Research Article

Importance Of Anatomical Imaging Signs In Predicting The Transverse Sinus Dominance Using Conventional Magnetic Resonance Imaging

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Abstract

Background: The cerebral venous system comprises both superficial and deep veins, which contain nearly 70% of the brain's blood volume and play a crucial role in maintaining normal cerebral perfusion.

Subject and methods: A retrospective study was conducted at Rizgary Teaching Hospital from January 1st, 2025, to November 1st, 2025. A convenient sample of 100 patients' MRI reports was reviewed. The first section of the questionnaire included gender, age, and indications for Magnetic Resonance Imaging. Signs and symptoms such as headache, headache with vertigo, seizure, headache and vomiting, dizziness, altered sensorium, and forgetfulness were documented. Categorical data was tested with the Chi-square test, and numerical data with the t-test. A P-value ≤0.05 was considered significant.

Results: The prevalence of females presenting with headaches was higher than that of males, at 75% compared to 67.5%. Headache and vomiting were more common in males (25%) than in females (15%). No statistically significant difference was reported between gender and the TS symmetrical and asymmetrical variation. The prevalence of asymmetry was 85% in males compared to 81.7% in females. The prevalence of left hypoplastic transfer sinus was higher than that of the right hypoplastic transfer sinus. The highest predictive value (96%) for diagnosing the laterality of the dominant TS was reported by gSSS inclination, with an interobserver reliability of 0.82. SSS flow-void laterality had the second-highest reliability for determining TS dominance, at 92%.

Conclusion and recommendation: Several anatomical features visible on MRI can predict TS dominance laterality. Right TS dominance is indicated by a gSSS that slopes downward to the right, with the SSS flow void positioned to the right of the more prominent, rightward angulation of the posterior falx, and a more inferiorly located left occipital lobe. The orientation of the gSSS to the right or left is strongly associated with and highly predictive of right- and left-sided TS dominance laterality.

Introduction

The cerebral venous system comprises both superficial and deep veins, which account for nearly 70% of the brain's blood volume and are essential for maintaining normal cerebral perfusion. The cerebral veins originate in the intracranial venous sinuses, and the patency of these sinuses is crucial for ensuring stable blood circulation. One of the leading causes of cerebral infarction and parenchymal haemorrhage is dural venous sinus thrombosis. Cerebral venous thrombosis (CVT) most commonly affects the transverse sinuses (TSs) and the superior sagittal sinus (SSS). [1] Studies have reported gender variation in the incidence of CVT, with females affected more frequently than males. [2] The diagnosis of CVT is challenging, mainly because its signs and symptoms are nonspecific. [3] The most common presenting symptoms in a recent study in Iraq were headache, focal neurological signs, papilledema, seizures, and vomiting. [4]

The transverse sinuses are often unequal in size; the right sinus is usually larger than the left. The left is more commonly hypoplastic than the right. This anatomical variation can be explained as follows: the right is the direct continuation of the superior sagittal sinus, which is larger than the straight sinus. Meanwhile, the left continues from the straight sinus. A retrospective study found that the transverse sinus was symmetrical in 66.9% of cases. In one-third of cases, the left transverse sinus was hypoplastic in 21.3% and aplastic in 4.1%, whereas the right transverse sinus was hypoplastic in 5.5% and aplastic in the remaining 0.7%. The study concluded that the right transverse sinus is dominant over the left. [5] Imaging data of cerebral veins obtained from individuals, excluding cranial sinus and jugular venous diseases, are relatively limited. Therefore, an increasing number of researchers believe it is meaningful to image cerebral veins or venous sinuses in healthy people. [6] Neurologists and radiologists often miss or overdiagnoses cases because of limited access to imaging data. Individual differences can influence the anatomy of the cerebral veins and venous sinuses. The aim of this study is to assess the ability of multiple intracranial anatomical signs on non-contrast enhanced MRI T1-weighted images in anticipation of transverse sinus dominance. Furthermore, to study the normal anatomical variations of the transverse dural venous sinus, as shown by in MRI of patients and evaluate if there are any age- and gender related differences.

Subjects and methods

A retrospective study was carried out at Rizgary Teaching Hospital from January 1st, 2025, to November 1st, 2025. A convenient sample of 100 patients' MRI reports was reviewed. The investigator, with his supervisor's assistance, prepared a questionnaire. The first section of the questionnaire included gender, age, and indications for Magnetic Resonance Imaging. Signs and symptoms such as headache, headache with vertigo, seizure, headache and vomiting, dizziness, altered sensorium, and forgetfulness were documented. The groove for the superior sagittal sinus (g SSS), whether left or right, double-channel superior sagittal sinus (DC-SSS), or flat (non-lateralisation), was recorded. The predicted laterality of the dominant transverse sinus (TS): right, left, or co-dominant was investigated. The laterality of the SSS flow void: right, left, double, or midline, is also recorded. Posterior falx angulation: whether right, left, or no angulation was assessed. The inferior-most occipital lobe: left, right, or equal was evaluated. MRI images were assessed for anatomical variations of dural venous sinuses, including the superior sagittal, sigmoid, transverse, straight, and occipital sinuses. Standard variations of the transverse and sigmoid sinuses were noted, such as symmetry, hypoplasia, aplasia, or atresia. Transverse sinuses were measured one cm from the Torcula heterophili, and sigmoid sinuses were measured one cm from the transverse-sigmoid junctions. Their linear measurements were compared with the superior sagittal sinus. If the measurement was less than half the size of the superior sagittal sinus, it was considered hypoplastic; if not visible, it was considered aplastic. The TS cross-sectional area was measured on non-contrast sagittal 2-dimensional time-of-flight images and served as the reference standard.

Patients who underwent brain MRI for suspected cerebral venous sinus thrombosis, headache, or suspected vascular causes were included. Exclusion criteria included patients with dural venous sinus thrombosis, a history of previous surgery, lesions, or congenital absence of the sinuses.

Statistical analysis: The data were entered into an Excel spreadsheet and then analysed in SPSS version 26. Categorical data was tested with the Chi-square test, and numerical data with the t-test. A P-value ≤0.05 was considered significant. The Kappa score and the Pearson correlation coefficient were calculated.

Ethical consideration: The study was approved by the Kurdistan Board for Medical Specialisation. Verbal informed consent was obtained separately from each patient, and confidentiality was assured.

Results

Table 1 illustrates the relationship between gender and MRI indications. The prevalence of females presenting with headaches was higher than that of males, at 75% compared to 67.5%. Headache and vomiting were more common in males (25%) than in females (15%). Vertigo and dizziness were more frequently observed in females (31.7%) than in males (17.5%). Those presenting with headache and vertigo were more often males (30%), whereas females reported a lower figure (26.7%). The frequency of seizures, altered sensations, and mood disorders among males was 35%, 30%, and 10%, respectively. These differences were not statistically significant except for seizures (p=0.019).

Table 1: Indications for (MRI) by gender

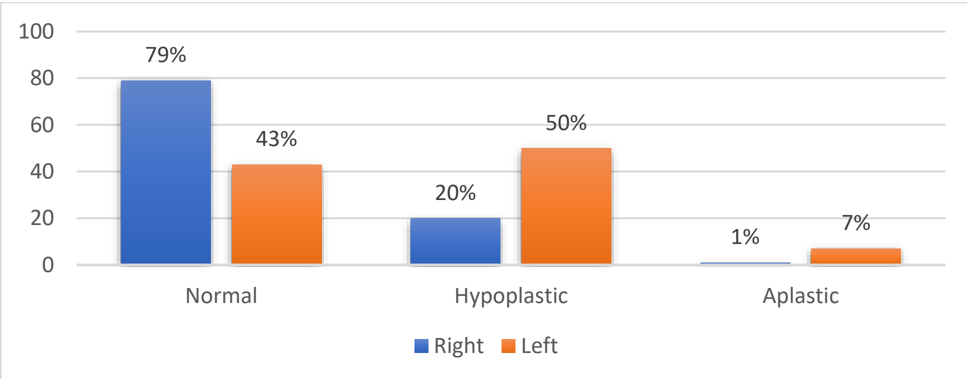
Symptoms	**Males No=40**	**Females No=60**	**Total Total=100**	**Chi-square test P-value**
	No(%)	No(%)	No(%)	
Headache	27(67.5)	45(75)	72(72)	0.276
Headache and vomiting	10(25)	9(15)	19(19)	0.326
Vertigo and dizziness	7(17.5)	19(31.7)	26(26)	0.078
Headache and vertigo	12(30)	16(26.7)	28(28)	0.443
Seizures	14(35)	9(15)	23(23)	0.019
Altered sensation	12(30)	13(21)	25(25)	0.239
Mood disorders	4(10)	14(23.3)	18(18)	0.073

In Table 2, a statistically significant difference was not reported between gender and the TS symmetrical and asymmetrical variations. The prevalence of asymmetry was 85% in males compared to 81.7% in females. The p-value was 0.440.

Table 2: The distribution of the studied sample by gender and symmetrical and asymmetrical transverse sinus

TS	Male 40	Female 60	Total 100	P-value
	No(%)	No(%)	No(%)	
Asymmetrical	34(85)	49(81.7)	83(83)	0.440
symmetrical	6(15)	11(18.3)	17(17)	

Figure 1: Distribution of the studied sample by anatomical variations of left and right transverse sinus (normal, hypoplastic and aplastic).

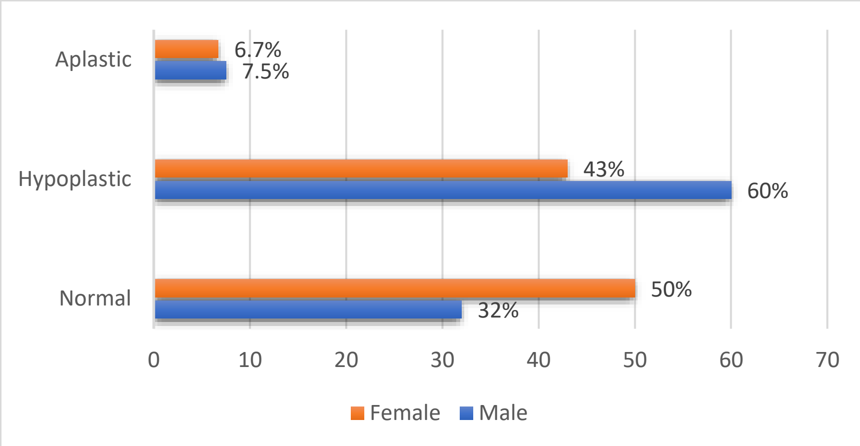


The prevalence of left hypoplastic transfer sinus was more than that of right hypoplastic transfer sinus.
In this Table 3, the highest predictive value (96%) for diagnosing the laterality of the dominant TS was reported by gSSS inclination, with an interobserver reliability of 0.82. SSS flow-void laterality had the second-highest reliability for determining TS dominance, at 92%. A non-significant predictive value was observed in cases with a flat gSSS inclination and a non-lateralised SSS flow void. A higher degree of agreement was noted between the measurements and anatomical features in predicting TS dominance. The kappa for gSSS and SSS flow void was 0.82 and 0.77, respectively.

Table 3: Prevalence, Positive Predictive Value (PPV), and Inter-Rater Reliability (Kappa scores) of the anatomical features of interest (groove for the superior sagittal sinus and superior sagittal sinus flow void laterality)

Anatomic features that were measured	The prevalence of the findings (Total sample 100)	The dominant TS Predicted laterality	PPV (positive predicted value)	Kappa score and P value
gSSS inclination			**96% (89/93)**	**Kappa=0.82** p<0.001
Right	65	Right	97% (63/65)	
Left	24	Left	92% (22/24)	p<0.001
DC-SSS	3	NA	NA	
Flat	4	Codominant	25% (1/4)	p=0.78
SSS flow void laterality			92% (86/93)	Kappa=0.77
Right	66	Right	95% (63/66)	p<0.001
Left	25	Left	88% (22/25)	p<0.001
DC-SSS	1	NA	NA	
Midline	2	Codominant	0% (0/2)	p = 0.14

Figure 2: Left transvers sinus by gender



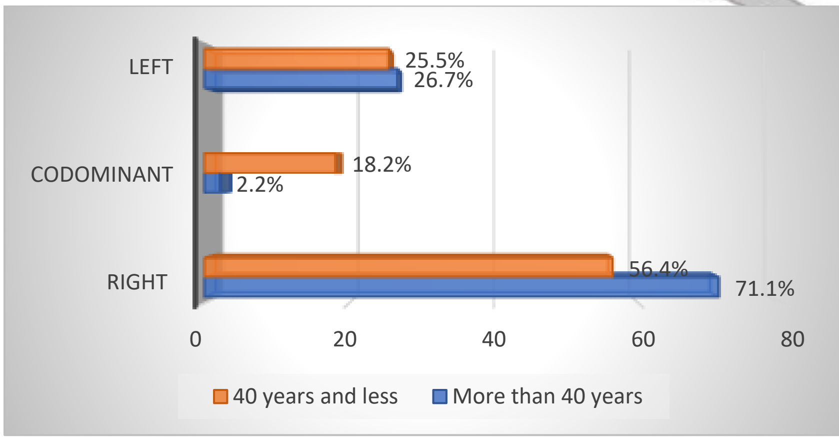
The prevalence of hypoplastic left TS was 60% among males and 43% among females. The difference was not statistically significant (p=0.216).

Table 4: Prevalence, Positive Predictive Value (PPV), and Inter-Rater Reliability (Kappa scores) of the anatomical features of interest (Posterior falx angulation and Inferior-most occipital lobe).

Anatomic features that were measured	The prevalence of the findings (Total sample 100)	The dominant TS Predicted laterality	PPV (positive predicted value)	Kappa score and P value
Posterior falx angulation			**75% (75/100)**	**Kappa=0.79** p<0.001
Right	67	Right	87% (58/67)	p<0.001
No-angulation	19	Co-dominant	16% (3/19)	P = .23
Left	14	Left	93% (13/14)	p<0.001
Inferior-most occipital lobe			**83% (83/100)**	**Kappa=0.80** p <0 .001
Left	73	Right	88% (64/73)	p < 0.001
Right	19	Left	84% (16/19)	**p < 0.001**
Equal	8	Co-dominant	25% (2/8)	p = .61
TS dominance			NA	**Kappa=0.94**
Right	68		NA	
Left	29		NA	
Codominant	3		NA	
NA (not applicable)				

Table 4 shows the laterality of the lowest part of the occipital lobe and the angulation of the posterior Falx. The falx was less accurate in predicting TS dominance, with PPVs of 83% and 75%, compared to the two previous anatomical features (gSSS Inclination and SSS flow-void laterality). A non-angulated posterior falx and occipital lobes with equal inferior excursion were not significant in determining the laterality of the dominant TS. The occurrence of these anatomical features was the lowest.

Figure 3: Distribution of the TS dominance by age groups



The prevalence of rightward deviation of TS was 71% among those aged 40 years and older and 56.4% among those aged less than 40 years. The p-value was significant (0.032).

Table 5 shows the positive relationship between the right dominance of TS and the rightward deviation of the posterior falx, a more inferiorly positioned left occipital lobe, and a gSSS sloping down to the right, along with the right-sided positioning of the SSS flow void. A right-dominant TS is positively associated with the rightward angulation of the posterior falx, with the Pearson correlation coefficient being r=0.59. The laterality of the inferior-most occipital lobe to the right also correlates positively with TS dominance (r=0.59). Likewise, the rightward angulation of the posterior falx in relation to the inclination of gSSS shows a positive correlation (r=0.79). An inclination sloping to the right, designated as positive, is associated with right-sided flow-void positioning, with a correlation coefficient of r=0.86.

Table 5: Pearson correlation coefficient of the four anatomical features that predict TS dominance.

	Transverse sinus dominance to the right	**Angulation of posterior falx to the right**	**Laterality of inferior-most occipital lobe to the right side**	**Inclination of gSSS**	**SSS flow void laterality to the right**
Transverse sinus dominance	1				
Angulation of posterior falx	0.59	1			
Laterality of the inferior-most occipital lobe	0.59	0.62	1		
Inclination of gSSS	0.73	0.79	0.59	1	
SSS flow void laterality	0.79	0.71	0.65	0.86	1

Discussion

In the current study, 60% of participants were female, and 40% were male. They presented with headache (75%), headache and vomiting (19%), vertigo and dizziness (26%), headache and vertigo (28%), seizures (23%), altered sensation (25%), and mood disorders (18%).

A study in India revealed the most frequent reason for MRV was headache (75.4%). Seizures
(5.3%), headache and vertigo (13.1%), headache and vomiting (3.2%), vertigo (2%), abnormal sensorium (0.5%). [7] The symmetrical transfer sinus was reported in 17% in the current study, while a previous study in India reported a much higher figure, 56.7%. [8]

A study in Egypt revealed that two-thirds had normal, symmetrical transfer sinuses (67.2%) and only one-third had asymmetrical transfer sinuses (32.8%). The gender variation was not reported among the cases, but the asymmetry was more prevalent among females (17%). [9]

Hypoplastic left TS was the most common anatomical variation in 50% of the present study, while the Indian study revealed a lower figure (31.8%). [8] The hypoplastic left TS was more prevalent among males 60% in the present study, while the females were 43.3%. The difference was not statistically significant; similar to a previous study in India, left-sided TS hypoplasia was more prevalent among males than females (24.9% vs 19.3%). [7]

The study demonstrated that the gSSS appears as a focal prominence in the midline posterior calvarium. This anatomical feature strongly suggests TS laterality. The landmark resembles the Rock of Gibraltar; therefore, it was named the 'Gibraltar sign'. [10] In this study, a rightward slope was associated with right-dominant TS (97%). The left-sided gSSS predicted left TS (92%). The sign was observed in 89 out of 100 cases and was absent in 11. The flow void for the SSS was identified at the attachment point of the posterior falx to the calvarium. The laterality of this flow void can also serve as a highly accurate anatomical marker for predicting congenital TS. In this study, four anatomical features were used to indicate the laterality of the dominant TS. The gSSS and flow void reported the highest predictive values of 96% and 92%, respectively. The other two anatomical landmarks, the angulation of the posterior falx and the laterality of the inferior-most occipital lobe, were less reliable. The positive predictive values for both were 75% and 83%, respectively.

In the current study, a rightward angulated posterior falx and a more inferiorly positioned left occipital lobe were both Petalia-related imaging findings. Both anatomical features showed a strong correlation (Pearson correlation coefficient) with rightward lateralisation of TS. This could be explained by a congenitally dominant left parietal lobe, leading to caudal and rightward deviation of the left occipital lobe and a rightward deviation of the posterior falx. [11]

The higher prevalence of right TS could be explained by anatomical variations in the sinuses, such as the relatively larger SSS, which drains mainly into the right TS, and the relatively smaller straight sinus, which empties into the left TS. A shorter pathway exists between the right atrium and the right internal jugular vein. The resistance to venous flow on the right side will be lower than on the left, indicating a longer pathway for the left brachiocephalic vein. The right TS distends more during development due to its direct in-line exposure to the hammer effect of right atrium pulsation. [12] Petalia-related caudal positioning of the left occipital lobe produces a compressing effect on left TS during development, leading to hypoplasia of left TS. The evaluation of TS dominance will help diagnose any underlying pathological condition, if present, such as TS thrombosis. The suspicion of right TS thrombosis will increase in the presence of a small right TS with g-SSS that slopes to the right. [12]

A study in Turkey found that among participants with rightward bending of the occipital patella, 72% had a larger TS on the right. The direction of bending was predictive of TS dominance on the ipsilateral side, with PPVs of 72% for right and 70% for left. [13] This figure is lower than the current study's findings (84% PPV for right vs 88% for left).

A recent study in Baghdad assessed the significance of anatomical indicators in predicting TS dominance. The positive predictive value (PPV) for gSSS and the flow-void direction of the superior sagittal sinus towards the right were both notably high, at 95.5% and 93.2%, respectively. Right-sided angulation of the posterior flax and the rightward orientation of the occipital lobe also exhibited a positive predictive value of 90.9%. [14] The findings aligned with those of the current study for gSSS and flow void SSS, but the current results were lower for angulation of the posterior flax (75%) and the laterality of the inferior-most occipital lobe (88%).

A group of reviewers evaluated the occipital lobe bending and the Gibraltar sign of the SSS groove on axial T2-weighted images. Of the 51 subjects with right-dominant TS, 37 out of 51 (72%) exhibited occipital bending to the right, and 35 out of 51 (68.6%) showed a sloping of the gSSS to the right. They demonstrated that right TS dominance was strongly associated with right-sided occipital bending. [15] In the current study, 83% of TS dominance was predicted by occipital lobe bending. Researchers did not conclude whether occipital bending is an anatomic variation or a functional phenomenon with practical implications. However, patients with psychiatric diseases like major depressive disorder, schizophrenia and bipolar affective disorder are more likely to present with occipital bending than healthy controls. [16]

The current study reported a statistically significant relationship between age group and MRI abnormalities of the TS. A study in Egypt reported no significant difference in TS abnormalities across age groups. [17] A more recent study in Egypt showed a significant difference between age groups with TS abnormalities; 27.3% vs 11.4% in age groups >40 years and ≤ 40 years, respectively (p=0.041). [18]

A study in Bangladesh found symmetrical transverse sinuses in 38% of participants, whereas the current study reported a much lower figure (17%). Among the variations of the transverse sinuses, the left-sided hypoplastic transverse sinus was found in 17.1% of participants in the Bangladeshi study, and the right-sided hypoplastic transverse sinus in 2.9%. [19]

While the present study showed different figures, the right-sided hypoplasia was 20%, and the left-sided hypoplasia was 50%.

The morphology of the venous sinus was evaluated in Turkey. They reported a 16.5% frequency of variation in the right transverse sinus. Hypoplasia was observed in 30 patients, while aplasia remained in three patients. The frequency of variation of the left transverse sinus was 29.5%. Hypoplasia was detected in 56 patients, while aplasia was detected in three patients. [20]

The conventional MRI images were successful in diagnosing thrombosis, with sensitivities and specificities of 79.2% and 89.9%, respectively. [21]

These variations have practical implications, especially in the presence of neurological features, as they may be misdiagnosed as pathological conditions such as thrombosis. [18]

The study has certain limitations, including selection bias: patients were included rather than healthy individuals, despite the exclusion criteria. Only one health centre was involved; therefore, the findings cannot be generalised to other health facilities. Nevertheless, the study has some strengths, including being the first conducted in the Kurdistan region of Iraq.

Conclusion and recommendations

Several anatomical features visible on MRI can predict TS dominance laterality. Right TS dominance is suggested by a gSSS that slopes downward to the right, with the SSS flow void aligned to the right of the more prominent, rightward angulation of the posterior falx, and a more inferiorly positioned left occipital lobe. The gSSS resembles the shape of the Rock of Gibraltar; its orientation to the right or left is strongly associated with and highly predictive of right- and left-sided TS dominance laterality. These anatomical features will help inform the interpretation of future brain MRV studies. Further studies with a larger sample size are recommended.

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