

Morphometric Measurement of Sacral Hiatus in Dry Human SacrumSabin Poudel,¹ Pranoti Sinha,² Karma Lakhi Bhutia²¹School of Health and Allied Sciences, Pokhara University²Department of Anatomy, Sikkim Manipal Institute of Medical Sciences, Gangtok, Sikkim.**ABSTRACT**

Introduction: Sacral hiatus is the chief location for caudal epidural anesthesia during surgery of perineal region and also for a pain free parturition. Thus, this study was conducted to examine, measure and record the morphometry of sacral hiatus and to analyze it for any anatomical variations with clinical implications.

Methods: The cross-sectional study was carried in the Department of Anatomy, Sikkim Manipal Institute of Medical Science, Gangtok, Sikkim. For the study seventy dry human sacral bone with entire sacral hiatus were measured. The shape of the sacral hiatus was observed. Level of the apex, base, length, width and anterior posterior diameter of sacral hiatus was measured with Digital Vernier Caliper. The study was approved by Institutional Ethical Committee (IEC No:SMIMS/IEC/2017-01). Data were analysed by one-way analysis of variance (ANOVA) and the difference was considered significant when $P < 0.05$. SPSS 20 was used for data analysis.

Results: The study revealed inverted “U” shaped sacral hiatus as the common shape in 35(50%) followed by inverted “V” shaped sacra in 18 (25.71 %) followed by irregular shaped sacral hiatus in 8 (11.42 %) cases. A Dumbbell shaped sacral hiatus was observed in 4 (5.71%) cases with a bony protuberance protruding medially from both edges. Absence or complete agenesis of sacral hiatus, a rare phenomenon, was observed in 3 (4.28%) and bifid in 2(2.85%) specimens only.

Conclusion: The prevalence of inverted “U” shaped sacral hiatus and constriction of the sacral canal at apex of sacral hiatus was found high. This knowledge of variation in shape of sacral hiatus could be clinically important while providing caudal anesthesia and doing epidural block.

Keywords: *Anesthesia, Morphometry, Sacral Hiatus, Shape, Vernier caliper*

INTRODUCTION

Sacrum is flattened, wedge-shaped bone formed by the union of five sacral vertebrae during the age of 18-28 years old, and formed the large bony vertebrae called vertebral magnum. It lies at the upper, back part of the pelvic cavity, articulating in between two innominate bone at sacroiliac joint forming bony pelvic.¹

Sacral hiatus is a small orifice at the posteroinferior part of sacral canal, formed as a result of lack of union of laminae of the 5th (or sometime 4th) sacral vertebrae. The superficial and deep posterior sacrococcygeal ligaments with subcutaneous fatty tissue and skin covers the hiatus. The contents of sacral hiatus are caudaequina, filumterminale and spinal meninges where the piamater continues as filumterminale up to coccyx whereas the dura and arachnoid mater ends at the level of 2nd sacral segment. The sacral hiatus can be palpable in the skin of intergluteal cleft, two inches above the tip of coccygeal segment in the dorsal surface of body. The developmental anatomy of sacrum is very complex and any alteration from the normal causes extreme effects in morphometry of sacrum resulting deformities.²

The main contents of sacral hiatus are fifth sacral nerve, filumterminaleexterna, coccygeal nerve roots and fibro fatty tissue. Since the caudal epidural block approach is made through sacral hiatus, the proper knowledge of shape and range of sacral hiatus is essential. There may be the failure of union between the laminae of all the sacral vertebra causing defective bony dorsal wall of sacral or may fuse in middle resulting absence of sacral hiatus.³

Sacral hiatus is the site chosen to proceed in epidural space for providing analgesia and anesthetic drugs for many surgeries, lumbar spinal injuries and for administration of severe lower backache. The anatomical variations in the morphology of the sacral hiatus have implications in the clinical practice and knowledge of these variations may improve both the accuracy and safety of caudal epidural anesthesia so as to prevent the risk of dural sac puncture during caudal epidural block.⁴

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When the shape of sacral hiatus is elongated, extreme care is taken as there is high chance of needle projecting into the lumbar cistern which expands to the second sacral segment. Anatomical variations in size, shape and orientation of sacrum brings problems in caudal anesthesia. Agenesis of sacral spinous process leads to defective muscle attachment resulting low backache. These anatomical variations may lead to failure of caudal epidural anesthesia. If anesthetist finds any variation and disorientation of sacral hiatus, one should pick lumbar epidural anesthesia or other procedures to sacral epidural anesthesia to avoid the risk of soft tissue injury and harmful side effects of anesthetic medicines.⁵

The proper knowledge of variation of sacral hiatus helps to perform the successful block of sacral nerves by locating epidural space through sacral caudal epidural block procedure by identifying the hiatus in between the natal cleft in the dorsal surface of the body. Thus, understanding the anatomical variation of the sacral hiatus will ease the perineal epidural puncture stratagem.⁶ Therefore this study is an effort to analyze the different anatomical and morphometric variations of sacral hiatus.

MATERIALS AND METHODS

This study contains completely ossified human sacra of undetermined age and sex, collected under a study period of one year (2017 February-2018 February). These bones were obtained from the Anatomy Department, Sikkim Manipal Institute of Medical Science (SMIMS), Tadong, Gangtok, Sikkim. The sample size was seventy. Sacral index was calculated for gender determination. The shape, level of apex and base of sacral hiatus were observed by eyes. The length, depth and intercornual width of sacral hiatus were measured by digital Vernier caliper. The depth was measured with the help of divider. The measurement was done on intact parts of normal bones. Bones in poor shape and conditions were not included in the study.

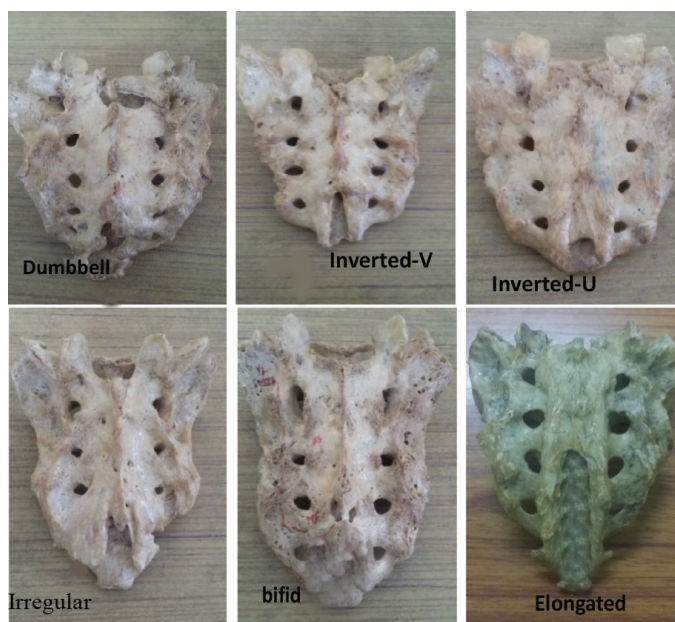
Finally, collected data were entered on Microsoft Excel version 2010 and data were analyzed by using Statistical Package for Social Science (SPSS version 20.0). The result were obtained by calculating mean, median, standard deviation and association of difference in mean of different variable was done by (ANOVA) where the difference was considered significant when $P < 0.05$.



Photograph 1: Showing the measurement of length and depth of the Sacral Hiatus using Vernier caliper and divider respectively

RESULTS

Out of the 70 dry bones which were taken for the study, the distribution of the shape of sacral hiatus was 50% inverted “U” shape followed by 25.71 % sacra inverted “V” shape. Non uniform irregular shaped of sacral hiatus was seen in 11.42 % cases while a dumbbell shaped sacral hiatus was observed in 5.71% cases with a bony protuberance outgrowth heading in the midline from both edges. Absence or complete agenesis of sacral hiatus was a rare phenomenon and observed in 4.28%. Similarly bifid sacral hiatus was observed in 2(2.85%) specimens only.



Photograph 2: The different shapes of Sacral Hiatus

| Shape of Sacral Hiatus | Male (Number and percentage) (N=47) | Female (Number and percentage) (N=23) | Total (N=70) |
|------------------------|-------------------------------------|---------------------------------------|--------------|
| Inverted-U shaped | 25 (53.19) | 10 (43.47) | 35 (50.00) |
| Inverted-V shaped | 12 (25.53) | 06 (26.08) | 18 (25.71) |
| Dumbbell shaped | 03 (06.38) | 01 (04.34) | 04 (05.71) |
| Irregular | 03 (06.38) | 05 (21.73) | 08 (11.42) |
| Bifid | 02 (04.25) | 00 | 02 (02.85) |
| Complete agenesis | 02 (04.25) | 01 (04.34) | 03 (04.28) |

Table 1: Shape of sacral hiatus

()* denotes percentage

Table 2: Level of apex of sacral hiatus with respect to level of sacral vertebra

| Level of apex | Male (N=47) | Female (N=23) |
|---------------------------------|-------------|---------------|
| 2 nd Sacral vertebra | 01 (2.10) | 01 (04.34) |
| 3 rd Sacral vertebra | 20 (42.55) | 07 (30.43) |
| 4 th Sacral vertebra | 25 (53.19) | 15 (65.21) |
| 5 th Sacral vertebra | 01 (02.10) | 00 (00) |

() *Percentage

Apex of Sacral Hiatus-The apex was most commonly observed at 4th sacral vertebra in 40 of cases (57.14%) as shown in Table no. 2. However, there was variation seen in the level of apex and it reached between middle of second sacral vertebral segment to fifth sacral vertebral segment.

Base of Sacral Hiatus-Base of sacral hiatus was commonly seen at the level of 5th sacral vertebra in 62 cases (88.57%). The result is tabulated in Table no. 3.

Table 3: Level of base of sacral hiatus with respect to level of sacra

| Level of Base | Male (N=47) | Female (N=23) |
|---------------------------------|-------------|---------------|
| 4 th sacral vertebra | 06 (12.76) | 02 (8.69) |
| 5 th sacral vertebra | 41 (87.23) | 21 (91.30) |

() *Percentage

Length of Sacral Hiatus- The length of Sacral Hiatus ranged between 6.2mm to 51.45mm with mean length of 21.49mm ± 9.19 mm. The total result is tabulated in Table no. 4 and 5.

Table 4: Length, breadth and anteroposterior(AP) diameter of sacral hiatus

| SN | Length | N | P% | Breadth | N | P% | AP | N | P% |
|----|--------|----|-------|---------|----|-------|-------|----|-------|
| 1 | 1-10 | 08 | 11.42 | 0-5 | 01 | 01.42 | 0-3 | 01 | 01.42 |
| 2 | 11-20 | 26 | 37.14 | 6-10 | 27 | 38.57 | 4-6 | 20 | 28.57 |
| 3 | 21-30 | 28 | 40.00 | 11-15 | 38 | 54.28 | 7-9 | 35 | 50.00 |
| 4 | 31-40 | 07 | 10.00 | 16-20 | 03 | 04.28 | 10-12 | 13 | 18.57 |
| 5 | 41-50 | 00 | 00.00 | 21-25 | 01 | 01.42 | 13-15 | 1 | 01.42 |
| 6 | 51-60 | 01 | 01.42 | 26-30 | 00 | 00.00 | 00 | 00 | 00.00 |

SN*Serial number, N* Number of sacra, P%* Percentage

Antero-posterior diameter of Sacral Hiatus- Our study revealed, Sacra having mean antero-posterior diameter of Sacral Hiatus at apex was 8.08mm ± 3.21mm range from 3mm to 14mm. The total result is tabulated in Table 4 and 5.

Intercornual distance of Sacral Hiatus- The mean transverse width of Sacral Hiatus at base is 11.45 ± 3.21mm range is (5.67mm to 22.36mm).

Table No. 5: Showing the mean, median, standard deviation and ANOVA data

| Parameters | Length SH(mm) | Intercornual Distance(mm) | AP-diameter SH(mm) | P-value | F-value |
|---------------|---------------|---------------------------|--------------------|---------|---------|
| Male | | | | | |
| Mean | 23.44 | 12.00 | 8.24 | 0.016 | 6.14 |
| Median | 24.54 | 11.82 | 08.5 | | |
| N | 47 | 47 | 47 | | |
| SD | ±10.09 | ±3.3548 | ±2.01556 | | |
| Female | | | | | |
| Mean | 17.69 | 10.35 | 7.76 | 0.044 | 4.203 |
| Median | 17 | 10.40 | 8.00 | | |
| N | 23 | 23 | 23 | | |
| SD | ±6.45 | ±2.65 | ±2.45 | | |
| Total | | | | | |
| Mean | 21.49 | 11.45 | 8.08 | 0.395 | 0.735 |
| Median | 21.42 | 11.27 | 8.00 | | |
| N | 70 | 70 | 70 | | |
| SD | ±9.39 | ±2.16 | ±2.16 | | |

While comparing the length of the Sacral Hiatus between the males and females a significant difference of P-value 0.016 was observed and a significant difference of P-value 0.044 was

seen in the intercarnal distance between males and females. However, no significant difference was seen in AP diameter of Sacral Hiatus.

Table 6: Comparison of present study with previous others studies.

| Morphology of Sacrum | Present study | William (2017) | Sabnam (2016) | Dona (2016) | Neeta (2014) | Santanu (2013) | Nagar (2004) |
|----------------------|---------------|----------------|---------------|-------------|--------------|----------------|--------------|
| <u>Shape</u> | | | | | | | |
| U-shape | 50.00% | 30.66% | 22.47% | 70.09% | 28.12% | 65.00% | 41.50% |
| V-shape | 25.71% | 44.66% | 29.12% | 14.09% | 43.75% | 23.00% | 27.00% |
| Irregular | 11.42% | 13.66% | 20.22% | 12.82% | 12.50% | 12.00% | 14.10% |
| Dumbbell | 5.71% | 6.66% | 6.74% | 0.85% | 9.38% | - | 13.30% |
| Spina bifida | 2.85% | 1.33% | 2.24% | - | 3.12% | - | 1.50% |
| Agenesis | 4.28% | 1.33% | 16.85% | - | 3.12% | - | - |
| <u>Apex</u> | | | | | | | |
| S5 | 1.42% | 5.33% | 5.61% | 6.84% | - | 23% | 3.4% |
| S4 | 57.14% | 54.66% | 55.05% | 74.36% | 60% | 72% | 55.9% |
| S3 | 38.57% | 38.66% | 35.95% | 17.09% | 33.33% | 5% | 37.3% |
| S2 | 2.85% | 1.33% | 1.12% | 1.75% | 6.67% | - | 3.4% |
| <u>Base</u> | | | | | | | |
| S5 | 88.57% | 66.66% | 81.60% | 95.73% | 63.33% | - | 72.40% |
| S4 | 11.42% | 20.00% | 5.74% | 4.27% | 20.00% | - | 18.90% |
| Coccyx | - | 12.00% | 12.64% | - | 16.67% | - | 8.60% |
| <u>Sacralhiatus</u> | | | | | | | |
| Length(mm) | 6.20-53.82 | 10 – 65 | - | 8.80-54 | 10-62 | 30 – 43 | 5-30 |
| Width(mm) | 5.65-22.36 | 10 - 20 | - | 6 - 21 | 6-17 | 7 -12 | 3-19 |
| AP(mm) | 3-14 | 0.30-0.80 | - | 0.20-0.50 | 0.40-0.90 | 6 – 8 | 2-14 |

DISCUSSION

Several studies have been carried by many researchers about sacral hiatus and also in correlation with different clinical purposes and varied objectives. Almost all the studies measure different parameters (dimension) of sacral hiatus and showed their results. Our study revealed alteration in the shape and other morphometric parameters of sacral hiatus so we made an effort to categorize these parameters. The most common shape of sacral hiatus was inverted “U” shape, found in 50% (25 male and 10 female) which coincides with previous studies.^{5,6} Nevertheless, our result did not match with study carried out in central Rajasthan⁷, New Delhi⁸ and Rohtak, North India⁹ where they reported inverted “V” sacral hiatus as common shape in 42%, 43.75% and 29.21% respectively. In 5.71% of sacra (3 in males and 1 in female) shape of sacral hiatus was dumbbell shape, which was similar to previous research carried in Nil Ratan Sircar Medical College, Kolkata⁵ (3%) and Karpagam Faculty of Medical Sciences & Research, Coimbatore, Tamilnadu¹⁰ (5%) respectively. A research conducted in Gujrat¹¹ and West bengal^{12,13} regarding morphometric study of sacral hiatus and its clinical implication, coincides with present study. Spina bifida or agenesis of sacral hiatus occurs due to failure of fusion of sacral vertebrae. However, in spina bifida caudal epidural block is still manageable. Spina bifida was seen in 2.85% (only in

males) in our study which was in accordance with work carried in Kolkotta⁵ 4% (only in male) and Gujarat¹¹ in 1.5%. Irregular shape of sacral hiatus was present in 8 (11.42%) which is similar to study carried in of Rajasthan.⁷

In our study the most frequent position of apex of sacral hiatus was seen in 40(57.14%) at the level of S4 vertebra, 27(38.57%) cases at the S3 level and in only in 1(1.42%) at the level of S5 and 2(2.85%) at 2nd sacral vertebra. Our results are in agreement with the studies done in Rajasthan⁷ where apex was found at S4 in 54.66%, Tamilnadu¹⁰ 56.36% and Ahemdabad, Gujarat¹¹ 55.9% respectively. The exact location of level of apex of sacral hiatus is vital since it's an anatomical marker to perform caudal epidural block. There was noticeable alteration in the level of apex ranging from S2 to S4. There is always high risk of penetration of dural sac during caudal epiblock, if the level of apex lies at higher level (2nd or 3rd) sacral vertebra. Therefore, extra preventative care should be taken while introducing syringe needle into the sacral canal. Our study is in accordance with all other studies where we noted that location of apex can vary from upper part of third sacral vertebra to lower part of fifth sacral vertebra. The incidence of location of base at 4th sacral vertebra was seen in 11.42% which was similar to the study conducted in

Tamilnadu¹⁰ (18.9%) and Vallah, Amritsar¹⁴ (13.42%).

Previous studies revealed the average length of sacral hiatus to range from 20.1mm to 26.1mm which was similar to present our study 21.49 mm \pm 9.39mm.^{7, 8, 15} But the study performed in different medical colleges of West bengal¹³ and Gadag, Karnatak¹⁶ described higher average value 35.92mm and 29.5mm respectively.

Similarly, the range of breadth of sacral hiatus observed in the present study was 5.52-22.3mm with mean width 11.45mm \pm 3.21mm which was similar to the result of West Bengal range (6-23.3mm) with mean 12.10mm.¹² The depth or Anteroposterior diameter of the sacral hiatus at the apex is extremely vital since it should be adequately large to administer needle into the sacral canal. Assorted diameters of the depth of sacral hiatus may result subcutaneous accumulation of anesthetic drug. In the present study the mean anteroposterior diameter of sacral canal at the apex was 8.08 \pm 2.16mm with a range of 0.3 to 14mm. The findings of the present study is similar to studies done by in New Delhi, India⁸, West Bengal¹³ and Japan.¹⁷

CONCLUSION

There were significant anatomical differences seen in the shape and the location of level of sacral hiatus. The proper anatomical knowledge of these observed variant characteristics of different parameters of sacral hiatus helps to carry out successful caudal epidural block for anesthetic and analgesic purpose in surgery for orthopedic, spinal disorders, back pain and painless delivery. Thus, better concept of the anatomical variation of sacral hiatus is very much essential to clinicians those who execute caudal epidural block.

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