ISTANBUL UNIVERSITY PRESS
RESEARCH / ARAŞTIRMA
DOI: 10.26650/IUITFD.1520388
İst Tıp Fak Derg 2025 / J Ist Faculty Med 2025

EVALUATION OF THE FALX CEREBRI FROM THE PERSPECTIVE OF THE FENESTRA AND ITS POSSIBLE CLINICAL OUTCOMES

FALX CEREBRİ'NİN FENESTRA PERSPEKTİFİNDEN DEĞERLENDİRİLMESİ VE OLASI KLİNİK SONUÇLARI

Latif SAĞLAM[1], Melis BAYRAM[2], Özcan GAYRETLİ[1], Osman COŞKUN[1], Ayşin KALE[1], Adnan ÖZTÜRK[3]

[1]İstanbul University, İstanbul Faculty of Medicine, Department of Anatomy, İstanbul, Türkiye
[2]İstanbul University, İstanbul Faculty of Medicine, Student, İstanbul, Türkiye
[3]İstanbul Health and Technology University, Faculty of Medicine, Department of Anatomy, İstanbul, Türkiye

ORCID IDs of the authors: L.S. 0000-0001-6796-7484; M.B. 0009-0008-1472-0507; Ö.G. 0000-0001-7958-3170; O.C. 0000-0002-0337-4927; A.K. 0000-0002-2305-420X; A.Ö. 0000-0002-5819-0543

Cite this article as: Sağlam L, Bayram M, Gayretli Ö, Coşkun O, Kale A, Öztürk A. Evaluation of the falx cerebri from the perspective of the fenestra and its possible clinical outcomes. J Ist Faculty Med 2025;88(1):20-25. doi: 10.26650/IUITFD.1520388

ABSTRACT

Objective: The human falx cerebri is an important anatomical structure due to the hemispheres it is adjacent to and the dural venous sinuses it contains. It is also an important landmark in determining the midline in the interhemispheric transcallosal approach for lateral and third ventricular tumours in neurosurgical practises. Thus, the goal of this cadaveric study was to investigate the existence, number, and topography of fenestra on the falx cerebri in the Turkish population.

Material and Methods: For this study, 60 adult Turkish cadaveric dura maters were examined. The number of falx cerebris and the existence and topography of fenestra on the falx cerebri was determined. The length and width of the fenestra were measured using a digital compass.

Result: All falces cerebrum were single, and no double or triple falx cerebri were observed. There was fenestra on the falx cerebri in five cases (8.3% of all cases), and two of them included multiple foramina (%40 of all fenestrae). In addition, one fenestra was on the middle part of the falx cerebri, whereas the other was placed on the posterior part of this partition. The mean length and width of these fenestrae were 23.3x7.5 mm.

Conclusion: The novel findings documented in this study may be important to increase the success rate of diagnostic and operative procedures of the falx cerebri or adjacent structures and to minimise intraoperative complications during neurosurgical applications.

Keywords: Falx cerebri, fenestra, topography, variations, neurosurgical applications

ÖZET

Amaç: İnsan falx cerebri'si, komşu olduğu hemisferler ve içerdiği dural venöz sinüsler nedeniyle önemli bir anatomik yapıdır. Ayrıca, nöroşirürji uygulamalarında lateral ve üçüncü ventrikül tümörleri için interhemisferik transkallozal yaklaşımda orta hattın belirlenmesinde önemli bir landmarktır. Bu nedenle, mevcut kadavra çalışmasının amacı, Türk toplumunda falx cerebri üzerindeki fenestra varlığını, sayısını ve topografyasını araştırmaktı.

Gereç ve Yöntem: Bu çalışma için 60 yetişkin Türk kadavra dura mater'i incelendi. Falx cerebri sayısı, falx cerebri üzerinde fenestra varlığı ve fenestranın topografyası belirlendi. Fenestranın uzunluğu ve genişliği dijital kaliper kullanılarak ölçüldü.

Bulgular: Falces cerebrorum'un tamamı tekli olup, ikili veya üçlü falx cerebri gözlemlenmedi. Beş olguda (tüm olguların %8,3'ü) falx cerebri üzerinde fenestra vardı ve bunların ikisinde çoklu foramenler (tüm fenestraların %40'ı) vardı. Ayrıca fenestralardan biri falx cerebri'nin orta kısmında, diğeri ise bu bölümün arka kısmında yer alıyordu. Bu fenestraların ortalama uzunluğu ve genişliği 23,3x7,5 mm idi.

Sonuç: Bu çalışmada belgelenen yeni bulgular, falx cerebri veya komşu yapılara yönelik tanısal ve operatif prosedürlerin başarısını artırmak ve nöroşirürji uygulamaları sırasında intraoperatif komplikasyonları en aza indirmek için önemli olabilir.

Anahtar Kelimeler: Falx cerebri, fenestra, topografya, varyasyonlar, nöroşirürji uygulamaları

Corresponding author/İletişim kurulacak yazar: Latif SAĞLAM – latif.saglam@istanbul.edu.tr

Submitted/Başvuru: 22.07.2024 • **Revision Requested/Revizyon Talebi:** 25.07.2024 •
Last Revision Received/Son Revizyon: 19.10.2024 • **Accepted/Kabul:** 04.11.2024 • **Published Online/Online Yayın:** 17.01.2025

INTRODUCTION

The falx cerebri, a sickle-shaped partition of the meningeal cranial dura mater, lies in the longitudinal fissure between the two cerebral hemispheres, with a narrow anterior end and a broad posterior part (1). This large fold is anteriorly fixed to the crista galli of the ethmoid bone and blends posteriorly with the upper surface of the tentorium cerebelli (1, 2). The convex superior margin of the falx cerebri is attached to the internal cranial surface on either side of the midline, and this attachment runs as far posteriorly as the internal occipital protuberance (1, 2). The superior sagittal sinus runs along a slight cranial groove in the midsagittal plane, and the falx cerebri is attached to the lips of this groove. The lower free edge of the falx lying on the corpus callosum is concave and contains the lower sagittal sinus (1, 3).

Anatomical variations of the falx cerebri are very rare. These variations include complete ossification of the human falx cerebri, absence or total agenesis of the falx cerebri, agenesis of the anterior falx cerebri, and fenestrated falx cerebri (4-10).

The falx cerebri is an important neurosurgical landmark that helps to find the midline of the cranial cavity in the anterior interhemispheric transcallosal approach in the excision of cerebral tumours (10, 11). Therefore, fenestrations of the falx cerebri may confuse in finding the midline (7). Additionally, fenestrations in the falx cerebri, for example after head trauma, may be misinterpreted by radiologists or neurosurgeons as resulting from head trauma (11). Another beneficial function of the falx cerebri is thought to act as a barrier for subdural haemorrhage to cross the midline (8). Hence, a large fenestration may allow potential subdural haematomas to cross the midline.

Because it restricts the movement of the brain and reduces deformation along the midline, the shape, rigidity, and position of the falx cerebri are important (12). It has been reported that the falx cerebri may cause strain, especially on the corpus callosum, during impact (13). Therefore, it has been emphasised that changes in the dimensions of the falx can change the stress distribution within the skull (14).

Although previous studies provide a baseline for the understanding and identification of fenestrations on the falx cerebri, research studies investigating fenestrated falx cerebri are very scarce (15, 16). In that context, the aim of this anatomical study was to analyse the existence, number, and topography of the fenestra on the falx cerebri in the Turkish population, which could be important for neurosurgeons and neuroradiologists.

MATERIAL AND METHODS

The present study included a sample of 60 adult Turkish cadaveric dura maters (age and sex were unknown) fixed with a formaldehyde-phenol-glycerine-ethanol mixture in the Department of Anatomy at İstanbul University, İstanbul Faculty of Medicine. None of the cases had any evidence of gross pathology or previous surgical procedures. The exclusion criteria were visibly injured, ruptured falx cerebri, and falx cerebri with pathology or deformity. The number of falx cerebri, the presence of fenestra and the topography of fenestra on the falx cerebri was determined. The length and width of the fenestra were calculated. Additionally, the falx cerebri height (FCH) was measured as the shortest perpendicular distance from the distal point of the great cerebral vein to the lateral border of the superior sagittal sinus (Figure 1). A single author performed the measurement three times to provide intraobserver reliability, and the mean value per parameter was recorded in the final calculation of the statistics. A digital calliper accurate to 0.01 mm (INSIZE Co., Ltd., Taiwan) was used for the measurement. The morphometric parameters were noted in mm. The Clinical Research Ethical Committee of İstanbul Faculty of Medicine approved the study (IRB (Date: 09.08.2024, No: 15).

Statistical analysis

IBM SPSS Statistics version 21.0 was employed for the acquired data evaluation and analysis (IBM SPSS Corp., Armonk, NY, USA). Descriptive statistics for categorical variables were presented as frequencies (n) and percentages (%), while continuous variables were summarised using means and standard deviations (SD) or medians with corresponding ranges (minimum-maximum), depending on the distribution of the data. Since there were no two independent group variables such as gender in our data set, comparisons of the falx cerebri measurements could not be made.

RESULTS

No duplications or abnormalities in the falx cerebri were found, and the dural venous sinuses did not exhibit struc-

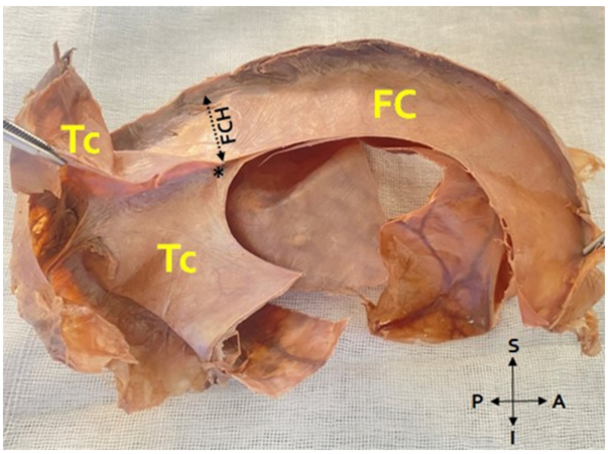

Figure 1: The falx cerebri height (FCH), falx cerebri (FC), tentorium cerebelli (Tc), anterior (A), posterior (P), superior (S), inferior (I), and distal point of the great cerebral vein (*)

tural anomalies, such as hypoplastic transverse sinuses, variations in the superior sagittal sinus (SSS), or occipital sinus abnormalities. The mean FCH was 53±5.02 mm in 60 dura maters. Fenestra were observed on the falx cerebri in five cases (8.3% of all cases) (Figure 2 a, b; Figure 3 a, b, c), and two of these fenestrae had multiple foramina (Figure 3 b, c) (40% of all fenestrae). One fenestra was located on the middle part of the falx cerebri (Figure 3 a), while the other was situated on the posterior part of this fold (Figure 2 b). The mean length and width of these fenestrae were 23.3x7.5 mm (ranged from 7.8x2.8 mm to 40.3x5.9 mm). The detailed morphological and morphometric data of the falx cerebri are shown in Table 1.

DISCUSSION

Isolated variations of the falx cerebri are extremely rare findings. These variations are usually in the form of fenestration or hypoplasia developing in the anterior part of the falx cerebri. In this paper, all falces cerebrum were single. We did not find publications that reported double or triple falx cerebri in a population in our country or elsewhere. On the other hand, numerous cases, such as bifrontopolar subdural haematoma and absence of the falx cerebri, complete ossification of the human falx cerebri, total agenesis of the superior sagittal sinus and falx cerebri, missing falx, agenesis of the anterior falx cerebri, total agenesis of the

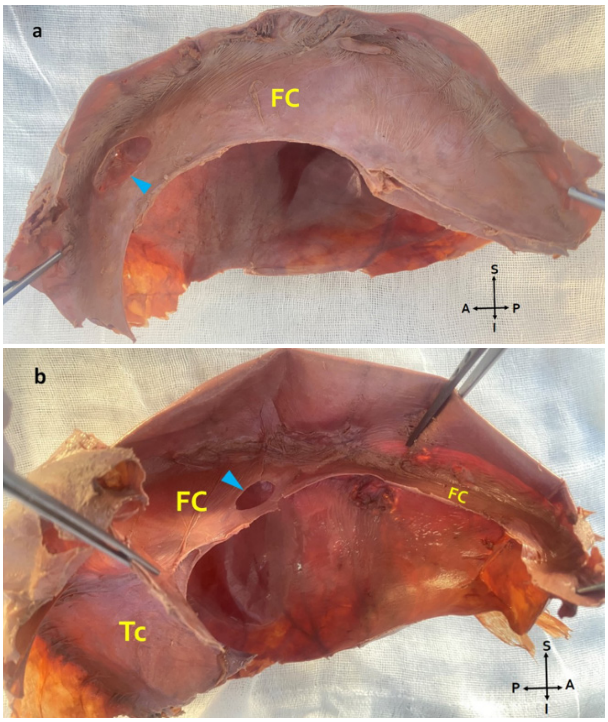

Figure 2: a) Blue arrowhead shows a fenestration located on the anterior part of the falx cerebri **b)** Blue arrowhead indicates a fenestration located on the posterior part of the falx cerebri: falx cerebri (FC), anterior (A), posterior (P), superior (S), inferior (I)

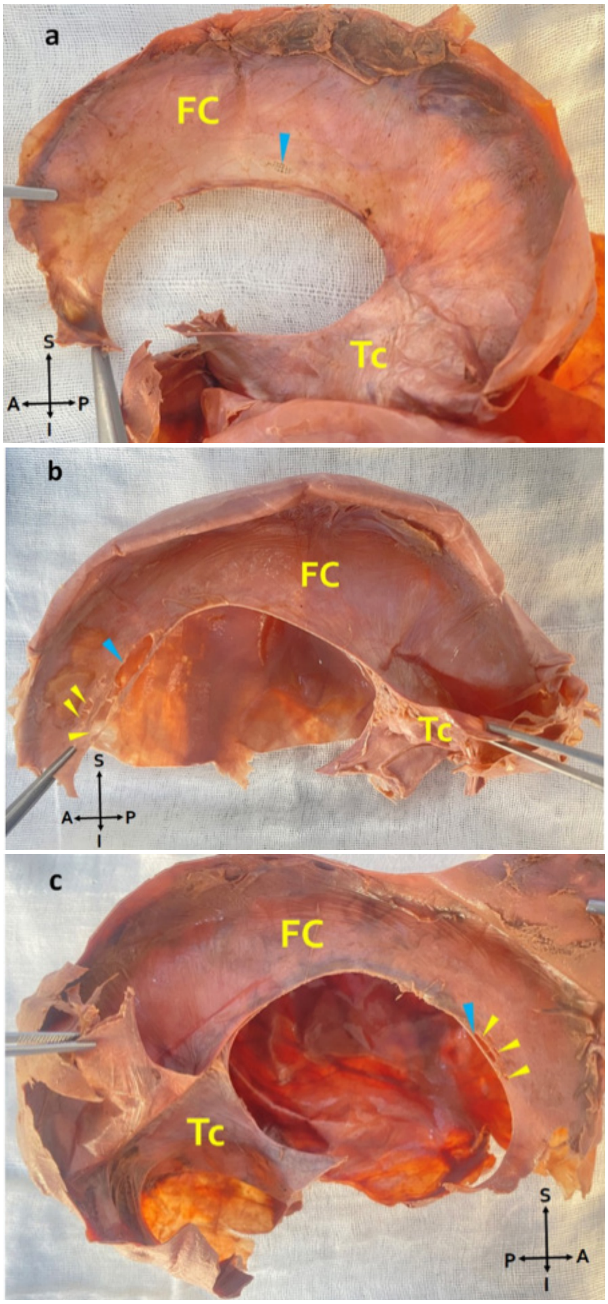

Figure 3: a) Blue arrowhead shows a fenestration located on the middle part of the falx cerebri. **b** and **c)** Blue and yellow arrowheads indicate a fenestration including multiple foramina located on the anterior part of the falx cerebri: falx cerebri (FC), tentorium cerebelli (Tc), anterior (A), posterior (P), superior (S), inferior (I)

falx cerebri with narrowing of the superior sagittal sinus, and fenestrated falx cerebri and additional sinuses in the tentorium cerebelli, have been previously reported in the literature (4-10). Mossman has well shown that falx cerebri and superior sagittal sinus anomalies coexist, as their embryological development is interlinked (17).

Table 1: Detailed morphologic and morphometric properties of the falx cerebri

Cadaver No	The number of falx cerebri	Fenestra(s) on the falx cerebri	Height of the falx cerebri (mm)
1	single	no	46.9
2	single	no	45.1
3	single	no	36.9
4	single	no	46.8
5	single	no	40.4
6	single	no	48.5
7	single	no	41.3
8	single	yes	48.5
9	single	no	43.4
10	single	no	53.3
11	single	no	48
12	single	no	49.9
13	single	no	43.6
14	single	no	44.9
15	single	no	41.9
16	single	no	39.4
17	single	no	49.2
18	single	no	42
19	single	no	40.5
20	single	no	40.1
21	single	no	51.2
22	single	no	46.7
23	single	no	46.5
24	single	no	48.5
25	single	no	41.9
26	single	no	42.6
27	single	no	49.7
28	single	no	45.3
29	single	no	40.6
30	single	no	52.3
31	single	no	39.2
32	single	no	46
33	single	no	55.5
34	single	no	55.1
35	single	no	50.5
36	single	no	52.1
37	single	Yes, included multiple foramina	44.1
38	single	yes	46.2
39	single	yes	57
40	single	no	47.9
41	single	no	53.2
42	single	no	47.3
43	single	no	54.4
44	single	no	41.6
45	single	no	40.2
46	single	no	49
47	single	no	49.5
48	single	no	39
49	single	no	51.2
50	single	no	55.4
51	single	no	41.4
52	single	no	47.8
53	single	no	49.5
54	single	no	50.6
55	single	Yes, included multiple foramina	46.4
56	single	no	50
57	single	no	48
58	single	no	44.1
59	single	no	35.1
60	single	no	48.6

mm: millimetre

Galligioni et al. evaluated 200 selected adult carotid angiograms in which the inferior longitudinal sinus was visualised (18). Because this sinus was located in the posterior two-thirds of the free margin of the falx, they used the position of this sinus to measure the height of the falx cerebri at different points. They determined three lines, A, B, and C, starting from the tuberculum sellae and extending to the inner side of the skull from front to back. Line A defined the linear line extending to the inside of the skull at the bregma. Line B represents the linear line drawn from line A at a 30-degree angle and extending to the inside of the skull. Line C refers to the linear line crossing the proximal end of the great cerebral vein extending to the inside of the skull. They named the distances (height of the falx cerebri) extending from the points where these lines intersect the inferior longitudinal sinus (the free lower edge of the falx cerebri) to the inside of the skull as lines a, b, and c from anterior to posterior. They reported that these heights varied from 28 to 48 mm at the anterior (a), 41 to 62 mm at the middle (b), and 40 to 62 mm at the posterior points (c).

In their study performed on 52 adult Turkish cadaver specimens, Kayalioglu et al. classified the height of the falx cerebri into 3 types based on the study of Jiang and Jia (15, 16). They found that the mean falx cerebri height from its free edge towards the splenium of the corpus callosum was 45.6±3.6 mm in type I, 47±4.7 mm in type II, and 44.1±2.7 mm in type III. Their findings are close to those presented in research by Dausacker, performed on cadaveric specimens (19).

Staquet et al. investigated the height of the falx cerebri in 40 anonymous brain CT scans (14). They determined this height as the part of a linear line starting from the midpoint of the clinoid process, passing through the tentorial apex, and extending to the upper edge of the falx cerebri, between the tentorial apex and the upper edge of the falx cerebri. Consequently, they reported that the height of the falx cerebri varied between 29 and 48 mm. The average height (FCH) was 46.53±5.07 mm in our study, and the measurement is compatible with the results reported by Galligioni et al., Kayalioglu et al., and Staquet et al. (14, 16, 18).

The height of the falx cerebri is important in the resection of tumours of the region (16). Consequently, we believe that our mean FCH value may guide a safe surgical approach to the great cerebral vein, the beginning of the straight sinus, or the end of the inferior sagittal sinus. In addition, FCH may be beneficial for neurosurgeons for treating lesions involving the relevant region.

The last edition of Gray's Anatomy stated that the anterior part of the falx cerebri may have some irregular perforations (1). Jiang and Jia, in their study, conducted on 100 Chinese foetus cadaveric specimens, observed natural defects in 31% of their cases. The length and width of the defects varied from 0.6x0.3 to 2.7x1.4 cm, most often approximately the size of a bean. They also pointed out that other types consisting of smaller and scattered peasized spaces or even sieve-like spaces might be detected (15).

Kayalioglu et al. reported natural defects in 12 (23%) of their specimens (16). In their study on Turkish specimens, the sizes of the defects ranged from 0.31x0.18 cm to 1.7x0.7 cm. In both studies, most defects were on the anterior part of the falx cerebri, and most were round or oval in shape. Nayak and Vasudeva, in their report on a case of fenestrated falx cerebri and additional sinuses in the tentorium cerebelli, determined that the anterior part of the falx cerebri (4 cm behind the crista galli) had fenestrations and looked like a mesh (10). We observed fenestra in five cases (8.3% of all cases) on the falx cerebri (Figure 2 a, b; Figure 3 a, b, c), and two of the fenestrae included multiple foramina (40% of all fenestrae) (Figure 3 b, c). The vast majority of fenestrations (60%) were located on the anterior part of the falx cerebri, with two exceptions, one on the middle (20%) (Figure 3 a) and the other on the posterior part (20%) (Figure 2 b). The mean length and width of the fenestrae were 23.3x7.5 mm (ranged from 7.8x2.8 mm to 40.3x5.9 mm). Our results do not correspond to those presented in the investigations by Jiang and Jia and Kayalioglu et al. (15, 16). The different number of specimens and/or ethnicity may influence the different results.

Although the rate of fenestrae in this study was less than that in previous studies, it was obtained at a significant rate (8.3%). Interestingly, unlike previous studies, the shape of nearly half of the fenestrae (40%) resembled a mesh-like structure. In this context, radiologists may misinterpret fenestrae and that knowledge of the unusual topography of the fenestrae in the posterior part of the falx cerebri may prevent diagnostic confusion. For example, a patient with a fenestration who presents to the emergency room with a head injury may have their radiographs mistakenly considered as being due to head trauma and may be subject to unnecessary applications.

Crucial vascular networks and functionally significant neural structures surround tumours in the lateral and third ventricles. The microsurgical excision of these tumours necessitates meticulous preoperative planning. The interhemispheric transcallosal approach is also one of the surgical options for the excision of these tumours. The falx cerebri serves as an important landmark in determining the midline in the interhemispheric transcallosal approach for lateral and third ventricular tumours (11). The fenestrations may challenge the identification of the midline, both at the onset and during surgery, increasing the risk of inadvertent injury to critical neurovascular structures and vital brain regions (7, 9). Because the sizes of the fenestrae in this study were larger than those in previous studies, we believe that larger fenestrae may make midline orientation seriously difficult, and accordingly, the risk of developing surgical complications may increase. In addition, as larger fenestrae on the falx cerebri were observed in the current study, subdural haemorrhage may easily cross the midline, and potential misdiagnosis may occur.

This study has some limitations; There was no data on the clinical presentation of our cases. If they had, we can show whether fenestration was associated with a particular clinical presentation.

CONCLUSION

In this study, we investigated the morphology of the falx cerebri and documented its isolated variations in the Turkish population. The sizes of the fenestrae were larger, and one fenestra was located posteriorly on the falx cerebri, which was different from those of previous studies. Fenestrations may complicate midline identification in the transcallosal approach for lateral and third ventricular tumours, heightening the potential for unintentional damage to key neurovascular structures and essential brain areas. Additionally, radiologists or neurosurgeons may misinterpret it as developing due to head trauma.

Ethics Committee Approval: Ethics committee approval was received for this study from the İstanbul Faculty of Medicine (Date: 09.08.2024, No: 15).

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- L.S., Ö.G.; Data Acquisition- L.S., M.B.; Data Analysis/Interpretation – O.C., A.K.; Drafting Manuscript- L.S.; Critical Revision of Manuscript- A.K.; Final Approval and Accountability- L.S., M.B., Ö.G., O.C., A.K., A.Ö.; Technical or Material Support- L.S., M.B.; Supervision- A.Ö., A.K.

Acknowledgement: We are eternally grateful to our cadavers for their sacrifice and to their precious families for their patience.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 42nd ed. China: Elsevier Health Sciences; 2021.p.398.
2. Moore KL, Dalley AF, Agur AMR. Clinically Oriented Anatomy. 7th ed. Philadelphia: Lippincott, Williams & Wilkins; 2014.p.865.
3. Hollinshead WH. Anatomy for Surgeons. Volume 1, 3rd ed. Philadelphia: Harper & Row, Publishers, Inc.; 1982.p.9-11.
4. Tubbs RS, Kelly DR, Lott R, Salter EG, Oakes WJ. Complete ossification of the human falx cerebri. Clin Anat 2006;19(2):147-50. [CrossRef]
5. Hudson A. Bifrontopolar subdural hematoma and absence of the falx cerebri. Can Med Assoc J 1965;93(14):761.
6. Kocak B, Hasiloglu ZI, Kizilkilic O, Kocer N, Aydin S, Islak C. Total agenesis of superior sagittal sinus and falx cerebri in a patient who has a subacute subdural hematoma crossing midline: case report. Neurosurgery 2013;72(5):E863-7. [CrossRef]
7. Gupta SK, Aggarwal A. The missing falx: a potential surgical pitfall during interhemispheric transcallosal approach. Acta Neurochir 2017;159(10):1909-11. [CrossRef]
8. Kulkarni AM, Lee SY. Incidentally detected total agenesis of the falx cerebri: Potential significance of this rare finding. Eur J Radiol Open 2019;6:163-4. [CrossRef]
9. Finch NW, Ding D, Oldfield EH, Druzgal J. Agenesis of anterior falx cerebri in patient with planned interhemispheric approach to third ventricle mass. World Neurosurg 2018;109:162-4. [CrossRef]
10. Nayak SB, Vasudeva SK. Fenestrated falx cerebri and additional sinuses in the tentorium cerebelli. J Craniofac Surg 2020;31(6):e585-6. [CrossRef]
11. Cikla U, Swanson KI, Tumturk A, Keser N, Uluc K, Cohen-Gadol A, et al. Microsurgical resection of tumors of the lateral and third ventricles: operative corridors for difficult-to-reach lesions. J Neurooncol 2016;130(2):331-40. [CrossRef]
12. Bradshaw DR, Ivarsson J, Morfey CL, Viano DC. Simulation of acute subdural hematoma and diffuse axonal injury in coronal head impact. J Biomech 2001;34(1):85-94. [CrossRef]
13. Ho J, Zhou Z, Li X, Kleiven S. The peculiar properties of the falx and tentorium in brain injury biomechanics. J Biomech 2017;60:243-7. [CrossRef]
14. Staquet H, Francois PM, Sandoz B, Laporte S, Decq P, Goutagny S. Surface reconstruction from routine CT-scan shows large anatomical variations of falx cerebri and tentorium cerebelli. Acta Neurochir (Wien) 2021;163(3):607-13. [CrossRef]
15. Jiang D, Jia B. Investigation of 100 falx cerebri and tentorium cerebelli. Chin Med J 1980;93(2):107-10.
16. Kayalioglu G, Erturk M, Varol T. Heights of the cerebral falx. Surgical and clinical implications. Neurosciences (Riyadh) 2004;9(4):257-60.
17. Mossman HW. Human embryology: Prenatal development of form and function. Baltimore: Williams & Wilkins; 1972.p.174-525.
18. Galligioni F, Bernardi R, Mingrino S. Anatomic variation of the height of the falx cerebri. Its relationship to displacement of the anterior cerebral artery in frontal space-occupying lesions. Am J Roentgenol Radium Ther Nucl Med 1969;106(2):273-8. [CrossRef]
19. Dausacker J. Praktisch-anatomische Befunde an der mittleren und hinteren Schadelgrube. Würzburg: Medizinische Dissertation; 1974.p.207.