JF and venous sinuses include intracranial meningiomas, paragangliomas (glomusjugulare, from the jugular ganglion of the vagus nerve), schwannomas, metastatic lesions and infiltrative inflammatory processes in surrounding structures such as the middle ear and sinus venous thrombosis.<sup>8</sup>

In the present study, the right-side jugular foramen was larger than the left in 56.6%. This accounts for the fact that the internal jugular vein passing through the right foramen might be larger than the left. Similar finding was supported by the study done by Thamke et al., Patel R et

Study		Transverse		Sigmoid		Jugular	
		Right	Left	Right	Left	Right	Left
<b>Our study</b>	N	30	30	30	30	30	30
	Mean	6.16	3.93	10.71	8.25	5.87	4.31
	SD	1.11	1.57	5.87	2.29	1.32	1.26
<b>Thamke et al</b>	N	12	12				
	Mean	0.85	0.84	NA	NA	NA	NA
	SD	0.24	0.3				
<b>Patel R et al</b>	N					100	100
	Mean	NA	NA	NA	NA	16.5	16
	SD					12.17	11
<b>Shruti et al</b>	N					NA	NA
	Mean	NA	NA	NA	NA	7.51	7.16
	SD					1.56	1.89
<b>Jovanovic et al</b>	N			-	-		
	Mean	NA	NA	7.78	6.55	NA	NA
	SD			1.48	1.15		

Table 3. Comparison of morphometry with other studies<sup>7,10,11,13</sup>

al. and Shruti et al. in their study.<sup>10,11,13</sup> Embryological, the difference in size of the two internal jugular veins, when present, is already visible in the human embryo at the 23-mm stage (8 weeks post-conception) and probably results from differences in the pattern of development of the right and left brachiocephalic veins.<sup>6</sup>In a study done by Shruti et al.<sup>11</sup> right jugular foramen was greater than left in 178 (71.2%), lesser than left in 52 (20.8%) while equal to left 20 (8%) patients. While in a study done by Patel et al.<sup>10</sup> the size of the jugular foramen right sided dominance in 75%, left sided dominance in 23% and equal in 2% cases. In a cadaveric study done by Thamke et al.among 12 cadavers, the mean diameter of right transverse sinus was  $8.5\pm 2.4$ mm and left was  $8.4\pm 0.3$ mm contrary to our study where right transverse sinus was  $6.16\pm 1.11$ mm and left transverse sinus was  $3.93\pm 1.57$ mm (Table. 3).<sup>13</sup>

Alper et al.described about transverse sinus abnormalities - 20% aplasia and 39% hypoplasia of the left sinus, 6% hypoplasia and 4% aplasia of the right sinus and 31% symmetric sinuses.<sup>1</sup> Our results also show 6.6%

hypoplastic and aplastic transverse sinuses were on the left side only. In a study done by Jovanović I et al.the mean diameter of right sigmoid sinus groove was  $7.78\pm 1.48$ mm and left was  $6.55\pm 1.15$ mm while in our study mean diameter of right sigmoid groove was  $10.71\pm 5.87$   $8.25\pm 2.29$ mm with dominant right sigmoid sinus in 53.3% cases and equal to left side in 46.7% cases.<sup>7</sup>

Ekinci and Unur studied 70 skulls and found that in 61.4% of cases, the right jugular foramen was larger than the left. In 24.3% the left was larger while in 14.3% of cases, they were equal in size.<sup>3</sup> In our study, 60% of jugular foramen were dominant in right side, while equal size in 40% cases.

Similarly, in our study mean diameter of jugular foramen has statistically significant linear relationship with the diameter of the transverse sinus. Moreover, mean diameter of sigmoid sinus groove has statistically significant linear relationship with the diameter of the transverse sinus as well.

**Conclusions:**

Diameter of the transverse sinus has significant positive linear correlation with the sigmoid sinus groove and jugular foramen; this relationship could be considered in venous sinus related pathology.

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