STUDY ON MORPHOLOGICAL VARIABILITY OF SACRAL BONES

Rachita Laxmikant Malwatkar[1], Yuvaraj Jayprakash Bhosale[2]

[1]Assistant Professor, Department of Anatomy, Raipur Institute of Medical Sciences, Raipur.
[2]Additional Professor, Department of Anatomy, Seth G. S. Medical College and KEM Hospital, Parel, Mumbai.

ABSTRACT

Anatomical variations in the sacral bones are clinically important, while administering local anaesthetic agents in caudal block. The present study is a posthumous examination of variation in sacral bones from a tertiary care medical college.

MATERIALS AND METHODS

A total of 107 complete, undamaged dry sacral bones were analysed for the following parameters: Shape, length, transverse width, antero-posterior diameter of sacral hiatus; Location of the apex and base of sacral hiatus in relation to level of sacral vertebra; Distance from the apex and base of sacral hiatus to the level of S2 spine; Distance between the two superior ends of lateral sacral crests; Distance between right and left superior end of lateral sacral crest and the apex of sacral hiatus; Variations such as sacralisation of lumbar vertebra, dorsal deficient wall and agenesis of sacral hiatus.

RESULTS

The most commonly observed shape was inverted U (38.31%), majority of the bones had sacral hiatus at the level of S4 (66%) while the base of the hiatus at S5 (89%). Mean (SD) (in mm) length of sacral hiatus was 22.5 (9.1), width was 15.16 (3.15) and anteroposterior diameter was 4.18 (1.07). Mean (SD) of distance (in mm) between S2 spine and the apex of sacral hiatus was 38.15 (9.4) and base was 60.3 (9.2).

CONCLUSION

We found out a huge variability in the shape, location and dimensions of sacral bones and sacral hiatus. It is important for the clinicians to keep in mind this variability while performing caudal epidural block.

KEYWORDS

Posthumous, Vertebra, Variation.

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INTRODUCTION

Sacrum meaning 'Temple' in Greek and 'Sacred' in Latin is a large vertebral bone housing all the caudal spinal nerves.[1] Sacral hiatus, the caudal opening of the sacral canal contains lower sacral and coccygeal nerve roots, filum terminale externa and fibro-fatty tissue. Due to imperfect development of laminae, the dorsal wall of the sacra is variably deficient.[2] Sacral hiatus is clinically important as caudal block, also known as caudal epidural anaesthesia, is a commonly undertaken procedure carried out either for the management of chronic back pain or while doing major abdominal surgeries. Crucial to the administration of local anaesthesia is the identification of location of sacral hiatus for easy access into sacral epidural space and the attempt in doing so was carried out first time in 1941.[3] Studies had evaluated the anatomical variation of sacral bone and came up with varying findings.[4,5] Hence, we envisaged the present study to assess the morphometrical variation of the sacrum that may have an impact on the clinical significance during the administration of epidural anaesthesia.

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Corresponding Author:
Dr. Yuvaraj Jayprakash Bhosale,
Additional Professor,
Department of Anatomy,
Seth G S Medical College and KEM Hospital,
Parel, Mumbai-400012.
E-mail: dryuvaraj@gmail.com
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MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Seth GS Medical College and KEM Hospital, Mumbai, after obtaining review exemption from the Institutional Ethics Committee. A total of 107 complete, undamaged dry sacral bones that were undetermined gender and age were obtained and were kept free from any dust, moth or insect. Anatomical measurements were taken on these specimens using a steel scale, measuring tape, divider, goniometer, compass, 60-degree square and protractor (Fig. 1, 2 and 4). Since the posterior superior iliac spines, which are readily palpable on the body surface of the patient, imposed on the superolateral sacral crests of the sacrum and our measurements were carried out on dry sacral bones, the latter points were used as landmarks in the measurements. As the dural sac terminates around the level of S2, the distance from apex and base of the sacral hiatus to the level of the S2 spine was also measured. The following parameters were estimated for each sacral bone: Shape of sacral hiatus; Location of the apex of sacral hiatus in relation to level of sacral vertebra; Location of the base of sacral hiatus in relation to level of vertebra; Length of sacral hiatus; Transverse width of sacral hiatus; Anteroposterior diameter of sacral hiatus at the apex; Distance from the apex of sacral hiatus to the level of S2 spine; Distance from the base of sacral hiatus to the level of S2 spine; Distance between the two superior ends of lateral sacral crests; Distance between right superior end of lateral sacral crest and the apex of sacral hiatus; Distance between left superior end of lateral sacral crest and the apex of sacral hiatus; Variations such as sacralisation of lumbar vertebra, dorsal deficient wall and

agenesis of sacral hiatus. Descriptive statistics was used for representing each of the above mentioned parameters.

RESULTS

Of the total 107 sacra three showed agenesis of sacral hiatus (Fig. 3G), two showed dorsal deficient wall (Fig. 3H) and two showed dorsal deficient wall and unfused sacral vertebrae. These seven sacra were included only for studying the shape of sacral hiatus and were excluded from the study for evaluation of rest of the parameters.

Shape of Sacral Hiatus

The most common shape observed was inverted U (Fig. 3A) and V (Fig. 3B), which was present in 41/107 (38.31%) sacra and in 28/107 (26.16%) sacra respectively. Table 1 lists the number of other shapes of sacral bones that were observed in the present study. Both the above types were considered as normal and the sacral hiatus was present against 5th and 4th sacral segments. Agenesis of sacral hiatus, a rare phenomenon was observed in 3 (2.8%) specimens only (Fig. 3G).

Location of Apex and Base of Sacral Hiatus

Location of the apex of sacral hiatus in relation to level of sacral vertebra varied from S2 to S5 vertebra level. A large majority of the bones had the sacral hiatus at the level of S4 vertebra (66/100) followed by S3 vertebra (31/100), S5 (2/100) and S2 (1/100). Similarly, location of the base of sacral hiatus in relation to level of vertebra varied from S4 vertebra to coccyx. A total of 89/100 had the base against S5 vertebra and was found against S4 vertebra in 8/100 sacra and against coccyx in 3/100 bones.

Dimensions of Sacral Hiatus

Mean (SD) Length (mm) of sacral hiatus was 22.5 (9.1) with a range between 10 and 50. Mean (SD) transverse width (mm) of sacral hiatus at its base was 15.16 (3.15) and ranged between 6 and 23 mm. The anteroposterior diameter of sacral hiatus at its apex varied from 2-7 mm with the mean (SD) of 4.18 (1.07) mm. Mean (SD) of distance (in mm) between S2 spine and the apex of sacral hiatus was 38.15 (9.4), while the same for the base of sacral hiatus was 60.3 (9.2) mm. The distance between two superior ends of lateral sacral crests varied from 50-85 mm with a mean (SD) of 65 (5.7) mm. Mean (SD) of the angle (in^{o}) between the 9th and 10th parameters was 57.27 (5.6), while for 9th and 11th parameter was 57.23 (6.1).

Sl. No.	Shape of Sacral Hiatus	n (%)
1	Inverted U	41 (38.31)
2	Inverted V	28 (26.16)
3	M shaped	12 (11.21)
4	Dumbbell	11 (10.28)
5	Irregular	5 (4.67)
6	Bifid	3 (2.8)
7	Dorsal Deficient Wall	4 (3.73)
8	Agenesis of Sacral Hiatus	3 (2.8)

Table 1: Shapes of Sacral Vertebra (N=107)

Study ID	Key Findings
Nagashree et al[4]	• 51 dry human sacral bones were studied. • 23.5% were inverted 'U' shaped, 39.2% inverted 'V' shaped, 25.4% elongated, 9.8% irregular and 1.9% had complete agenesis. • The level of apex of sacral hiatus was commonly found against 4th sacral vertebra level in 56%. • The level of base of sacral hiatus was commonly found against 5th sacral vertebra. • The mean length of sacral hiatus was 21.5 mm.
Dhananjay et al[5]	• 103 dry human sacral bones were studied. • Agenesis of the hiatus was observed in 3 bones. • Mean (SD) length of the sacral hiatus was 34.13 (11.82) mm (Range 7–76 mm). • Mean (SD) of width of sacral hiatus at level of sacral cornua was 13.71 (2.24) mm (Range 9–20 mm).
Shewale et al[6]	• 204 dry human sacral bones were studied. • A typical sacrum consisting of 5 segments was observed in 142 (69.60%) cases. • The most common shape of sacrum that was observed were inverted 'U' (83 cases; 40.69%), inverted 'V' (66 cases; 32.35%). • Complete spina bifida and absence of sacral hiatus was observed in 2 cases (i.e. 0.98%). • The apex of sacral hiatus was most commonly located at 4th sacral vertebra in 133 (66.5%) cases. • Mean length of sacral hiatus was 23.44+10.59 mm in males and 20.44 +7.96 mm in females. • Mean values for transverse width at the base of hiatus observed were 13.68+3.87 mm in males and 13.45+2.88 mm in females. • Narrowing of sacral canal at the apex of sacral hiatus (diameter less than 3 mm) was observed in significant number of cases (15 cases; 7.5%).
Shinde et al[7]	• 100 dry human sacra were studied. • The inverted U shaped sacral hiatus was the most common (56%) followed by inverted V shaped sacral hiatus in 24% of sacra. • The other variations like irregular shaped hiatus (10%), bifid hiatus (2%), dumbbell shaped hiatus (5%), complete spina bifida (1%) and absent

	hiatus (2%) were also observed by the authors.
Desai et al [8]	• 271 dry human sacra studied. • The most commonly observed shape of sacral bone was inverted U-shape (42.12%) followed by inverted V-shape (35.43%), irregular (12.99%). • The mean length of sacral hiatus was 21.70 mm. • The mean anteroposterior diameter of sacral canal at the apex of sacral hiatus was 5.50 mm.
Sasikala et al[9]	• 30 human dry sacra studied. • 80% of the sacra had 5 segments, 10% had 6 segments, 6.7% had 4 segments and 3.3% had spina bifida. • 53.3% were inverted 'U' shaped, 36.7% were inverted 'V' shaped. • Apex of sacral hiatus was present at the level of S4 in 72.4% and at S5 in 20.7% of bones.

Table 2: Summary of Key Findings from Similar Studies in the Same Population

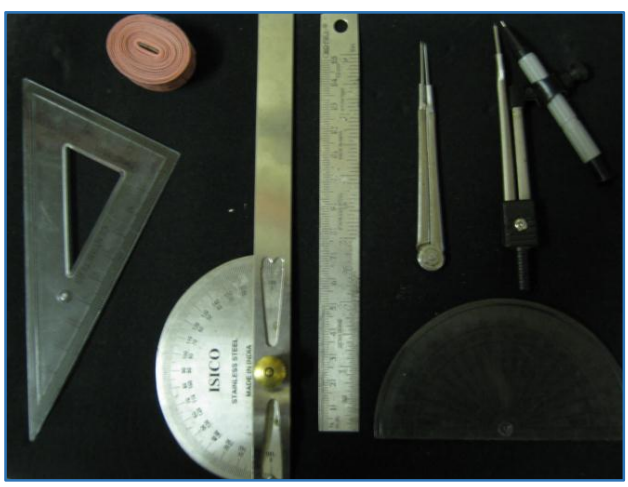
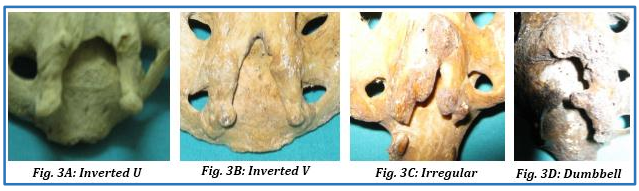


Fig. 1: Illustration showing the Instruments Used for the Study Set Square, Measuring Tape, Goniometer, Steel Scale, Divider, Compass, Protractor

Fig.2: Illustration showing Measurement of Length of Sacral Hiatus



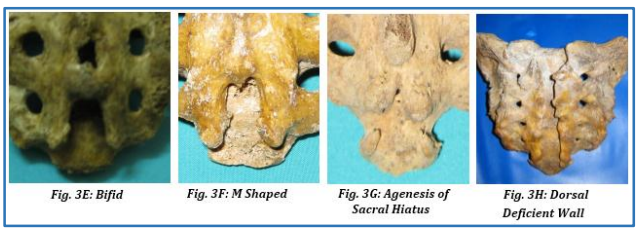


Fig. 3: Variations in Shapes of Sacral Hiatus

Fig. 4: Illustration showing Measurement of Transverse Width of Sacral Hiatus

DISCUSSION

The present study was undertaken to assess the variability in the shape, location and dimensions of sacra in 107 sacral bones. We found that the most commonly observed shape was inverted U (38.31%), majority of the bones had sacral hiatus at the level of S4 (66%), while the base of the hiatus was located at S5 vertebra (89%). Mean (SD) length of sacral hiatus was 22.5 (9.1) mm, while the width was 15.16 (3.15) mm.

The sacra, bone articulates with the coccyx caudally and the wide base which lies superiorly binds to the fifth lumbar vertebra and forms a lumbosacral angle. It is set obliquely and curved longitudinally, its dorsal surface being convex, the pelvic concave. Usually, the fifth inferior articular process of sacrum is connected to the coccygeal cornua by intercornual ligaments and forms the sacral hiatus. But a huge anatomical variation has been observed and has been reported by various authors. Table 2 enlists the key findings of studies that had evaluated a similar hypothesis.

The success of caudal epidural block depends on the correct identification of the sacral hiatus and caudal epidural space. Significant unidentified anatomical variations in the same would lead to failure in delivering the anaesthetic agents. Usually, the patient is kept in prone position and then the cornua is palpated and then the spinal needle is inserted 2-3

mm at an angle of 45 degrees through sacrococcygeal ligament. Reports state a failure rate of nearly 5%[10] and a much higher (14.83%) in children.[11] Recently, various strategies such as using low-current epidural simulation or ultrasonogram have been shown to accurately identify the caudal epidural space.[12,13] Developmental defects have been reported commonly in the vertebral column to an extent of 3 - 35%.[14] Spina bifida is a very important vertebral anomaly of which the commonest is spina bifida occulta. As the name suggests patients with spina bifida occulta will be asymptomatic and often the diagnosis will be either accidental or posthumous. Severe cases of spina bifida can be associated with number of disorders like intraspinal lipoma, tethered cord syndrome, genitourinary dysfunction, lumbar spondylolysis, foot deformities and syringomyelia.[15] Additionally, spina bifida is one of the reasons for failure of caudal epidural block. Another clinical application of knowledge of sacral hiatus is required during the injection of corticosteroids in patients suffering from sciatica.[16]

CONCLUSION

Huge variability was observed in the shape, location and dimensions of sacral bones and sacral hiatus. It is important for the clinicians to keep in mind this variability while performing caudal epidural block.

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