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STUDY OF MORPHOLOGICAL AND MORPHOMETRIC VARIATIONS OF CLINICALLY SIGNIFICANT SACRAL HIATUS IN BOTH THE GENDERS

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ABSTRACT

One of the commonest factors for failure of caudal epidural anesthesia is anatomical variations in morphology and morphometry of sacral hiatus which occur frequently in both the genders. This route is used to create caudal anaesthesia by injecting a local anaesthetic into the epidural area. Sound knowledge of anatomy in this region will help in accurate identification of sacral hiatus and is essential to avoid procedural complications. [1, Kumar V et al]. **MATERIAL AND METHODS:** The study was conducted on 73 dry human sacra in the Department of Anatomy, MGMCRI, Puducherry. After the determination of gender, the sacra were classified as 40 male and 33 female sacra. Both nonmetric and metric parameters of SH were measured.

RESULTS

The most prevalent shape of SH in both the genders were inverted U shape followed by inverted V shape and less common shape were dumbbell & irregular shape, with one female sacrum having complete dorsal wall agenesis. Location of apex of SH in both the genders were seen at the level of S4 vertebra (n=43) and location of base of SH in both the genders were seen at the level of S5 vertebra (n=50). The mean length of SH in male and female were 25.19 and 22.66mm, mean width of SH at the base in male and female were 13.79 & 11.98 mm, mean depth of SH at the apex in male & female were 5.50 & 3.93mm , mean distance between apex and S2 spinous process in male and female were 29.54 mm & 28.73 mm, mean distance between two superolateral crest in male & female were 61.11mm & 62.57 mm , mean distance between left superolateral crest and apex in male and female were 64.36mm & 62.10 mm, mean distance between right superolateral crest and apex in male & female were 64.19 & 60.66 mm. **CONCLUSION** The knowledge of incidences of variations of SH is crucial in clinical situations requiring CEB in both the genders to avoid complications.

INTRODUCTION

Sacrum is a union of five progressively smaller sacral vertebra and their costal elements. Dorsal surface of the sacrum is convex with 3-4 spinous tubercles. Below the 4th spinal tubercle an arched SH is identified in the posterior wall of sacral canal. The lamina of the 5th sacral vertebra fails to meet behind causing a U-shaped gap called the SH. SH is used as a landmark to give caudal epidural analgesia [2, Letterman GS et al]. The surface landmark of SH is about 2 inches above the coccyx. On examination the gap of the SH is like a triangle, having base below and apex above. An apex at the fourth sacral vertebra is considered as normal. The base may be present at 5th sacral vertebra or at the coccyx [3, Lasts Anatomy Regional & Applied**].** If the laminas of the higher sacral vertebra are not fused, then there will be a high sacral hiatus. [4, Evangelos et al]. If there is nonfusion of the laminae of all the sacral vertebra, there will be midline gap known as dorsal agenesis [5, Singh R et al]. Anatomical knowledge of sacral hiatus is a prerequisite for the success rate of caudal epidural anaesthesia. The reliability and success of CEA depends upon anatomical variations of SH as observed by various authors [6, Sekiguchi M et al (7), Trotter M et al**].** SH is roofed by firm elastic membrane –the sacrococcygeal ligament which is an extension of ligamentum flavum. The 5th inferior articular process project caudally and flank the SH and it is known as sacral cornua. Sacral canal is triangular in shape. It is the continuation of spinal canal. Each lateral wall has four intervertebral foramina. The sacral canal contains cauda equina and filum terminale. At the S2 level, the subarachnoid and epidural spaces cease to exist. Lower sacral spinal roots and filum terminale pierce the dura mater and arachnoid mater at this level. The sacral canal below this level contains extradural fat, vertebral venous plexus, lower sacral nerve roots and filum terminale. [8, Standring's]. The distance between the dural sac and tip of the hiatus is approximately 16-75mm; mean being 45mm. Structures emerging through sacral hiatus are filum terminale, fifth sacral spinal nerves, and pair of coccygeal nerves. For inducing painless labor, anesthetic agent is injected into the SH which acts on coccygeal and sacral nerves and relaxes perineal musculature and also CEB relieves lower back pain [9, Edward.B et al**].** Sacral hiatus has been used as an access point for the administration of CEA in lumbar radiculopathy, spinal stenosis, diabetic polyneuropathy, cancer pain management, post herpetic neuralgia, urology, obstretics and General surgery [10, Klocke R et al]

AIM

To determine the significance of variations of the sacral hiatus in both the genders.

OBJECTIVES

To perform morphological and morphometric parameters of sacral hiatus & compare the variations between male and female sacra.

MATERIAL AND METHODS

After obtaining approval from Institutional ethics committee, the study was conducted in the department of Anatomy, Mahatma

Gandhi Medical college & Research Institute, Puducherry on 73 dry human sacra of unknown sex. Sexual dimorphism was determined by measuring various indices of the sacrum and based on the values; the bones were categorized as 40 male sacra and 33 female sacra.

Inclusion criteria- Fully ossified sacral bones without any damage or variation was taken for the study.

Exclusion criteria- Sacral bones with pathological deformity, developmental anomalies, mutilation, fractures or post-mortem damage that could alter morphometric measurements were excluded.

Statistical analysis – The collected data was entered into a table using Microsoft Excel. Results were described as mean ± standard deviation (SD), using Student's t- test, morphometric dimensions of male and female sacra were compared, and p values were determined. The level of significance was set as p value ≤ 0.05. While p value ≥ 0.05 is considered to be statistically not significant.

Morphological parameters-

1) Shape of sacral hiatus- Noted by the appearance of the margins of the SH opening.
2) Location of apex of sacral hiatus – Noted with respect to sacral vertebra. Apex is the highest point of the SH opening in the midline.
3) Location of base of sacral hiatus – Noted with respect to sacral vertebra. Base is the lowest and widest point of the SH opening in the midline.

Morphometric parameters-

a. Length of Sacral hiatus (mm): the distance from midpoint of apex to base of SH opening.
b. Width of sacral hiatus or transverse diameter (mm): the distance between the two inner sides of the sacral cornua.
c. Depth at apex or anteroposterior diameter (mm): the distance between two bony walls at the apex of the SH.
d. Length from the apex of SH to S2 spinous process.
e. Length at the base of the triangle (mm): Distance between the two superolateral crest.
f. Length of the right border of the triangle (mm): Distance between the apex of SH and right superolateral crest.
g. Length of the left border of the triangle (mm): Distance between the apex of SH and left superolateral crest.

RESULTS

Table 1: Shape of the SH in both male and female with statistical analysis.

SHAPE OF SACRAL HIATUS	Gender				Total		Chi-square test	p-value
	FEMALE		MALE					
DORSAL AGENESIS	1	3.0%	0	0.0%	1	1.4%	2.717	0.606
DUMBELL	2	6.1%	2	5.0%	4	5.5%		
IRREGULAR	1	3.0%	2	5.0%	3	4.1%		
U	15	45.5%	20	50.0%	35	47.9%		
V	14	42.4%	16	40.0%	30	41.1%		
Total	33	100.0%	40	100.0%	73	100.0%		

Figure: 1 – shows various shapes of the SH. A) Shows dorsal wall of agenesis B) SH with irregular shape C) SH with inverted 'U' shape D) SH with inverted 'V' shape.

Table 2: shows the level of apex of sacral hiatus in both male and female sacrum with statistical analysis.

LOCATION OF APEX OF SACRAL HIATUS	Gender				Total		Chi-square test	p-value
	FEMALE		MALE					
AGENESIS	1	3.0%	0	0.0%	1	1.4%	2.072	0.722
S2	1	3.0%	2	5.0%	3	4.1%		
S3	10	30.3%	12	30.0%	22	30.1%		

S4	20	60.6%	23	57.5%	43	58.9%		
S5	1	3.0%	3	7.5%	4	5.5%		
Total	33	100.0%	40	100.0%	73	100.0%		

Table 3: Shows the level of base of sacral hiatus in both male and female sacra with statistical analysis.

LOCATION OF BASE OF SACRAL HIATUS	Gender				Total		Chi-square test	p-value
	FEMALE		MALE					
COCCYGEAL	2	6.1%	3	7.5%	5	6.8%	1.391	0.708
DEFICIENT DORSAL WALL	1	3.0%	0	0.0%	1	1.4%		
S4	7	21.2%	10	25.0%	17	23.3%		
S5	23	69.7%	27	67.5%	50	68.5%		
Total	33	100.0%	40	100.0%	73	100.0%		

Table 4: presents various morphometric parameters of sacral hiatus with statistical information.

	Group	N	Mean	SD	SE	Independent t-test	p-value
LENGTH OF SACRAL HIATUS	FEMALE	33	22.66	10.48	1.82	0.981	0.330
	MALE	40	25.19	11.35	1.80		
WIDTH OF SACRAL HIATUS	FEMALE	33	11.98	3.20	0.56	2.425	0.018
	MALE	40	13.79	3.14	0.50		
DEPTH AT APEX	FEMALE	33	3.93	1.50	0.26	3.978	< .001
	MALE	40	5.50	1.82	0.29		
DISTANCE BETWEEN APEX TO S2 SPINE	FEMALE	32	28.73	10.25	1.81	0.312	0.756
	MALE	40	29.54	11.31	1.79		
DISTANCE BETWEEN TWO SUPEROLATERAL CREST	FEMALE	33	62.57	3.83	0.67	1.587	0.117
	MALE	40	61.11	3.99	0.63		
	FEMALE	33	62.10	5.48	0.95	1.553	0.125

D/W LT. SUPEROLATERAL CREST AND APEX	MALE	40	64.36	6.69	1.06		
D/W RT SUPEROLATERAL CREST AND APEX	FEMALE	33	60.66	4.25	0.74	2.530	0.014
	MALE	40	64.19	7.03	1.11		

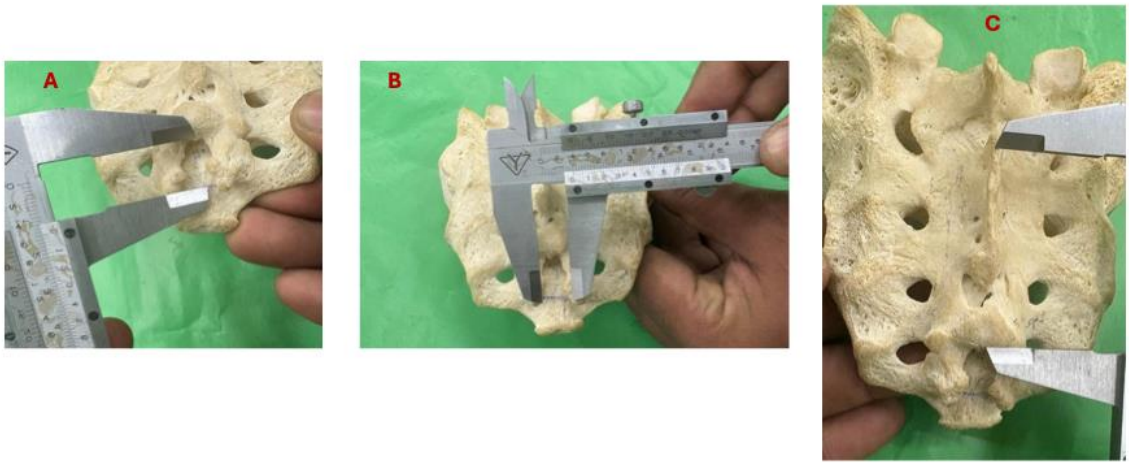

Figure: 2 – shows morphometric measurements of SH.

A) Length of the SH
B) With of the SH at the base
C) Distance between apex and S2 spinous process.

DISCUSSION

Shape of sacral hiatus- we have recorded five different shapes of the SH. They are inverted U, V, dumbbell, irregular and complete dorsal wall agenesis. In the present study the inverted U shape was the most prevalent configuration both in male sacra and female sacra (male =50.0%; female 45.5%). These findings closely align with the research conducted by [11, Aggarwal et al) (40.35%) (12), Seema et al (42.47%) (13, Desai et al (42.12%) and 14, Archana singh et al (60.7%)]. In contrast, a study conducted by [15, Vinod Kumar et al] and his colleagues identified inverted V shape as significantly more common occurring in 46.53% of cases, while the inverted U as 29.70% of cases. This morphological variation highlights the diversity in anatomical presentations of the SH among people. In our study V shape was slightly more in the female than male sacra (male= 40.0%; female =42.4%). These

findings were similar to those reported by [16, Mustafa et al (24%)]. This was followed by Dumbell shape (male =4%; female = 6.1%), irregular shape (male = 5.0%; female = 3.0%), Dorsal wall agenesis (male=0.0%; female = 3.0%).

Some of the causative factors for change in the shape of sacral hiatus are unilateral incomplete development of sacra, presence of ossified sacrococcygeal ligament, reduced sacral hiatus. In the present study inverted U and V shape were most commonly recorded and provide more space for the passage of the needle while performing CEB. The present study found one female dry sacrum with a deficient dorsal wall which was also reported by [17, Gaikwad et al].

Location of apex of sacral hiatus – In both the genders the location of apex of sacral hiatus was seen more at the level of S4 vertebra (male =57.5%; female = 60.6%). The level of apex of SH can vary from S2 to S5 vertebra. Puncturing of dural sac is more common when the apex is located at S2 vertebra due to the lower limit of dural sac. Length of the spinal needle should be carefully measured in case of higher apex. [18, Nagar et al, 12, Seema et al, 11, Aggarwal et al, 19, Nihija et al] also reported apex most commonly at the level of S4 vertebra. But [20, Nadeem G] in his study on German bones found apex at the level of S3 vertebra.

Location of base of sacral hiatus- In both the genders the location of base of sacral hiatus was seen more at the level of S5 vertebra (male = 67.5%; female = 69.7%). The level of base of SH shows considerable variation which ranges from S4 vertebra to the coccyx. According to [18,Nagar SK et al]the level of base at S5 vertebra was seen in (72.60%) , [12,Seema Singh et al] the level of base at S5 vertebra was seen in 70.46%, [21, Sinha MB et al] the level of base at S5 vertebra was seen in 88.71%, [20, Nadeem G et al]the level of base at S5 vertebra was seen in 62%, [22, Javed Akhtar et al] the level of base at S5 vertebra was seen in 79.84%, [23, Ukokha U et al] the level of base at S5 vertebra was seen in 88%, [24, Chhabra N et al]63.33%.

Length of sacral hiatus (mm) - The mean length of sacral hiatus in male was 25.19± 11.35 and in female gender it was 22.66 ± 10.48. The length of sacral hiatus varies between 10.01 to 30mm in 58% of cases. [24, Chhabra N et al]reported mean length of SH to be 25.05±10.96 mm which varied from 9.98 mm to 61.98 mm, According to[20,Nadeem G et al] 57% of sacral length was in between 11-30mm.[12, Seema et al]also observed mean ± length of SH in two third of cases to be between 11-30mm. [23,Ukokha U et al] recorded mean length of SH to be 20.05 ± 9.22 mm. According to [1, Kumar V et al] the mean sacral length in male was 20mm and in female were 18.9 mm.

Width of sacral hiatus (mm) – The mean width of sacral hiatus in male was 13.79± 3.14 and in female it was 11.98 ±3.20. Width at the base of SH shows considerable variations from 0.3 – 18mm. [11,Aggarwal et al] gave it as 11.95 ± 2.78,[18, Nagar et al] recorded it as 10-15 mm, [22,Jawed Akhtar et al] reported it as 12.4± 3.89 mm. [1,Kumar V et al] recorded the mean width of SH as 13 mm with range of 5-20 mm. [24, Chhabra N

et al]reported the width at the base as 12.84 mm. [23,Ukoha U U et al] reported mean width of SH as 12.35 ± 3.12 mm .[21,Sinha M B et al]found width at the base in between 10.1 to 15mm in 41.93 % cases followed by 5.1 to 10mm in 35.48% cases.

Depth at apex or anteroposterior diameter (mm) – In the present study the mean depth at apex in male = 5.50± 1.82; female = 3.93± 1.50. Antero posterior diameter at apex should be adequately large to admit an accurate needle. Variation in diameter may lead to subcutaneous deposition of anesthetic drug.[12, Seema et al] reported the mean AP diameter as 4-6mm , [19, Nihaja et al] as 6.4± 3.1mm [18,Nagar SK et al] reported as 4.8mm,[20,Nadeem G et al] and [23,Ukoha U et al] recorded as 5.53mm and 5.52 ± 1.89 mm respectively. [6, Sekiguchi et al] found an anteroposterior diameter of the sacral canal less than 2mm in 1% of specimens, which made it difficult to use a 22 gauze needle for CEA.

Distance between apex and S2 spinous process (mm) - In the present study the mean distance between apex and S2 spinous process in male = 29.54±11.31; female = 28.73 ± 10.25. [25, Rohini Punja et al] documented the distance between apex and S2 spinous process in male as 20.1-71.0 mm and in female as 35.3- 62.6 mm. Care should be taken to push the needle into the sacral canal to avoid damage to the dural sac.

Distance between two superolateral crest (mm) – In the present study the distance between right and left superolateral crest in male = 61.11±3.99; female = 62.57 ± 3.83.[26, Manicka Vasuki et al] documented the distance between two superolateral crest as 51-60 mm in 40 dry sacra that accounts for 53%. [25, Rohini Punja et al] documented the distance between right and left superolateral crest in male as 52.1-72.2mm and in female as 55.6 - 70.2 mm

Distance between left superolateral crest and apex (mm) – In the present study the distance between left superolateral crest and apex in male was 64.36 ± 6.69; female 62.10± 5.48.[25, Rohini punja et al] documented the distance between left superolateral crest and apex in male as 28.3 - 67.2mm and in female as 31.5 – 61.1 mm.

Distance between right superolateral crest and apex (mm) – In the present study the distance between right superolateral crest and apex in male was 64.19± 7.03; female 60.66± 4.25. [(25) Rohini Punja et al] documented the distance between right superolateral crest and apex in male as 28.3- 69.3 mm and in female as 31.6- 61.3 mm. [27,Senoglu et al] reported that trigonum sacrale which is formed by the lines joining the right superolateral crest and apex , left superolateral crest and apex, and line joining the right and left superolateral crest form an equilateral triangle. While [28, Bagheri et al] reported that in 55 % of cases, both sides of the triangle were smaller than the base of the triangle.

Our study showed complete dorsal wall agenesis in one sacral vertebra. A study by [29], Vanitha et al] also recorded complete agenesis of dorsal wall of the sacrum.

ABBREVIATIONS: SH: Sacral hiatus, CEB: Caudal epidural block.

Limitations of the study: the major limitation of the study was the smaller sample size. We recommend future studies to include a large and more diverse sample from the same region

CONCLUSION - Anatomical variations occur frequently in sacral hiatus in both the genders. Hiatal apex at S1 or S2, base at S3, short hiatal length, narrow transverse diameter, and decreased depth pose high risk while administration of CEA for different purposes. Our findings demonstrated that the trigonum sacrale is not an equilateral triangle.

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