Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2022;39:222-230

Morphological Study of Foramen Venosum in Dry Human Skulls in Northeastern Brazil

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Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT
Introduction: the foramen venosum (FV) is located in the larger wing of the sphenoid bone and allows the passage of emissary veins that help to balance the intra and extracranial pressure. Knowledge of its morphology and associated structures has an important surgical value. Thus, the aim of this study was to analyze the morphology of FV and its relation to adjacent foramina in Northeast Brazil. This study was conducted using a total of 117 human adult skulls of Federal University of Paraíba were classified by gender, FV type and laterality, being evaluated the diameter of FV, foramen ovale (FO) and foramen spinosum (FS), as well as the distance of FO and FS to FV (DFVFO and DFVFS). Values of $p \leq 0.05$ were considered significant. Out of the 117 analyzed skulls, 52 (44.4%) skulls (65 sides, 29 on the right and 36 on the left) presented FV, being 63.46% females and 36.53% males. 33.3% of FV were unilateral and 11.1% were bilateral. The FV were mostly oval (50.7%) and round (49.3%) types. Mean diameter of FV was 3.56±0.7mm, FO 7.88±1.16mm, FS 4.01±0.39mm, DFVFO 8.18±1.09mm and DFVFS was 14.54±1.68mm. Only FO (p=0.009) and FS (p=0.001) had significant differences between genres, and DFVFO had among sides (p=0.021). FV has a high prevalence in Northeast Brazil, predominantly in women on the left side with oval and round types. Its relation with other foramina showed differences among genres and sides. This shows the relevance of the FV study to minimize the risk of iatrogenic injury during surgical interventions in this region.
Keywords: Anatomy; Skull; Brazil; Veins; Foramen Ovale.

Introduction

The foramen venosum (FV), also called sphenoidal emissary foramen or *Foramen of Vesalius*, in honor of the Belgian physician Andrea Vesalius discovery in 1543 [1,2,3], is located in the larger wing of the sphenoid bone, at the level of the middle fossa of the skull. It is inconstant, present in about 40% of individuals and can be displayed unilaterally, bilaterally or duplicated - two FV in the same side[4,5,6,7]. Moreover, the occurrence and morphology of this foramen vary in different regions of the world, as reported by several authors[2,3,6].

This foramen, when present, makes the connection between the pterygoid venous plexus and the cavernous sinus through the access of small veins, called emissary veins[3,8,9]. Valves of those veins help to balance the intra and extracranial pressure. Under normal circumstances, the flow through them is low, however, in cases of increased intracranial pressure, these veins become an important source of blood drainage[6]. In addition, this could collaborate to the infection spreading from the extracranial origin or infratemporal region into the middle cranial fossa[10,11].

Moreover, the FV is close to other foramina that give way to noble structures, such as the foramen ovale (FO), that gives way to the mandibular nerve, accessory meningeal artery and the petrous nerve, and the spinosum foramen (FS), where passes the middle meningeal artery[10,12,13]. Even then, because of that proximity, neurosurgical interventions aimed at the FO or FS can reach the FV and compromise several structures, having clinical implications[1,14,15,16].

Therefore, the aim of this study was to analyze morphological characteristics and morphometrics parameters of FV and their relation to other cranial foramina in Northeastern Brazil to provide anthropological data of this population for safer treatment in this region.

Materials and Methods

The present study was approved by the Ethics and Research Committee of Federal University of Paraiba (number CAAE 28571120.5.0000.5188), where data collection was performed, respecting the willing in Resolution 466/2012, of the National Council of Educational (CNE).

A total of 117 dried human adult skulls without infant conformation, any gross pathology or abnormality that would make the data collection impossible, were

10.51929/jms.39.222.20224
ISSN 2177-0298

analyzed. The skulls were obtained from the Human Anatomy Laboratory of the Federal University of Paraiba (UFPB), located in Northeastern Brazil.

For the evaluation of occurrence of FV, skulls were examined by looking through the inferior view, pictures were taken, and data recorded in Excel's table. After that, all skulls had classified by genre[17] and rated by laterality as unilateral (right or left) or bilateral (Figure 1). The FV had also the type classified as round, oval and irregular according to Raval *et al.*[6] (Figure 2). A digital caliper (Eccofer®, João Pessoa, Paraíba, Brazil) with accuracy of 0.01 mm was used to collect morphometric data of the FV, FO, FS, as well as the distance of FO and FS to FV (DFVFO and DFVFS) (Figure 3) by only one evaluator.

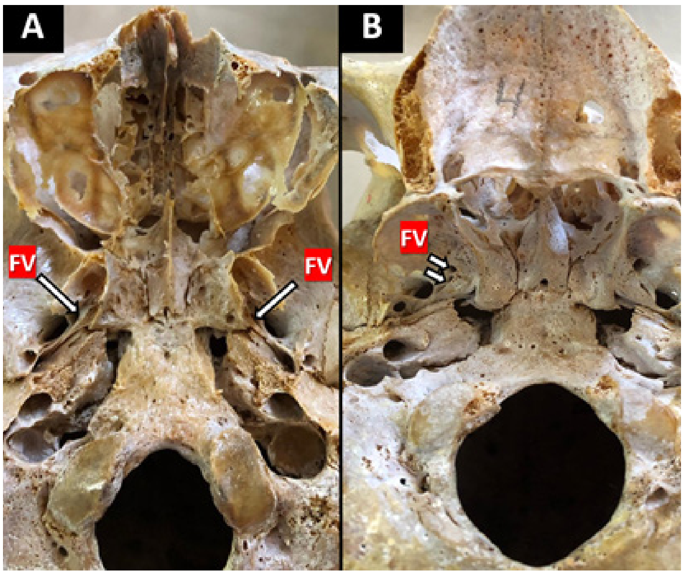

Figure 1. Foramen venosum anatomical variations. A. Bilateral foramen venosum. B. Double foramen venosum. FV – foramen venosum. *Inferior view. (Collection Research)

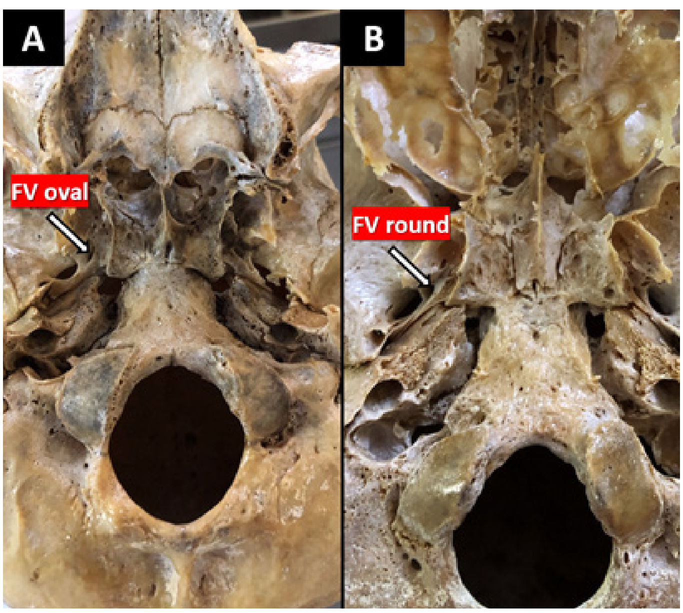

Figure 2. Foramen venosum types. A. Foramen venosum oval. B. Foramen venosum round. FV – foramen venosum. *Inferior view. (Collection Research)

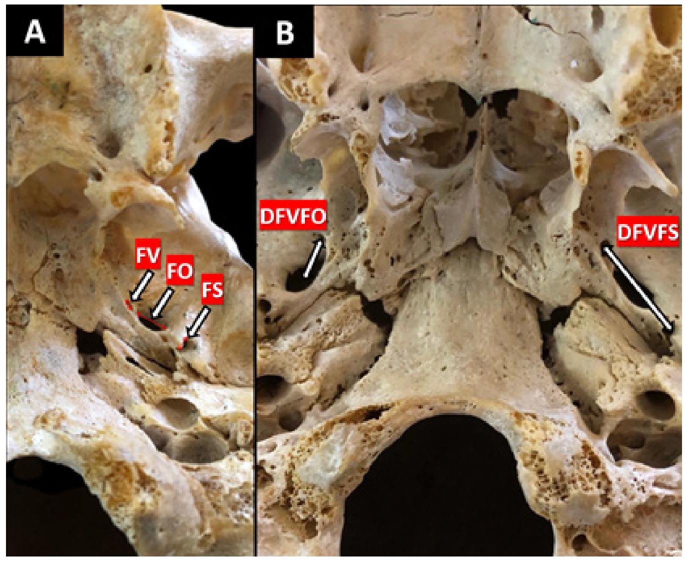

Figure 3. Morphometric analysis. A. Foramina in inferior view. FV – largest diameter of foramen venosum; FO – largest diameter of foramen ovale; FS – largest diameter of foramen spinosum; B. Distance measurements to the foramen venosum. DFVFO - Distance between the center of foramen venosum to the center of foramen ovale; DFVFS - Distance between the center of foramen venosum to the center of foramen spinosum. (Collection Research)

Statistical Analysis

Kolmogorov-Smirnov test was applied to evaluate the normality of the sample. Then, Mann-Whitney Test and Student's T Test was applied to evaluate differences between sexes and sides using SPSS software version 26 for Windows. Values of $p \leq 0.05$ were considered significant.

Results

A total of 117 skulls were used in this study, being 70 from females and 47 from males. Sixty-five (55.55%) skulls, being 37 (31.62%) females and 28 males (23.93%), did not have the foramen venosum. So, the analysis was made in fifty-two (44.45%) skulls (totalizing 65 sides, 29 FV on the right and 36 on the left): 33 (28.2%) females and 19 (16.2%) males with foramen venosum (Table 1).

Table 1. Foramen venosum's laterality percentage in both sexes (N=52 skulls)

Genre	Laterality of Foramen Venosum (%)			TOTAL
	Unilateral		Bilateral	
	Right side	Left side		
Male	6 (5.1%)	10 (8.5%)	3 (2.6%)	19 (16.2%)
Female	10 (8.5%)	13 (11.1%)	10 (8.5%)	33 (28.2%)
Total	16 (13.7%)	23 (19.6%)	13 (11.1%)	52 (44.4%)

FV's laterality was analyzed and 33.3% of the FV were unilateral: 19.6% on the left side (11.1% in females and 8.5% in males) and 13.7% on the right (8.5% in females and 5.1% in males). FV bilateral was found in 11.1% of the skulls, being 8.5% in females and 2.6% in males (Table

1). Only one skull (female) presented a double foramen at the right side (Figure 1).

Regarding the FV classification, it was found 33 with oval type (50.7%): 13.8% in males (3.1% on the right side and 10.7% on the left) and 36.9% in females (16.9% on the right and 20% on the left). We found 32 FV with round type (49.3%): 20% in males (10.7% on the right and 9.3% on the left) and 29.3% in females (13.9% on the right and 15.4% on the left). Irregular type was not found in both sexes (Table 2).

Table 2. Foramen venosum's type percentage in both sexes (N=65 FV)

Types of FV	Male skulls		Female skulls		TOTAL
	Right	Left	Right	Left	
Oval	2 (3.1%)	7 (10.7%)	11 (16.9%)	13 (20%)	33 (50.7%)
Round	7 (10.7%)	6 (9.3%)	9 (13.9%)	10 (15.4%)	32 (49.3%)
Irregular	0%	0%	0%	0%	0%
TOTAL	22 (33.8%)		43 (66.2%)		65 (100%)

About the morphometric parameters, the mean value of FV measurement was 3.56±0.7 mm, being 3.57±0.53 mm (range= 2.60-4.90 mm) on the right side and 3.54±0.81 mm (range= 2.90-4.70 mm) on the left side. In males this value was 3.51±0.42 mm (range=2.80-4.70mm), being 3.62±0.53 mm (range= 2.80-4.70mm) on the right side and 3.43±0.31 mm (range= 2.80-3.90 mm) on the left side. The mean in females was 3.58±0.81 mm (range=2.60-7.80 mm), being 3.56±0.54 mm (range= 2.60-4.90 mm) on the right side and 3.60±1.00 mm (range= 2.90-4.70 mm) on the left side (Table 3). No differences were observed between sexes (p=0.791) and sides (p=0.162).

The mean value of FO measurement was 7.88±1.16 mm (range=6.20-11.0 mm), being 7.96±1.14 mm (range=5.60-10.0 mm) on the right side and 7.81±1.18 mm (range=6.20-11.0 mm) on the left side. In males this value was 8.32±0.94 mm (range=6.60-10.0 mm), being 8.38±1.15 mm (range = 6.60-10.0 mm) on the right side and 8.27±0.80 mm (range= 7.20-10.0 mm) on the left side. The mean for females was 7.66±1.21 mm (range=6.20-11.0 mm), being 7.78±1.12 mm (range= 5.60-9.90 mm) on the right and 7.56±1.30 mm (range= 6.20-11.0 mm) on the left (Table 3). Statistically significant difference was observed between sexes (p=0.009) but not between sides (p=0.677).

The mean value of FS measurement was 4.01±0.39 mm (range=3.30-4.80 mm), being 3.57±0.53 mm (range=3.30-4.80 mm) on the right and 3.54±0.81 mm (range=3.30-4.70 mm) on the left. In males this value was 4.22±0.34 mm (range=3.30-4.70 mm), being 4.08±0.36 mm (range= 3.30-4.50 mm) on the right side and 4.32±0.30 mm (range = 3.80-4.70 mm) on the left. In female skulls the mean value of FS was 3.90±0.37 mm (range=3.30-4.80 mm), being 3.94±0.41 mm (range= 3.30-4.80 mm) on the right side and 3.86±0.33 mm (range=3.30-4.50 mm) on the left side (Table 3). Statistically significant difference was observed between sexes, being higher in males (p=0.001) but not between sides (p=0.653).

The measurements DFVFO and DFVFS presented the following results: the mean of DFVFO was 8.18±1.09 mm, being 8.48±1.09 mm (range=6.50-12.40 mm) on the right and 7.95±1.05 (range=6.40-10.90 mm) on the left. In males the mean was 8.13±1.02 mm (range=6.50-10.10 mm), being 8.42±1.01 mm (range= 6.50-10.10 mm) on the right side and 7.93±1.01 mm (range= 6.60-10.0 mm) on the left side. In females the mean was 8.21±1.14 mm (range=6.40-12.40 mm), being 8.51±1.15 mm (range= 7.50-12.40 mm) on the right side and 7.96±1.10 mm (range= 6.40-10.90 mm) on the left (Table 3). Statistically significant difference was observed between sides (p=0.021) but not between sexes (p=0.978).

In relation to DFVFS measurement was 14.54±1.68 mm (range=10.80-18.20 mm), being 14.98±1.63 (range=11.90-18.20 mm) on the right and 14.19±1.66 mm (range=10.80-17.20 mm) on the left. In males the mean was 14.63±2.04 mm (range=10.90-18.20 mm), being 15.45±2.18 mm (range= 11.90-18.20 mm) on the

Table 3. Mean (mm) ± SD values of foramen venosum measurements in both sexes (N=65 FV)

	MALE				FEMALE			
	Right side		Left side		Right side		Left side	
Para meters	Min- Max	Mean (SD)	Min- Max	Mean (SD)	Min- Max	Mean (SD)	Min- Max	Mean (SD)
FV	2.80-4.70	3.62 (0.53)	2.80-3.90	3.43 (0.31)	2.60-4.90	3.56 (0.54)	2.90-4.70	3.60 (1.00)
FO	6.60-10.00	8.38 (1.15)	7.20-10.00	8.27 (0.80)	5.60-9.90	7.78 (1.12)	6.20-11.00	7.56 (1.30)
FS	3.30-4.50	4.08 (0.36)	3.80-4.70	4.32 (0.30)	3.30-4.80	3.94 (0.41)	3.30-4.50	3.86 (0.33)
DFVFO	6.50-10.10	8.42 (1.01)	6.60-10.0	7.93 (1.01)	7.50-12.40	8.51 (1.15)	6.40-10.90	7.96 (1.10)
DFVFS	11.90-18.2	15.45 (2.18)	10.90-16.8	14.06 (1.80)	12.90-18.1	14.77 (1.33)	10.80-17.2	14.26 (1.61)

FV: largest diameter of foramen venosum; FO: largest diameter of foramen ovale; FS: largest diameter of foramen spinosum; DFVFO: distance between the center of foramen venosum to the center of foramen ovale; DFVFS: distance between the center of foramen venosum to the center of foramen spinosum; N: number of sides with foramen venosum; Min: minimum; Max: Maximum; SD: standard deviation.

right side and 14.06±1.80 mm (range=10.90-16.80 mm) on the left. In females, this mean was 14.50±1.49 mm (range=10.80-18.10 mm), 14.77±1.33 mm (range= 12.90-18.10 mm) on the right side and 14.26±1.61 mm (range=10.80-17.20 mm) on the left (Table 3). No statistically significant difference was observed between sexes (p=0.768) and sides (p=0.060).

Discussion

In the greater wing of the sphenoid bone, several foramina allow the extracranial passage of neurovascular structures, such as foramen venosum (FV), foramen ovale (FO) and foramen spinosum (FS). The FV is an inconstant foramen that has important clinical and surgical implications. Percutaneous interventions directed to the FO, for example, can reach the FV and its structures during punctures[14,15,16]. This can happen in the treatment of trigeminal neuralgia, which is performed by rhizotomy using a trans-oval approach[2,15,18,19].

This demonstrates the importance of carrying out studies involving this foramen and establishing relations with the adjacent structures. The present study not only analyzed the FV morphology and morphometry in a population in the Northeast of Brazil but also associated it, in an original way, with FO and FS to determine possible neurosurgical implications.

The first anatomical description of FV was made by Andrea Vesalius in 1543 on his book "De humani corporis fabrica". He said that this foramen is a rare variation unilaterally and even rarer bilaterally[20]. However, this conflicts with the findings of our study and over times, studies have shown that this prevalence is higher than previously thought.

The present study showed a FV prevalence of 44.4% (higher in female population – 28.2%), most of these were unilateral (33.3%), but we had a considerable prevalence of bilateral FV (11.1%) (Table 1). The prevalence of FV in females was also observed in other studies[2,12,16,21,22,23,24] (Table 4).

Table 4. Comparison of percentage of foramen venosum laterality in different populations.

Population	Genre	N (percentage of FV)	Laterality of Foramen Venosum (%)		
			Unilateral		Bilateral
			Right	Left	
Aviles-Solis *et al.*[37], Mexico	Not specified	5 (20%) Ntotal: 25	2 (8%)	2 (8%)	1 (4%)
Bayrak* *et al.*[23], Turkey	Male: 30 (9.5%) Female: 59 (18.6%)	89 (28.1%); Ntotal: 317	36 (11.4%)	31 (9.8%)	22 (6.9%)
Boyd[28], Scotland**	Not specified	540 (36.5%) Ntotal: 1478	157 (10.6%)	166 (11.2%)	217 (14.7%)
Chaisuksunt *et al.*[11], Thailand	Male	185 (47.7%)	42 (11.1%)	76 (20.2%)	67 (17.8%)
	Female	83 (22%)	23 (6.1%)	41 (10.9%)	19 (5%)
Ginsberg* *et al.*[4], United States of America	Not specified	98 (79.7%) Ntotal: 123	38 (30.9%)	38 (30.9%)	60 (48.8%)
Godas *et al.*[24], Brazil	Male	17 (15.7%) Ntotal: 108	12 (11.1%)	2 (1.8%)	3 (2.8%)
	Female	24 (22.2%) Ntotal: 108	10 (9.2%)	11 (10.2%)	3 (2.8%)
Görürgöz and Paksoy[16], Turkey	Male	74 (28.4%) Ntotal: 260	18 (6.9%)	24 (9.2%)	32 (12.3%)
	Female	116 (44.6%) Ntotal: 260	20 (7.6%)	18 (6.9%)	78 (30%)
Gupta *et al.*[15], India	Not specified	68 (34%); Ntotal: 200	16 (8%)	24 (12%)	28 (14%)
Jadhav *et al.*[7], India	Not specified	72 (28.8%); Ntotal: 250	25 (10%)	19 (7.6%)	28 (11.2%)
Kale *et al.*[25], Turkey	Not specified	156 (44.9%); Ntotal: 347	33 (9.5%)	36 (10.4%)	87 (25.1%)

Murlimanju *et al.*[21], India	Male	11 (14.1%) Ntotal: 78	5 (6.41%)	2 (2.56%)	4 (5.12%)
	Female	18 (23.07%) Ntotal: 78	4 (5.12%)	5 (6.41%)	9 (11.53%)
Lazarus *et al.*[35], South Africa	Not specified	10 (10%); Ntotal: 100	5 (5%)	5 (5%)	-
Leonel *et al.*[27], São Paulo, Brazil	Not specified	77 (45.2%); Ntotal: 170	20 (11.7%)	25 (14.7%)	32 (18.8%)
Maletin *et al.*[31], Serbia	Not specified	60 (34.8%); Ntotal: 172	18 (10.4%)	26 (15.1%)	16 (9.3%)
Nascimento *et al.*[22], North-East of Brazil	Male: 17 (8.7%) Female: 19 (9.8%)	36 (18.5%); Ntotal: 194	6 (3.1%)	18 (9.3%)	12 (6.1%)
Natsis *et al.*[26], Greece	Not specified	78 (40%); Ntotal: 195	14 (7.2%)	22 (11.3%)	42 (21.5%)
Nayak *et al.*[30], Odisha, India	Not specified	9 (30%); Ntotal: 30	0	3 (10%)	6 (20%)
Nirmala and Hema[18], India	Not specified	90 (50%); Ntotal: 180	18 (10%)	30 (16.6%)	42 (23.3%)
Ozer and Govsa[29], Turkey	Not specified	60 (34.8%); Ntotal: 172	18 (10.4%)	26 (15.1%)	16 (9.3%)
Poornima *et al.*[38], India	Not specified	60 (60%); Ntotal: 100	15 (15%)	11 (11%)	34 (34%)
Raval *et al.*[6], India	Not specified	61 (40.6%); Ntotal: 150	12 (8%)	20 (13.3%)	29 (19.3%)
Rossi *et al.*[2], São Paulo, Brazil	Male: 40 (10 FV; 25%) Female: 40 (21 FV; 52.25%)	32 (40%); Ntotal: 80	12 (15%)	9 (11.25%)	11 (13.75%)
Shinohara *et al.*[14], São Paulo, Brazil	Not specified	135 (33.75%); Ntotal: 400	31 (7.75%)	42 (10.5%)	62 (15.5%)
Singh and Sekhon[19], India	Not specified	18 (64.3%) Ntotal: 28	8 (28.5%)	2 (7.2%)	8 (28.5%)
Present study	Male	19 (16.2%); Ntotal: 117	6 (5.1%)	10 (8.5%)	3 (2.6%)
	Female	33 (28.2%); Ntotal: 117	10 (8.5%)	13 (11.1%)	10 (8.5%)

*Radiological studies; **study with humans and animals; N: number of skulls with foramen venosum; Ntotal: total number of skulls analyzed; (-) uninformed; WM: White Male; BM: Black Male; WF: White Female; BF: Black Female.

These general results (44.4% of FV) are close to those found by other researchers[2,6,25,26,27], but the percentages between unilateral and bilateral types are different to our findings (Table 4). Moreover, Vesalius had stated that there is no significant difference in the frequency of foramen Vesalius between unilateral right and left sides[6]. This has been confirmed in recent research, just like ours[11,14,15,16,22,25,26,27,28,29,30,31]. Despite having a slightly higher frequency of the unilateral type on the left side there are no major differences between the sides (Table 4).

In 1931, Wood-Jones, in his study of non-metrical morphological characteristics of the skull as a criterion for racial diagnosis, demonstrated that venous portion of FO tend to become subdivided from the nervous portion by a narrowing of the orifice between compartments (anterior and posterior). This subdivision may proceed to the ingrowing of spicules of bone which may subdivide FO into two parts. The anterior may be regarded as FV. Furthermore, he stated that FV may be present in different ways between the sides or only in one side of the skull: when this occurs, the size of FO is usually different between the sides, being larger on that side without FV[32].

In addition, studies indicate that, when the FV is absent, the emissary vein that should pass through this structure, passes through the FO[33]. Thus, FV can replace the venous outlet of the FO. Despite that, a study[26] concluded that the absence or presence of FV (bilateral or unilateral) has no effect on the size of the FO and the sphenoidal emissary vein does not alter the FO venous component. It is an additional venous pathway. But we did not analyze FO measure in skulls without FV to make this comparison.

It also important to mention that the oval and round types prevalence was very close (50.7% and 49.3%, respectively – Table 2), with difference of only one skull. In the studies analyzed[6,16,23,24], there is no consensus as to the side with the highest prevalence among the types. Another point observed was that they found distances up to 62.2%[23] between these shapes and, in two of these[6,24], the round type was predominant. In another two[16,23] the higher prevalence is in oval and lower in irregular shape, just like us Görürgöz and Paksoy[16] also presented a higher prevalence of the oval type on the left in males (Table 5).

Another point analyzed in this study was the diameters of the FV, FO and FS foramens and the relations (using the distance between these last two to FV) they present among themselves, in view of the proximity of these structures and possible surgical implications. When comparing with other studies, important differences were found in the way of taking measurements.

Some authors used imaging exams[4,16,23,27,34] and others, performed the measurements in dry skulls using a caliper[2,6,14,15,22,28,35,36], like the present study, or photogrammetry[11,29,37] (Table 6). However, the measures fluctuate a lot, even using similar methods to acquire them.

An important data[29] observed that FV with less than 0.5 mm are most reliable and safe for percutaneous techniques. Literature presented variables values in FV diameter, ranging between 0.69[14] -3.62 mm (present study) and with differences between the sides (Table 6). Studies[11,35], like ours, showed higher values in the extraction of measurements from the extracranial view. In addition, Lazarus *et al.*[35] demonstrated that the measurements taken by the intra and extracranial view have statistically significant differences. Thus, it is necessary consider the way to carry out the measurements, the population studied and the adjacent structures during procedures in the middle cranial fossa.

Another point observed is the asymmetry of FV. Lanzieri *et al.*[34] demonstrated that the asymmetry of FV can appears in association with a carotid-cavernous fistula where pass the drainage from the cavernous sinus by the emissary vein into the pterygoid plexus. Even though, this may be abnormal in majority of cases, but it may occur due to mesodermal dysplasia or the result of a pathological process. So, it is important to be aware of possible anomalies associated with the FV presence.

Regarding the distances of structures close to FV, these also have importance to promote greater safety of the procedures performed in that region. This study analyzed the distance measurements of FV-FO (DFVFO) and FV-FS (DFVFS), who obtained higher averages on the right side in both genres. This side is the same that has a higher mean of FO measure. Although FV value in women was higher on the left side, the averages are very close between the sides. DFVFO was the only measure that presented statistically significant difference on the right (p=0.021) but not among the genres.

Other studies[35,37] also had higher averages of FV on the right side. In contrast, most studies[2,6,14,23,26,29,30] found this on the left side (Table 6). Some of these studies performed DFVFO measure[2,14,29,30,35], and had superior averages on the side with higher FV. About DFVFS, the studies that analyze this data did not evaluate the FS measure[14,23,29], but in our study, these averages were higher on the left side in men and on the right side in women.

Table 5. Comparison of percentage of foramen venosum types in different populations.

Author, year, region	Genre	N (sides)	Type of Foramen Venosum (%)		
			Oval	Round	Irregular
Bayrak et al.23, Turkey	Not specified	111	76 (68.5%)	28 (25.2%)	7 (6.3%)
Godas et al.24, Brazil	Male: 20 Female: 27	R: 28 L: 19	R: 8 (17.1%) L: 4 (8.6%)	R: 13 (27.6%) L: 13 (27.6%)	R: 7 (14.9%) L: 2 (4.2%)
Görürgöz and Paksoy16, Turkey	Male	R: 50 L: 56	R: 18 (6%) L: 20 (6.7%)	R: 12 (4%) L: 16 (5.3%)	R: 7 (2.3%) L: 8 (2.7%)
	Female	R: 98 L: 96	R: 50 (16.7%) L: 42 (14%)	R: 22 (7.3%) L: 21 (7%)	R: 11 (3.7%) L: 21 (7%)
Raval et al.6, Gujarat region, India	Not specified	R: 41 L: 49	R: 7 (7.7%) L: 15 (16.7%)	R: 34 (37.8%) L: 30 (33.4%)	R: 0% L: 4 (4.4%)
Present study	Male	R: 9 L: 13	R: 2 (3.1%) L: 7 (10.7%)	R: 7 (10.7%) L: 6 (9.3%)	0%
	Female	R: 20 L: 23	R:11 (16.9%) L: 13 (20%)	R: 9 (13.9%) L: 10 (15.4%)	0%

N: number of sides with foramen venosum; (-) uninformed; R: right; L: left.

Table 6. Comparison of foramen venosum measurements of both sexes in different populations.

Author, year, region	Genre	N (sides)	Measurements (mm)				
			FV	FO	FS	DFVFO	DFVFS
Aviles-Solis *et al.*[37], Mexico	Not specified	6	R: 2.07±0.38 L: 1.25± 0.25	-	-	R: 4.03±1.17 L: 4.24±0.81	-
Bayrak *et al.*[23], Turkey*	Not specified	178	R: 2.66±0.76 L: 2.82 ± 0.96	-	-	R: 2.31±1.31 L: 2.21 ± 1.14	R: 11.32±1.98 L: 11.26 ± 2.13
Berlis *et al.*[39], Freiburg, Germany*	Not specified	FV: 36 FO: 120 FS: 119	1.79±0.68	7.41±1.31	2.60±0.52	-	-
Chaisuksunt *et al.*[11], Thailand	Male	136	2.45±1.05	-	-	2.06±1.15	-
	Female	64	2.44±0.93	-	-	2.02±0.97	-
Görürgöz and Paksoy[16], Turkey	Male	74	R: 1.72±1.68 L: 1.54±1.18	-	-	R: 1.57±1.00 L: 1.45±0.99	R: 11.20±1.85 L: 10.77±2.32
	Female	116	R: 1.77±1.13 L: 1.88±1.20	-	-	R: 1.41±0.96 L: 1.24±0.79	R: 10.20±1.77 L: 10.03±2.34
Gupta *et al.*[15], India	Not specified	176	-	-	-	R: 1.36±0.32 L: 1.48±0.37	-
Lazarus *et al.*[35], South Africa	Not specified	10	R: 2.83±1.65 L: 2.79±1.40	-	R: 2.46±0.72 L: 2.54±0.76	R: 2.83±1.59 L: 2.42± 0.88	-
Nascimento *et al.*[22], North-East of Brazil	Male	17	2.65±1.03	-	-	2.05±1.19	-
	Female	19	3.08±0.99	-	-	3.06±1.24	-
Nayak *et al.*[30], India	Not specified	60	R: 1.13±0.30 L: 1.38±0.33	-	-	R:1.42±0.19 L: 2.17±0.28	-
Natsis *et al.*[26], Greece	Not specified	156	R: 2.63 ± 0.9 L: 2.79 ± 0.65	R: 7.72 ± 1.10 L: 7.44 ± 1.45	-	-	-
Ozer and Govsa[29], Turkey	Not specified	344	R: 0.86 ± 0.21 L: 1.07 ± 0.37	-	-	R: 2.30 ± 1.14 L: 2.46 ± 0.89	R: 10.76 ± 1.26 L: 10.42 ± 1.29
Raval *et al.*[6], India	Not specified	180	R: 0.98 ± 0.67 L: 1.12 ± 0.73	-	-	-	-
Rossi *et al.*[2], São Paulo, Brazil	Not specified	43	R: 1.45±1.04 L: 1.59±093	-	-	R: 1.83±0.30 L: 2.46±0.31	-
Shinohara *et al.*[14], São Paulo, Brazil	Not specified	197	R: 0.69 ± 0.30 L: 0.72 ± 0.35	-	-	R: 2.55 ± 0.90 L: 2.59 ± 0.93	R: 11.52 ± 1.72 L: 10.95 ± 2.02
Srimani *et al.*[40], India	Not specified	4	-	R: 7.75±1.16 L: 7.70±1.14	R: 2.01±0.31 L:2.03±0.29	-	-
Present study	Male	22	R: 3.62±0.53 L: 3.43±0.31	R:8.38±1.15 L: 8.27±0.8	R: 4.08±0.36 L: 4.32±0.3	R: 8.42±1.01 L: 7.93±1.01	R: 15.45±2.18 L: 14.06±1.8
	Female	43	R: 3.56±0.54 L: 3.6±1.0	R: 7.78±1.12 L: 7.56±1.3	R: 3.94±0.41 L:3.86±0.33	R: 8.51±1.15 L: 7.96±1.1	R: 14.77±1.33 L: 14.26±1.61

N: number of sides; FV: largest diameter of foramen venosum; FO: largest diameter of foramen ovale; FS: largest diameter of foramen spinosum; DFVFO: distance between the center of foramen venosum to the center of foramen ovale; DFVFS: distance between the center of foramen venosum to the center of foramen spinosum; R: right side; L: left side; (-) uninformed; *radiological studies.

In general, there is no consensus on the measurements of FV, FO, FS and their respective FV distances (DFVFO and DFVFS) between studies worldwide because the averages are variable (Table 6). This can be explained by the way the measurements were performed, either in the intra or extracranial view. It is worth mentioning that our measurements were analyzed in the extracranial view and the distances between the foramina (DFVFO and DFVFS) were made from the center of the FV to the center of the other (FO or FS).

Furthermore, it is difficult to accurately describe the mean of FV due to the heterogeneous pattern of methodologies and variables of the studies already carried out. Some use imaging tests, others performed with a lower "n" or did not classify by gender, as well as type of foramen, among others, which compromises the comparison.

Conclusion

FV has a high prevalence in Northeast Brazil, predominantly in the women on the left side with oval and round types. Its relation with other foramina showed differences between genres and sides. Variations in FV location, type and number seen in this study can suggest fenestrations or duplications in important veins, increasing the risk of injury of these vessels during surgical approaches to this region.

Limitations

We observed that mensuration of the foramen venosum is difficult. The study had been designed to measure all the foraminas adjacent to the FV (foramen ovale, foramen spinosum and foramen round). However, the measurements of the diameter of the foramen round and distance to the FV were not possible to be measured.

When we compared the measurements of the foraminas with other studies, there is no standardization in the methods mensuration. We performed the measurements only from the inferior view because there weren't so many open skulls.

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Received: April 18, 2022
Accepted: April 30, 2022

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