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ORIGINAL ARTICLE

Anatomical variations of sacral hiatus and its associations.

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ABSTRACT… Objective: To compare anatomy of sacral hiatus between the genders of case and control groups. To determine significance of hiatal variations between the genders of cases and controls. **Study Design:** Case-control study. **Setting:** PNS Shifa Hospital Karachi. **Period:** January 2020 to June 2020. **Material & Methods:** Total of 178 participants aged 18-65 years were enrolled in the study. Approval was taken from Ethical Review Committee of Bahria University Medical and Dental College (BUMDC). Participants were arranged into case and control groups. The hiatus and its dimensions were identified on lumbosacral spine radiographs inferior to the sacral spine using spinous and alar processes. Data was recorded in subject evaluation proforma and analyzed using SPSS version 23.0. **Results:** The V shaped hiatus was more prevalent in males, whereas in females it was U. The most common variant was the irregular shape. The hiatal apex in males was at S3. In females it was at S2. The base was seen at S5 in both genders. The mean length, anteroposterior diameter and transverse width of the hiatus was more in males as compared to females. The mean values of all parameters were less in cases as compared to controls. **Conclusion:** The V shaped sacral hiatus were most prevalent in males, whereas U shape in females. The hiatal apex was at a lower level in males, whereas the level of base was similar in both genders. The hiatus was shorter in cases of backache in both genders as compared to controls. The anteroposterior diameter and width were also less in cases as compared to the healthy controls.

Key words: Anatomical Variations, Backache, Sacral Hiatus, Lumbosacral spine.

INTRODUCTION

The human body has a complicated structure that is controlled by the DNA-encoded plan. While this design allows for improvements in the body, it can also lead to developmental defects or anatomical variations. Typically, variations are considered abnormalities in the body structure that have no pathological manifestation. However, in certain cases variations may worsen the pathological condition. They may also manifest as a surprise to the treating physician during a therapeutic procedure or intervention.[1,2,3]

Variations in the anatomy of sacrum occur frequently, making it the most variable part of the vertebral column. Numerous studies utilizing the dry human sacra have demonstrated variations in the different parameters of its inverted caudal opening, the sacral hiatus, such as shape, diameter, length and position in different races and genders.[4] In a study conducted by Kumari et al (2016), they found significant variations in the morphology of sacral hiatus. The level of apex of the sacral hiatus extended between 3rd to 5th sacral vertebrae. One sacrum was found to have unfused lamina, leading to an open sacral canal (spina bifida). The apex of sacral hiatus was found at S4 found in 80.95% sacra. Its base was found between 4th and 5th sacral vertebra. In majority of sacra, the base was at the level of S5. When shape of sacral hiatus was observed, U was the commonest shape, whereas M shaped was the rarest finding.[5] However, in another study conducted in Ethiopia on dry human sacra, the shape of sacral hiatus most commonly observed was V (41%) followed by U (37.7%) and irregular shape was least common.[6] The apex of the sacral hiatus showed variations from S1 to S5. S4 was

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the most common level (60.7% cases). The base of the sacral hiatus was most commonly located at S5 (78.7%). Similarly, the length of the sacral hiatus demonstrated variations from 6 mm to 80 mm. Transverse width of the sacral hiatus (intercornual distance) varied from 9mm to 21mm, whereas antero-posterior diameter of sacral hiatus varied from 3 mm to 9 mm.

Other studies have also shown similar variations.[7,8,9,10] However, no study has so far been carried out in Pakistani population to ascertain the significance of anatomical variations in the sacral hiatus in the living, an essential step towards administration of successful caudal epidural anesthesia, so this study was planned to bridge the gaps in the existing knowledge.

MATERIAL & METHODS

This case-control study comprised of 178 adults from ages 18-65 years. It was conducted at PNS Shifa Hospital from January-June 2020 after Ethical approval (ERC 03/2020).

Sample size was calculated using the method for "frequency in a population" on www.openepi.com. Population size of 400 and hypothesized frequency of 29.45% was used for the calculation with margin of error of 5% and confidence interval of 95%. The required sample for cases and control groups was 89 respectively. Total sample size was 178.

Participants were selected by non-probability convenience sampling. Those with pregnancy, bone diseases, spinal surgery and trauma were excluded from the study. Individuals with back pain were classified as group A while asymptomatic participants were recruited into group B (comparison group).

We determined the hiatal parameters using radiographs of lumbosacral spine. The measurements were verified by a consultant radiologist blinded to the study. The findings were recorded in the evaluation proforma. The data was analyzed using SPSS software 23.0. The parameters were compared with demographic data among the groups using Chi-square and Student t-test

Hiatal Parameters

1. Shape: it was determined by the margins of the hiatal opening.
2. Apex: the highest point of the hiatal opening in the midline, inferior to spinous processes of sacral bones.
3. Base: the lowest and widest point of the hiatal opening, in the midline.
4. Length (mm): the distance from midpoint of hiatal apex to its base.
5. Width (mm) or transverse diameter: the distance from the inner side of sacral cornua.
6. Anteroposterior diameter (depth) mm: the distance between bony walls at the apex of the hiatus.

RESULTS

The study consisted of total 103 women and 75 men. The female participants outnumbered the males (Figure-1). We compared six different hiatal parameters with reference to gender among case and comparison groups. The hiatal parameters compared were: shape, apex, base, length (mm), width (mm) and anteroposterior diameter (mm (AP)).

Among the male cases the most common shapes were U, V, irregular, dumbbell and M. The bifid hiatus was not observed. In the female cases the U and V shapes were most common. An equal number of dumbbell, M and irregular shapes were observed. The least common shape was bifid. In the comparison group the most frequent shapes among males were V, U and irregular. The dumbbell and bifid shapes were present in equal number. The "M" shaped hiatus was not observed. In the females the U shaped hiatus dominated all other shapes. The "M" shaped hiatus was observed in higher frequency as compared to irregular and bifid shapes. The difference in shapes between the genders in the control group was highly significant ($p<0.001$) (Table-I).

The majority of male cases had hiatal apex at the level of S3. An apex at S2, S1 and S4 was also observed. Among the female cases, the hiatal

apex was most commonly seen at S2. In the controls both males and females had apex at S3 with insignificant difference. In the female controls however, apex at S1 was not observed (Table-II).

The level of hiatal base in the male and female cases was at S5 and S3. In the comparison group, the base was present at the level of S5 in the majority of males and females. In the females however, the base was not seen at the level of S3. In the males it was not seen at the level of the coccyx. The differences among the groups were not significant (Table-III).

The mean hiatal parameters in the male cases were 24.40.3±7.84mm (length), 12.44±3.46mm (width) and 3.16±1.28mm (AP diameter). In female cases they were 22.93±7.37mm (length), 11.16±3.50mm (width) and 2.96±1.27mm (AP diameter). In the control group parameters in males were 30.34±9.74mm (length), 13.63±4.38mm (width) and 3.21±1.17mm (AP diameter). In the female controls they were 29.94 ± 10.26 mm (length), 13.17 ± 4.32 mm (width) and 3.47± 2.42mm (AP diameter) (Table-IV).

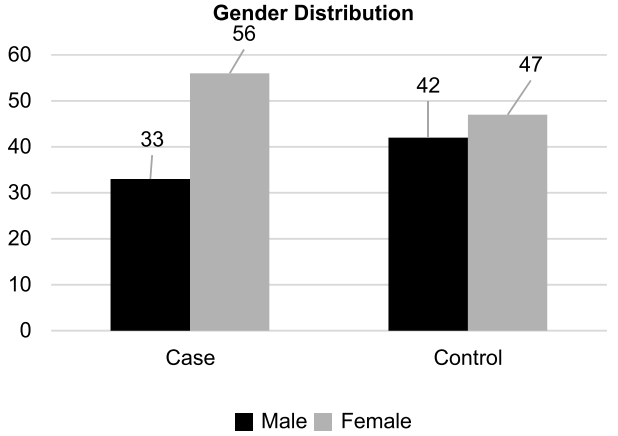

Figure-1. Gender distribution in both groups

Group			Gender		Total	P-Value
			Male	Female		
A	Shape of Hiatus	Inverted U	14 (42.4%)	33 (58.9%)	47 (52.8%)	0.251
		Inverted V	13 (39.4%)	12 (21.4%)	25 (28.1%)	
		M shape	1 (3.0%)	3 (5.4%)	4 (4.5%)	
		Dumbbell	2 (6.1%)	3 (5.4%)	5 (5.6%)	
		Bifid	0 (0.0%)	3 (5.4%)	3 (3.4%)	
		Irregular	3 (9.1%)	2 (3.6%)	5 (5.6%)	
	Total		33 (100.0%)	56 (100.0%)	89 (100.0%)	
B	Shape of Hiatus	Inverted U	3 (7.1%)	25 (54.3%)	28 (31.8%)	0.000
		Inverted V	31 (73.8%)	14 (30.4%)	45 (51.1%)	
		M shape	0 (0.0%)	2 (4.3%)	2 (2.3%)	
		Dumbbell	2 (4.8%)	3 (6.5%)	5 (5.7%)	
		Bifid	2 (4.8%)	1 (2.2%)	3 (3.4%)	
		Irregular	4 (9.5%)	1 (2.2%)	5 (5.7%)	
	Total		42 (100.0%)	46 (100.0%)	88 (100.0%)	

Table-I. Comparison of hiatal shapes

Group			Gender		Total	P-Value
			Male	Female		
A	Level of Apex	S1	2 (6.1%)	1 (1.8%)	3 (3.4%)	0.486
		S2	11 (33.3%)	26 (46.4%)	37 (41.6%)	
		S3	18 (54.5%)	25 (44.6%)	43 (48.3%)	
		S4	2 (6.1%)	4 (7.1%)	6 (6.7%)	
	Total		33 (100.0%)	56 (100.0%)	89 (100.0%)	
B	Level of Apex	S1	1 (2.4%)	0 (0.0%)	1 (1.1%)	0.749
		S2	8 (19.0%)	9 (19.6%)	17 (19.3%)	
		S3	31 (73.8%)	34 (73.9%)	65 (73.9%)	
		S4	2 (4.8%)	3 (6.5%)	5 (5.7%)	
	Total		42 (100.0%)	46 (100.0%)	88 (100.0%	

Table-II. Comparison of hiatal apex

Group			Gender		Total	P-Value
			Male	Female		
A	Level of Base	S3	1 (3.0%)	3 (5.4%)	4 (4.5%)	0.249
		S4	10 (30.3%)	14 (25.0%)	24 (27.0%)	
		S5	20 (60.6%)	39 (69.6%)	59 (66.3%)	
		Coccyx	2 (6.1%)	0 (0.0%)	2 (2.2%)	
	Total		33 (100.0%)	56 (100.0%)	89 (100.0%)	
B	Level of Base	S3	3 (7.1%)	0 (0.0%)	3 (3.4%)	0.058
		S4	6 (14.3%)	13 (28.3%)	19 (21.6%)	
		S5	33 (78.6%)	31 (67.4%)	64 (72.7%)	
		Coccyx	0 (0.0%)	2 (4.3%)	2 (2.3%)	
	Total		42 (100.0%)	46 (100.0%)	88 (100.0%)	

Table-III. Comparison of hiatal base

Parameter	Controls				Cases		
	Gender	Mean	Std. Deviation	P-Value	Mean	Std. Deviation	P-Value
Hiatal length in mm	Male	30.3456	9.74272	0.857	24.4064	7.84459	0.367
	Female	29.9407	10.26432		22.9352	7.37836	
Antero-posterior Diameter	Male	3.2116	1.17664	0.571	3.1617	1.28679	0.471
	Female	3.4713	2.42057		2.9649	1.27148	
Transverse Width	Male	13.6338	4.38487	0.632	12.4405	3.46147	0.09
	Female	13.1704	4.32890		11.1650	3.50752	

Table-IV. Comparison of hiatal length, width and depth

DISCUSSION

In this study we compared the anatomy of the hiatus between males and females among cases and controls. We investigated six parameters of the sacral hiatus including its shape, apex, base, length, width and depth. We then determined the significance of the variations. Previous studies have used dry bone sacra[6] and imaging techniques to determine hiatal parameters.[11] In the present study the most common shapes among the genders was U and V. However in the male groups the V shape was most frequent and in females it was the U shape. These shapes are considered as normal and suitable for caudal procedures.[12] Similar results were observed[6] although they observed dry sacral bone so did not differentiate them on the basis of gender.

We found no statistically significant difference in the incidence of hiatal shapes between male and female cases. However the difference was significant in the control group. It is evident that the 'U' and 'V' shapes were most common in both genders. Similar findings were reported in previous studies.[13,14,15] After extensive literature search we found no studies reporting significant findings.

The apex of the hiatus in the male and female cases was most commonly observed at S3 and S2 with varying incidences. In the female cases we observed higher incidence of hiatal apex at S2 (46.4%) as compared to male cases in which it was at S3 (54.5%). Similar findings were reported in Indian sacra.[16]

We found no significant difference in the level of apex of the hiatus between male and female cases. Similar findings were reported in Indian sacra.[17,18] We can assume that the variations observed are attributed to development. Furthermore our findings indicate a high lying apex in females which may prove difficult in clinical procedures (obstetric).

The base of the hiatus in the male and female cases in our study was most commonly observed at S5 with minor variation in incidences. Similar findings were documented.[12] Case control studies with contradictory findings were not detected

after extended literature search.

According to our observations there was no statistically significant difference between the genders in the cases with respect to the level of the hiatal base. Similar findings were reported in previous studies.[17,18] We believe that the variations observed are because of individual and genetic factors and do not pose a risk for low back pain or complications of caudal procedures.
In the current study the mean hiatal length was more in male cases as compared to the female cases. A longer hiatus in males as compared to females was also found[12] however in comparison to our study the hiatal lengths were smaller (males: 27.81+1.172mm; females: 24.73+2.21mm). We can assume that this difference in the measurements between the studies may be due to racial, regional, and observer related factors.

In the current study we found no statistically significant difference in the hiatal length between male and female cases. Similar findings were reported in Indian sacra.[17,18] We believe that the difference in hiatal lengths in the male and female cases could be an influence on the individual's experience of low back pain and should be considered prior to caudal approach in the clinical setting. No case control studies with significant findings were found. Among cross-sectional studies reported a significant difference in hiatal length between the genders was reported[11,13] which could be due to "methodological, dietary, socioeconomic, racial and genetic factors".

In the current study the average depth of the hiatus was smaller in the female cases as compared to the male cases. Similar to our findings higher values of hiatal depth in male (4.49+0.75mm) as compared to the female (4.45+0.88mm) low back pain patients were observed.[19] Also measurements were larger than our observations. The reason for higher values could be ethnic and methodological differences. We detected no significant difference in hiatal depth between the male and female cases. Similar results have been documented.[12]

The average transverse width in the male cases was larger as compared to the female cases. Similar observations were reported[10,11] however the measurements in male (9.50+2.59mm) and female (9.09+2.29mm) cases of the studies were significantly smaller than our study. The width observed in our female cases was also more than both groups in the studies. Larger hiatal widths in male than female cases (male: 16.6+2.04mm; female: 15.8+2.1mm)[19] (male: 17.7+2.7mm; female: 16.5+2.7mm)[20] in similarity with our study were documented. In contrast to our study these studies reported wider diameters.[19,20] The reason for the differences in observations could be variations in individual physical structure, genetic makeup and ethnicity.

In our study the difference of width between the male and female cases was not statistically significant. Similar findings were reported.[17,18] Significantly larger intercornual distance in male cases was also reported.[19,20] The differences in results could be related to methodological reasons.

CONCLUSION

The current study has demonstrated that anatomical variations occur frequently in sacral hiatus anatomy in both genders. In males, V shaped hiatus was most common whereas U shape was most common in females. The hiatal parameters, such as length, width and depth had lower values in cases as compared to controls, suggesting that they have strong association with backache. A hiatal apex at S1 or S2, base at S3, short hiatal length, narrow transverse diameter and decreased depth pose high risk of the condition. The knowledge of these variations is essential while administration of caudal epidural anesthesia for different purposes.

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2	Aisha Qamar	Introduction, Final review.	
3	Saneed Khaliq	Drafting, Critical review.	
4	Ayesha Mehwish	Drafting, References.	
5	Ahmed Ali	Literature Review.	
6	Shabih Zehra	Data Collection.	