

## THE PHARMA INNOVATION

# The study of morphometric analysis of sacral hiatus of human sacrum

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**Introduction:** Sacral hiatus (SH) is a significant landmark during caudal epidural block (CEB) which is employed for analgesia and anaesthesia during a wide range of clinical conditions. This requires a thorough knowledge of morphometric characteristics of SH and surrounding landmarks, but variability in morphometric dimensions exists among different populations.

**Aim:** The aim of this study is to examine measure and record the morphometry of sacral hiatus in order to study the anatomical variations of sacral hiatus which will be useful for administration of caudal epidural block and improve its reliability and success rate.

**Materials and Methods:** The study is done in the Department of Anatomy, Osmania Medical College, and in various other medical colleges in and around Hyderabad. The 200 dry sacra are collected from Department of Anatomy of Osmania Medical College, and in various other medical colleges in and around Hyderabad, during the period January 2011 - December 2012.

**Results:** Inverted U shape is the most common shape seen in 91 sacra (45.5%) and M shape is the rarest finding seen in 2 sacra (1%) in this study. Levels of apex vary from upper of second sacral vertebra to middle of fifth sacral vertebra. It is most commonly located at the level of fourth sacral vertebra in 106 sacral bones (56.99%) and it is least common at level of second sacral vertebra in 2 sacra (1.08%). Levels of base vary from middle of fourth sacral vertebra to middle of coccygeal vertebra. It is most commonly located at the level of fifth sacral vertebra in 150 sacral bones (80.65%) and is least common at level of 4<sup>th</sup> sacral vertebra in 11 sacral bones (5.91%). The length of sacral hiatus ranges from 5.75 mm to 49.5 mm with arithmetic mean of 24.804mm with median of 23.86mm. Standard deviation is found to be 9.415mm. Length is most commonly found in range of 20 – 30 mm in 77 sacra (41.10%) followed by 11 – 20 mm in 54 sacra (29.03%), Transverse diameter in the range of 5.54mm to 21.92mm with arithmetic mean of 13.861mm and median of 13.955mm. Standard deviation is found to be 2.520mm. In 89.25% (166) sacra the transverse diameter is found to be in range of 11mm to 20mm. Anteroposterior diameter is in the range of 1 mm to 10.96mm with arithmetic mean of 4.445 mm and median of 4.410 mm. Standard deviation is found to be 1.627 mm. Most of sacra that is in about 118 sacra (63.44%) the AP diameters are found to be between 4mm to 6mm. The presented study results coincided with majority of studies in other regions and it contributes to the available literature.

**Conclusion:** Multiple bony landmarks and their morphometric dimensions should be considered to locate the SH during CEB. Values for various morphometric parameters of SH are less in Indians in comparison to other populations, which should be contemplated during caudal epidural injections and trans-sacral thecaloscopy.

**Keyword:** Bony landmarks, Morphometric dimensions, caudal epidural block, caudal epidural injection, sacral hiatus

**INTRODUCTION:** The sacrum is a large triangular bone formed by union of five vertebrae. It is flanked by the two hip bones and outlines the posterosuperior wall of the pelvic cavity. The dorsal wall of the sacral canal presents an arched sacral hiatus (SH) below the third or fourth spinous tubercle. SH is formed due to failure of fusion of laminae of fifth sacral vertebra which exposes the posterior surface of the body of vertebra (Starding *et al.*, 2008) [1]. The SH has lower sacral and coccygeal nerve roots, filum terminale externa and fibro-fatty tissue. It is roofed by skin, subcutaneous fat and sacrococcygeal membranes. The lateral boundaries of the hiatus are constituted by two sacral cornua which are the remnants of the inferior articular processes (Kumar *et al.*, 2010) [2]. Recognition of the surrounding bony landmarks is a crucial step for localization of sacral hiatus and caudal epidural space (Aggarwal *et al.*, 2009) [3]. The reliability and success of CEB depends upon the comprehensive knowledge of anatomic variations of SH and surrounding bony landmarks (Nagar, 2004; Senoglu *et al.*, 2005) [4, 5]. Furthermore, trans-sacral thecaloscopy necessitates a thorough acquaintance of morphometric parameters of SH for the atraumatic usage of flexible endoscopes (Mourgela *et al.*, 2009) [6].

The use of fluoroscopy during epidural steroid injection is the preferred method or gold standard for placing the needle more accurately in the sacral hiatus. X-Rays, ultrasonography and fluoroscopy of lumbosacral spine will be of useful in identifying the absence of sacral hiatus, shapes of sacral hiatus and level of SH apex and base, it is not always feasible to do so because of time, cost constraints and the risk of radiation hazard. Some workers showed that there was a successful injection without using fluoroscopic view in 74% of the cases (Sengolu *et al.* 2010).

Morphometric study of sacrum has been done by many workers in many different geographical areas which concluded that understanding the variations of sacral hiatus may improve the success of caudal epidural block. But this type of study is limited in south Indian population.

The aim of this study is to examine measure and record the morphometry of sacral hiatus in order to study the anatomical variations of sacral hiatus which will be useful for administration of caudal epidural block and improve its reliability and success rate.

#### **Objectives of the study**

1. To study the various parameters of sacral hiatus.
2. To know the frequency of anatomical variations of sacral hiatus.
3. To improve the success rate of caudal epidural block

#### **Material and Methods**

The study is done in the Department of Anatomy, Osmania Medical College, Hyderabad and in various other medical colleges in and around Hyderabad.

**Sample:** Dry human sacrum.

**Size:** of sample -200 Sacra of unknown age and sex.

**Place of study:** The 200 dry sacra are collected from Department of Anatomy of Osmania Medical College, Hyderabad and in various other medical colleges in and around Hyderabad.

**Period of study:** January 2011-December 2012

**Type of study-Morphom:** The authors are thankful to Dept of Pharmacology and Osmania

Medical college & General Hospital, Hyderabad for providing facilities to carry out this work. Selection criteria-Includes inclusion criteria and exclusion criteria

**Inclusion criteria:** Only undamaged sacra with complete intact sacral hiatus were taken.

**Exclusion criteria:** Damaged sacra, Mutilated sacra, deformed sacra, Sacra with variations.

**Statistical Analysis:** The Statistical software XLSAT 2017 used for the analysis of data and Microsoft word and Excel has been used to generate graphs and tables.

**Instruments used for the present work are**

Digital vernier calipers with 0.01 accuracy, Divider, Measuring tape and Digital camera In order to avoid manual errors, sufficient care is taken and all parameters are measured accurately.

**Methods of data collection**

The present study includes 200 dry human sacra of unknown sex and age collected from Department of Anatomy of Osmania Medical College, Hyderabad and in various other medical colleges in and around Hyderabad. Random selection of sacra was done, labelled and measurements are taken. data collected entered in Microsoft excel sheets, tables and graphs are generated by Statistical software XLSAT 2017. The following parameters of sacral hiatus of each sacrum taken for the study were

**Non metric parameters**

The shape of sacral hiatus. 2). Level of apex of sacral hiatus with respect to sacral vertebrae. 3). Level of base of sacral hiatus with respect to sacral vertebrae. These were recorded by naked eye examination.

**Metric parameters**

Length of sacral hiatus: It was measured with help of vernier calipers from midpoint of base to apex of sacral hiatus. Anteroposterior diameter or depth of sacral hiatus at the apex. It was measured with help of vernier calipers or divider. Transverse width of sacral hiatus at the base. It was measured between the inner aspects of inferior limit of sacral cornua with help of vernier calliper.

**Observations and Results**

**Non metric parameters**

**1. Shape of the sacral hiatus**

In the present study 200 dry human sacra of unknown sex and age are taken. Shape of sacral hiatus is observed by naked eye examination. The various shapes found in this study are Inverted U (shown in Fig. 1) identified by their shape. Inverted V (shown in Fig. 2) identified by their shape.

Irregular shape – In this type lateral boundaries of the sacral hiatus are not completely smooth or uniform or when there is unilateral projection. (Shown in Fig. 3). Bifid shape or aperture in the dorsal wall - The laminae may fail to fuse above a fused part. (Shown in Fig. 4).Dumbbell shape - In this type there are projections from both sides which are more or less at the same level. (Shown in Fig. 5).

M type–in this type there is a downward projection in the midline indenting the apex of the sacral hiatus. (Shown in Fig. 6). Complete Spina Bifida–There is complete absence of the dorsal wall of sacral canal which results due to non-fusion of all lamina. In this case, there is no apex but base is still present. (Shown in Fig. 7). Absence of hiatus or Agenesis of hiatus – There is no sacral hiatus at all in which all laminae fuse which may results due bony overgrowth. (Shown in Fig. 8)



**Fig 1:** Inverted U Shape



**Fig 4:** Bifid Shape



**Fig 2:** Inverted V Shape



**Fig 5:** DUMB BELL Shape



**Fig 3:** Irregular Shape



**Fig 6:** M Shape



**Fig 7:** Complete Spina Bifida



**Fig 8:** Agenesis of sacral hiatus

Inverted U shape is the most common shape and M shape is the rarest finding in this study. Inverted U shape is most commonly seen in 91 sacra (45.5%), followed by inverted V shape in 43 sacra (21.5%). both inverted U and V shape are considered as normal shape observed in 134 sacra (76%). The irregular shape is seen in 36 sacra (18%), dumbbell shape in 11 sacra (5.5%), bifid shape in 3 sacra (1.5%) and M shape is less commonly seen in 2 sacra (1%). Complete spina bifida (absence of dorsal wall) in 7 sacra (3.5%) and Agenesis (absence of hiatus) also seen in 7 sacra (3.5%).

**Table 1:** Percentage distribution of various shape of the sacral hiatus

S. No.	Shape	No of Sacra (No - 200)	Percentage
1	Inverted U	91	45.5
2	Inverted V	43	21.5
3	Irregular	36	18
4	Dumbbell	11	5.5
5	Bifid	3	1.5
6	M shape	2	1
7	Agenesis	7	3.5
8	Complete spina bifida	7	3.5
	Total	200	100

14 sacra which are having complete spina bifida and agenesia are excluded from measurements as typical sacral hiatus is not present in them. Level of apex of sacral hiatus in relation to sacral vertebra. In the present study location of apex of sacral hiatus is observed by naked eye examination.

Levels of apex vary from upper of second sacral vertebra to middle of fifth sacral vertebra. It is most commonly located at the level of fourth sacral vertebra in 106 sacral bones (56.99%) followed by at the level of third sacral vertebra in 73 sacral bones (39.25%) and then at level of fifth sacral vertebra in 5 sacra (2.69%). it is least common at level of second sacral vertebra in 2 sacra (1.08%).

**Table 2:** Percentage distribution of level of apex of the sacral hiatus in relation to sacral vertebra

S. No.	Level of Apex	No of Sacra (NO- 186)	Percentage
1	S2	2	1.08
2	S3	73	39.25
3	S4	106	56.99
4	S5	5	2.69
	Total	186	100

**3) Level of base of sacral hiatus in relation to sacral and coccygeal vertebra**

In the present study location of base of sacral hiatus is observed by naked eye examination. Levels of base vary from middle of fourth sacral vertebra to middle of coccygeal vertebra. It is

most commonly located at the level of fifth sacral vertebra in 150 sacral bones (80.65%) followed by at the level of coccygeal vertebra in 25 sacra (13.44%) and is least common at level of fourth sacral vertebra in 11 sacral bones (5.91%).

**Table 3:** Percentage distribution of level of base of the sacral hiatus in relation to sacral vertebra

S. No.	Level of Base	No of Sacra (NO-186)	Percentage
1	S4	11	5.91
2	S5	150	80.65
3	Coccyx	25	13.44
Total		186	100.00

**A) Metric parameters**

**1. Length of sacral hiatus**

He length of sacral hiatus is measured from midpoint of base of sacral hiatus to apex of sacral hiatus. In the present study the length of sacral hiatus ranges from 5.75 mm to 49.5 mm with

arithmetic mean of 24.804mm with median of 23.86mm. Standard deviation is found to be 9.415mm. These findings are represented in table no.4

**Table 4:** Incidence of length of the sacral hiatus

S. No.	Length of the sacral hiatus	
1	Minimum	5.75 mm
2	Maximum	49.5 mm
3	Mean	24.804 mm
4	Median	23.86
5	Standard deviation	9.415mm

Length is most commonly found in range of 20 – 30 mm in 77 sacra (41.10%) followed by 11 – 20 mm in 54 sacra (29.03%), then 30 – 40 mm In 34 sacra (18.28%), 40 -50 mm in 13 sacra (6.99%) and 0- 10mm in 8 sacra (4.3%). Thus in about 131 sacra (70.43%) length is in found to be between 11mm – 30 mm. These findings are represented in table no.5 and graph no.5

**Table 5:** Percentage distribution of length of the sacral hiatus

S. No.	Length of SH	No of Sacra (NO-186)	Percentage
1	0 to 10	8	4.30
2	11 to 20	54	29.03
3	21 to 30	77	41.40
4	31 to 40	34	18.28
5	41 to 50	13	6.99
Total		186	100.00

**Transverse diameter of sacral hiatus**

The transverse diameter or width of sacral hiatus is measured at the level of base of sacral hiatus by measuring the distance between the 2 sacral cornua. In the present study the transverse

diameter is found in the range of 5.54 mm to 21.92mm with arithmetic mean of 13.861 mm and median of 13.955mm. Standard deviation is found to be 2.520mm. These findings are represented in table no.6

**Table 6:** Incidence of transverse diameter of the sacral hiatus

S. No.	Transverse Diameter	
1	Minimum	5.54 mm
2	Maximum	21.92 mm
3	Mean	13.861 mm
4	Median	13.955 mm
5	Standard deviation	2.520 mm

In 89.25% (166) sacra the transverse diameter is found to be in range of 11mm to 20mm. In 9.14%

(17) sacra it is found to between 0-10mm and in 1.61% (3) sacra it is found to between 21mm - 30

mm. All these findings represented in table no 7 and graph no.5.

**Table 7:** Percentage distribution of transverse diameter of the sacral hiatus

Transverse diameter	No of Sacra (No-186)	Percentage
0 to 10	17	9.14
11 to 20	166	89.25
21 to 30	3	1.61
Total	186	100.00

**Anteroposterior diameter of sacral hiatus at the level of apex of sacral hiatus**

The anteroposterior diameter is measured at the level of apex of sacral hiatus. In the present study the anteroposterior diameter is found in the range of 1 mm to 10.96mm with arithmetic mean of 4.445 mm and median of 4.410 mm. Standard deviation is found to be 1.627 mm. These findings are represented in table no: 8.

**Table 8:** Incidence of Anteroposterior diameter of the sacral hiatus

S. No.	Anteroposterior Diameter of sacral hiatus	
1	Minimum	1 mm
2	Maximum	10.96 mm
3	Mean	4.445 mm
4	Median	4.410 mm
5	Standard deviation	1.627 mm

Most of sacra that is in about 118 sacra (63.44%) the AP diameter are found to be between 4mm to 6mm. In 47 sacra (25.77%) it is found to be between 0-3mm, then in 19 sacra it is found to be between 7mm to 9mm. In 2 sacra (1.08%) it is more than 9mm. In significant number of sacra 25.77% narrow sacral canal is found. These findings are represented in Table no: 9.

**Table 9:** Percentage distribution of anteroposterior diameter of the sacral hiatus

AP Diameter	No of Sacra (NO-186)	Percentage
0 to 3	47	25.27
4 to 6	118	63.44
7 to 9	19	10.22
More then 9	2	1.08
Total	186	100.00

**Discussion**

Sacral hiatus is the preferred site for caudal epidural anesthesia (CEA) and analgesia as the dural sac ends at the middle of second sacral vertebra above the level of sacral hiatus. The approach to epidural space through sacral region produces more reliable and effective block of sacral nerves more than lumbar nerves. Therefore it is preferred for operations on anus, rectum, perineum, urethra and vagina (Abdel-monen *et al.* 2006) Caudal epidural anesthesia is the most popular regional anesthesia technique used in children. With advanced age, only the relative difficulty in localizing the sacral hiatus limits its use.

Sacral hiatus has been utilized for administration of epidural anesthesia in obstetrics as well as in orthopaedic practice for transpedicular and lateral mass screw placement (Nagar, 2004) [4].

In children caudal anesthesia is usually indicated for intra-and postoperative analgesia. Procedures involving the area of T10 to S5 dermatomes in children younger than 8 years of age or weight lower than 30 kg are more adequate.

In adults the technique is used mainly to control chronic pain. The loss of resistance technique should be used to confirm placement of the needle in the epidural space. To avoid dural puncture, its tip should be below S2, which corresponds to a mark in the skin 1 cm below the posterior superior iliac spine.

Correct needle positioning can be confirmed by the lack of subcutaneous edema or resistance to the injection, electrical stimulation with contraction of the anal sphincter, and determination of the clinical effects of the drug injected.

Severe complications are rare, but they include epidural abscess, meningitis, epidural hematoma, dural puncture and post-puncture headache, subdural injection, pneumocephalus and air embolism, lumbar pain, and catheter rupture.

**Shape of the sacral hiatus**

In most of the literature revealed that the, sacral hiatus is an arch shaped opening present at the caudal end of sacral hiatus.

In the present study we found that mostly common shape is Inverted U seen in 45.5% sacra.

Least common shape is M shape seen in 1% sacra. Other shapes Inverted V (21.5%), irregular (18%), dumbbell (5.5%) and bifid (1.5%).

Our findings correlated with the previous findings. Vinod Kumar *et al.* (1992) [7] showed most common shape was inverted-V seen in 94 (46.53%) which is higher than present study (21.5%). Inverted-U in 60 (29.70%) which is lower than present study. These findings did not match with present study. Nagar S.K. (2004) [4] study on Gujarati population, inverted U was most common seen in 41.5% sacra. This finding is almost similar to present study. In Abd El-Monem. Hegazy and Neven Gamil (2006) [8] study most common shape is inverted U seen in 46.7% sacra which matches with the present study. Zarana K Patel *et al.* (2011) [9] study on Gujarati population, inverted U was most common seen in 74 (49.33%) sacra which is similar to present study.

Njihia *et al.* (2011) [10] founded inverted V was most common seen in 32.1% sacra followed by dumbbell shape (31%) and inverted-U (16.7%). These findings do not match with present study. In Mohamed S. Mustafa *et al.* (2012) [11] found inverted U and inverted V in male and inverted V and dumbbell shaped in female dry sacra.

In the present study, these findings revealed that Both inverted U and inverted V are considered as normal and may be considered as the most favourable shapes for caudal epidural block as they provide adequate space for introducing needle into epidural space without any obstacle.

The present study revealed that, complete spina bifida is seen in 3.5% sacra. Absence of hiatus is seen in 3.5% sacra. Our findings similar with previous studies. According to Nagar (2004) [4] study in Gujarati population, complete agenesis was seen in 1.5% and absence of hiatus in 0.7%. These values are lower than the present study. In Senoglu *et al.* (2005) [5] study agenesis of the hiatus was detected in six (6.25%) sacra. This finding is higher than present study.

Abd El-Monem A. Hegazy and Gamil (2006) [8] in their study mentioned that spina bifida seen in 1.1% sacra which is lower than present study. Absence of hiatus is seen in 3 sacra which is

nearly matched with present study. Vishal *et al.* (2012) [12] in Karnataka reported a rare anomaly high sacral hiatus i.e., at the level of 3 sacral vertebrae and non-fusion of lamina of 1<sup>st</sup> sacral vertebrae.

In the present study, we found Failure rate is 7% seen in cases of agenesis or spina bifida cases. Non-fusion of lamina of 1 sacral vertebra may be associated with spina bifida occulta and may lead to painful condition of back.

#### **Level of apex with respect to sacral vertebra**

In the present study, level of apex vary from upper of second sacral vertebra to middle of fifth sacral vertebra. In the present study Apex is most commonly located at the level of fourth sacral vertebra in 106 sacral bones (56.99%). Least commonly located at level of second sacral vertebra in 2 sacra (1.08%). Others findings are at the level of third sacral vertebra in 73 sacral bones (39.25%) and then at level of fifth sacral vertebra in 5 sacra (2.69%). These findings correlated with the previous studies. This finding matches with present study. According to Nagar (2004) [4] study in Gujarati population apex was found most commonly at level of S4 in 55.9% and least at level of S2. These findings matched with the present study. In Abd El-Monem A. Hegazy and Gamil (2006) [8] study apex was at level of S4 vertebra in 45% which is lower than present study. Zarana Patel *et al.* (2011) [9] study on Gujarati population mentioned that found apex commonly present at the level of fourth sacral segment 59.33%.this finding does not matched with present study. Mohamed S. Mustafa *et al.* (2012) [11] mentioned in their study that of SH apex was commonly located at the level of the S4 in all groups of sacra followed by S5 in total and male sacra and both S3 and S5 equally in female sacra. Vishal *et al.* (2012) [12] in Karnataka reported a rare anomaly high sacral hiatus i.e., at the level of 3 sacral vertebrae and non-fusion of lamina of 1<sup>st</sup> sacral vertebrae. If apex is located at a higher level there is a chance of rupture of dural sac that may lead to complete spinal anaesthesia [19].



### Level of base with respect to sacral vertebra

In the present study levels of base vary from middle of fourth sacral vertebra to middle of coccygeal vertebra. In present study Base is most commonly located at the level of fifth sacral vertebra in 150 sacral bones (80.65%), at the level of coccygeal vertebra in 25 sacra (13.44%) and least common at level of fourth sacral vertebra in 11 sacral bones (5.91%).

In the present study, Vinod Kumar *et al.* (1992)<sup>[7]</sup> in their study mentioned that base was mostly at level of S5 in 83.17%. This finding exactly matched with the present study. Nagar (2004)<sup>[4]</sup> study in Gujarati population revealed base was most commonly at the level of S5 in 72.6% which is lower than present study and least common at the level of S4 in 11.1% which is higher than present study. In study by Zarana Patel *et al.* (2011)<sup>[9]</sup> the base was commonly present at the level of S5 in 79.33% which exactly matches with the present study. Mohamed S. Mustafa *et al.* (2012)<sup>[11]</sup> mentioned in their study that S5 was the common level for SH base in all groups of dry sacra. In lumbosacral spine radiographs the common level for base in all groups is S5 followed by S4 in female group and 1<sup>st</sup> coccygeal vertebra (10% and 10%) in male group.

According to some studies base is more fixed in location when compared to apex, hence it is preferred to give the block at the base<sup>[26]</sup>.

### Length of sacral hiatus

In the present study, the length of sacral hiatus ranges from 5.75 mm to 49.5 mm. Arithmetic mean is 24.804 mm and median value is 23.86 mm. Standard deviation is found to be 9.415mm. Length is most commonly found in range of 20-30 mm in 77 sacra (41.10%).

Our study similar with previous findings, in study by Vinod Kumar *et al.* (1992)<sup>[7]</sup> the mean length of hiatus was 20 mm in males and 18.9 mm in females. Nagar S.K. (2004)<sup>[4]</sup> in their study mentioned that length of hiatus varied from 5mm to 69 mm and the mean length of 22.8 mm which is similar with present study. Most sacra have the length in range of 11-30 mm in 65.8%. Senoglu *et al.* (2005)<sup>[5]</sup> reported the average length of the sacral hiatus was 32.1 (9.9) mm (range 12–53

mm) which is higher than present study. The length of the sacral hiatus was mostly between 20 and 40 mm. In 2006 Abd El-Monem A. Hegazy study stated that the mean length was 20mm with a range of 0-66 mm which is similar with present study. Zarana Patel *et al.* (2011)<sup>[9]</sup> in their study mentioned that the length of the sacral hiatus ranged between 4mm to 57 mm with arithmetic mean of 19.63mm. Patil Dhananjay *et al.* (2012)<sup>[13]</sup> observed the average length of the sacral hiatus was 34.13 mm with range 7–76 mm. These findings are higher than present study.

Our study finally revealed that, Length is influenced by defect of nonunion of 2<sup>nd</sup> and 3<sup>rd</sup> pair of lamina and also by coccygeal ankylosis.

### Transverse diameter or width of sacral hiatus at the base

In the present study according to table no: 6, the incidence of transverse diameter range is 5.54mm to 21.92mm, Arithmetic mean is 13.861mm and median is 13.955mm. Standard deviation is found to be 2.520mm. In 89.25% (166) sacra the transverse diameter is found to be in range of 11mm to 20mm.

Nagar (2004)<sup>[4]</sup> mentioned in their study that transverse width varies from 3 to 19 mm which is similar to present study. Zarana Patel *et al.* (2011)<sup>[9]</sup> reported transverse width of base of the sacral hiatus ranged between 1mm to 19mm. Njihia *et al.* (2011)<sup>[10]</sup> in their study mentioned mean inter-cornual distance wasmm which matches with present study. In Patil Dhananjay *et al.* study (2012) width of Sacral Hiatus at level of sacral cornua was in range 9-20 mm with mean of 13.71 which exactly matches with present study. Ramamurthi *et al.* (2013) in their study mentioned that the transverse width ranges from 10 mm to 22 mm with mean of 16.2 mm and median 13mm.

### Anteroposterior diameter of sacral hiatus at the level of apex of sacral hiatus

In the present study, the anteroposterior diameter is in the range of 1 mm to 10.96mm Arithmetic mean of 4.445 mm and median of 4.410 mm. Standard deviation is found to be 1.627 mm.

We found that, most of sacra that is in about 118 sacra (63.44%) the AP diameter is found to be between 4mm to 6mm. In significant high number of sacra 25.77% (less than 3mm) narrow sacral canal is found.

Vinod Kumar *et al.* (1992)<sup>[7]</sup> mentioned in their study that the anteroposterior diameter was 4.8 mm which is similar with present study. In Nagar (2004)<sup>[4]</sup> study anteroposterior diameter ranged from 2 mm to 14 mm with a mean of 4.88 mm which matched with present study. In 64.2% sacra were in range of 4-6mm and less than 3mm seen Nijihia *et al.* (2011)<sup>[10]</sup> in their study stated that anteroposterior diameter ranged from 03-18mm with a mean of 6.4mm.

### Conclusion

Sacral hiatus is preferred site for administration of caudal epidural anesthesia. The success and reliability of caudal epidural anesthesia depends on exact localization of sacral hiatus. Sacrum is one of the bone that exhibit anatomical variations commonly. The morphometrical study of sacral hiatus will improve success rate of caudal epidural anesthesia. The presented study results coincided with majority of studies in other regions and it contributes to the available literature.

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