

Morphometric Study of First Sacral Vertebra in Dry Human Sacra

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Abstract

Introduction: Sacrum is a well known site for internal fixation of spine. In internal fixation, iliosacral screws applied on sacrum corpus passes through S1 vertebra pedicle. There lies epidural space, nerve root and dural sac medial to the pedicle. So, it is important to know detailed anatomy of S1 vertebra to avoid neurovascular injuries. The present study was done to provide morphometric data about dimensions of first sacral vertebra to facilitate spinal instrumentation procedures by spine surgeons. **Aim:** To study the morphometric characteristics of first sacral vertebra in dry human sacra. **Methods:** This study was conducted on 109 dry human sacra, obtained from the bone library, Department of Anatomy of a tertiary care teaching institutes. **Results:** Vertebral body height of first sacral vertebra at midline ranged from 19-37 mm with mean of 30.0 mm. Vertebral body maximum transverse width and vertebral body mid-diameter of first sacral vertebra were ranged from 5-61 mm (mean of 44.6 mm) and from 23-37 mm (mean of 30.3 mm) respectively. Mean posterior pedicle height of S1 vertebra on left and right side were 25.2 mm and 25 mm respectively. Mean pedicle width of S1 vertebra on left and right side were 11.3 mm and 11.5 mm respectively. Mean pedicle depth of S1 vertebra on left and right side were 31mm and 29.1mm respectively. **Conclusion:** Data regarding first sacral vertebra will be useful for pedicle screw fixation and also for formation of screws.

Keywords: Morphometry; Pedicles; Screw Fixation.

Introduction

The sacrum is a large, triangular fusion of five vertebrae and forms the posterosuperior wall of the pelvic cavity, wedged between the two hip (innominate) bones [1]. The sacrum bone is the fulcrum of support for the human torso and as such is well-designed to take great physical stress [2].

Lumbosacral fusion and instrumentation are common procedures for several spinal disorders including spondylolisthesis, lumbar scoliosis and for metastatic, infectious, degenerative and traumatic diseases affecting the sacrum [3]. Posterior decompressive procedures, fusion and internal

fixation procedures need detailed information regarding the anatomy of the first sacral vertebra. So, the aim of present study was to provide morphometric data about dimensions of first sacral vertebra to facilitate spinal instrumentation procedures by spine surgeons.

Material and Methods

This study was conducted on 109 dry human sacra, obtained from Department of Anatomy of a tertiary care teaching institute. The sacra were of undetermined age and gender. Bones with lumbarisation of first sacral vertebra and sacralization of fifth lumbar vertebra were excluded from the study.

The measurements were taken by using digital Vernier calliper (0-200 mm with precision of 0.01mm), divider, ruler and thread.

S1 Vertebral Body Height (VBH)

It is distance (mm) between superior and inferior limit of S1 body at midline, measured with divider and rule (Figure 1).

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S1 Vertebral Body Mid-Diameter (VBD)

It is distance (mm) from anterior to posterior limit of S1 vertebral body at midline, measured with divider and ruler (Figure 2).

S1 Vertebral Body Maximum Transverse Width (VBW)

It is measured with divider and ruler (Figure 3).

Posterior Pedicle Height of S1 Vertebra (PPH)

It is distance (mm) between superior limit of S1 (at junction of pedicle and S1 vertebral body on dorsal aspect) and superior aspect of 1st sacral foramina. It is measured with divider and ruler (Figure 4).

Pedicle Width of S1 Vertebra (PW)

It is perpendicular distance (mm) between line joining anterolateral edge of S1 vertebral body to lateral edge of superior facet of S1 (Point from which perpendicular line drawn is medial edge of pedicle) (Figure 5).

Pedicle Depth of S1 Vertebra (PD)

It is distance (mm) between anterior limit (anterolateral edge of S1 vertebral body) and posterior limit (lateral edge of superior facet of S1) of pedicle at narrowest point. It is measured with divider and ruler (Figure 6).

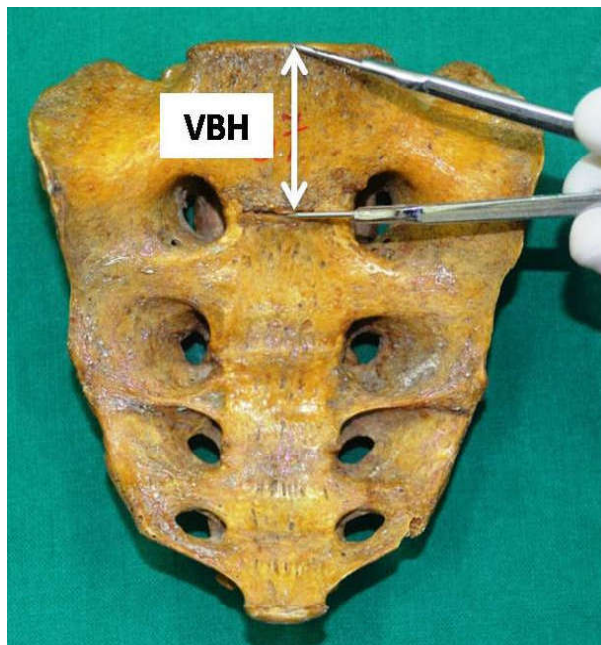


Fig. 1: Measurement of S1 vertebral body height (VBH)

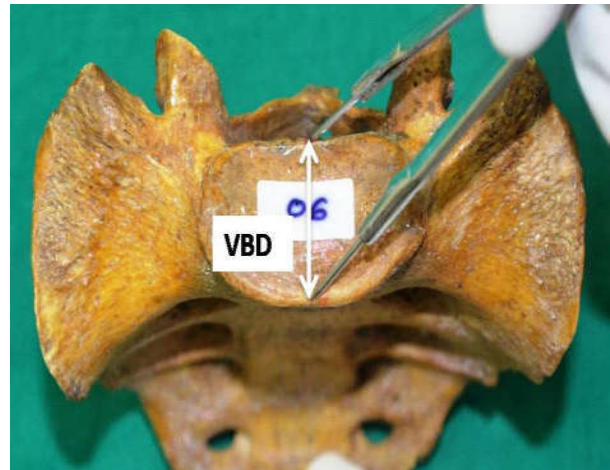


Fig. 2: Measurement of vertebral body mid-diameter (VBD) of first sacral vertebra

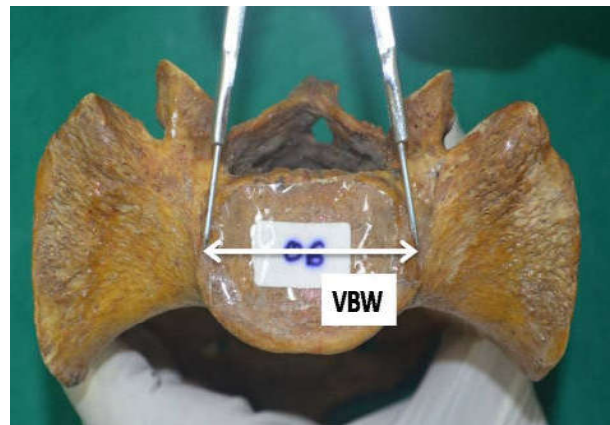


Fig. 3: Measurement of vertebral body width (VBW) of first sacral vertebra

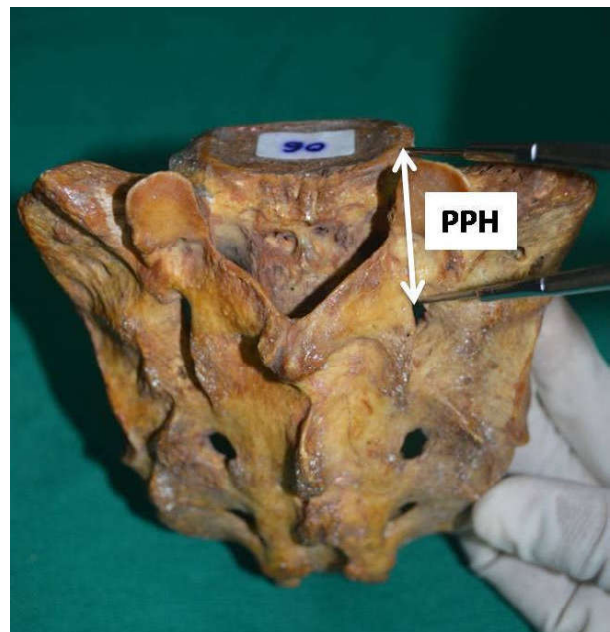


Fig. 4: Measurement of posterior pedicle height (PPH) of first sacral vertebra

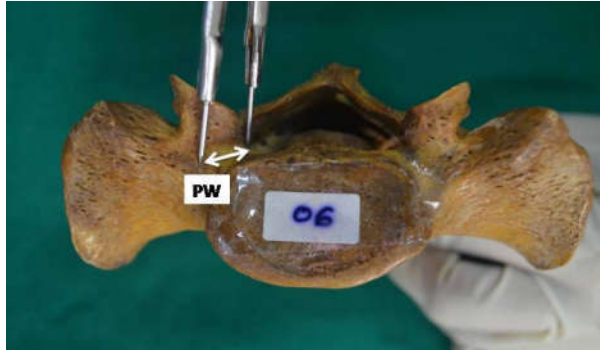


Fig. 5: Measurement of pedicle width (PW) of first sacral vertebra

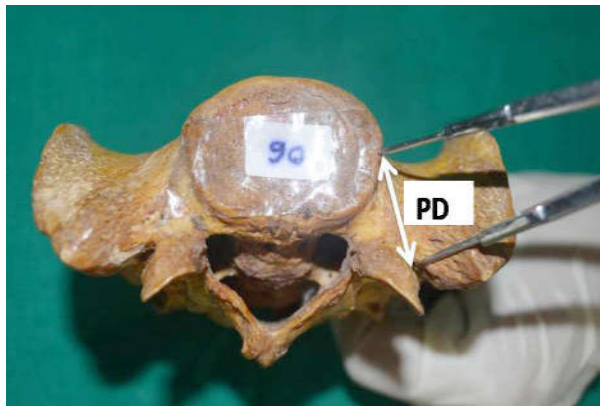


Fig. 6: Measurement of pedicle depth (PD) of first sacral vertebra

Results

Various parameters related to first sacral vertebra were measured in 109 dry human sacra of undetermined age and gender in the present study. All these measurements and observations are mentioned in Table 1 and 2.

Discussion

Lumbosacral screw fixation is used in treatment of lumbar burst fracture, vertebra metastases, lumbar scoliosis, spondylolisthesis and some other instability. Harrington and Dickenson suggested that most secure first sacral screw placement passes through the first sacral pedicle to the sacral promontory [4]. Anatomical structures along anterior surface of sacrum like lumbosacral trunk, internal iliac vessels are at high risk during sacral screw penetration [5]. Therefore, morphometric data of pedicle of first sacral vertebra is important for safe approach of screw placement.

The Tables 3-8 show comparison of means of various parameters of first sacral vertebra from previous studies; with that of the present study.

The mean vertebral body height in the present study is almost similar to that of previous studies mentioned in Table 3.

Table 1:

Parameters	Mean ± SD (in mm)	Range (in mm)
S1 Vertebral body height	30 ± 3.07	19-37
S1 vertebral body mid-diameter	30.3 ± 2.41	23-37
S1 vertebral body width	44.6 ± 5.91	5-61

Table 2:

Parameters	Mean ± SD (in mm)		Range (in mm)	
	Left	Right	Left	Right
Posterior pedicle height	25.2 ± 2.61	25.0 ± 2.43	20-32	19-31
Pedicle depth	31.0 ± 3.48	29.1 ± 3.00	20-44	22-39
Pedicle width	11.3 ± 1.38	11.5 ± 1.48	5-15	8-15

Table 3: Comparison of S1 vertebral body height (VBH) between superior and inferior limit of S1 body at midline with previous studies

Study	Year	Country	Material for study	Height (mm)
Candan A et al [3]	2009	Turkey	Dry bones	30.22 ± 2.35
Morales - Avalos R et al [7]	2012	Mexico	Dry bones	31.11 ± 2.80
Sinha M B et al [6]	2013	India	Dry bones	28.06 ± 2.30
Present study		India	Dry bones	30.0 ± 3.07

(mm - millimeter, VBH -Vertebral body height)

Table 4: Comparison of S1 vertebral body maximum transverse width (VBW) with previous studies

Study	Year	Country	Material for study	Width (mm)
Sachdeva K et al [10]	2011	India	Dry bones	M - 47.6 ± 7.1 F - 45.5 ± 4.8
Morales - Avalos R et al [7]	2012	Mexico	Dry bones	48.72 ± 4.64
Sinha M B et al [6]	2013	India	Dry bones	46.02 ± 4.64
Present study		India	Dry bones	44.6 ± 5.91

(mm - millimeter, VBW -Vertebral body width)

Table 5: Comparison of S1 vertebral body mid-diameter (VBD) with previous studies

Study	Year	Country	Material for study	Diameter (mm)
Basaloglu H et al [11]	2005	Turkey	Dry bones	31.0 ± 3.00
Candan A et al [8]	2009	Turkey	Dry bones	31.42 ± 2.83
Morales - Avalos R et al [7]	2012	Mexico	Dry bones	31.93 ± 2.91
Sinha M B et al [6]	2013	India	Dry bones	29.47 ± 2.48
Present study		India	Dry bones	30.3 ± 2.41

(mm - millimeter, VBD -Vertebral body mid-diameter)

Table 6: Comparison of posterior pedicle height of S1 vertebra (PPH) between superior limit of S1 & superior aspect of 1st sacral foramina with previous studies

Study	Year	Country	Material for study	Height (mm)
Candan A et al [3]	2009	Turkey	Dry bones	Left : 21.23 ± 2.18 Right : 20.74 ± 2.50
Morales - Avalos R et al [7]	2012	Mexico	Dry bones	Left : 24.42 ± 3.70 Right : 24.86 ± 3.89
Sinha M B et al [6]	2013	India	Dry bones	Left : 19.52 ± 3.14 Right : 19.33 ± 2.72
Present study		India	Dry bones	Left : 25.2 ± 2.61 Right : 25.00 ± 2.43

(mm - millimeter, PPH-Posterior pedicle height)

Table 7: Comparison of pedicle width of S1 vertebra (PW) between anterolateral edges of S1 vertebral body to lateral edge of superior facet of S1 vertebra with previous studies

Study	Year	Country	Material for study	Width (mm)
Sinha M B et al [6]	2013	India	Dry bones	Left : 11.50 ± 2.64 Right : 12.25 ± 2.36
Present study		India	Dry bones	Left : 11.3 ± 1.38 Right : 11.5 ± 1.48

Table 8: Comparison of pedicle depth of S1 vertebra (PD) between anterior & posterior limits of pedicle at narrowest point with previous studies

Study	Year	Country	Material for study	Depth (mm)
Sinha M B et al [6]	2013	India	Dry bones	Left : 28.55 ± 2.54 Right : 28.31 ± 2.66
Present study		India	Dry bones	Left : 31.00 ± 3.48 Right : 29.1 ± 3.00

Vertebral body maximum transverse width is used for calculation of index of body of first sacral vertebra (vertebral body mid-diameter / vertebral body width × 100) and corpo-basal index (S1 vertebral body width / sacral breadth × 100). Both these indices are useful in sex differentiation of sacrum [8,9]. The mean

vertebral body maximum transverse widths in the previous studies were higher than that in the present study.

The mean vertebral body mid-diameter in the present study is in accordance with that in previous studies.

Posterior pedicle height indicates safe vertical distance for screw placement without damage to adjacent structures [3]. The mean posterior pedicle height measured in present study resembles with that in studies by Morales Avalos et al [7] but it is higher than that in other studies by Sinha M B et al [6] and Candan A et al [3].

More pedicle width makes the sacrum stronger and it helps in fixation of screws [11]. It also indicates distance between sacral canal and path of screw placement. It helps to avoid injury to sacral canal structures. When compared with previous studies, mean pedicle width of S1 vertebra in the present study resembles that of left side and slightly higher on right side than that in the study by Sinha M B et al [6].

Sacral screws can be placed from posterior aspect either anteromedially or anterolaterally. Screws placed obliquely in a lateral direction can cause injury to iliac vessels, L5 nerve root and S1 nerve root. Safe screw implantation in the sacrum could be insured if it is placed above the level of first sacral foramen and directed forward and medially [12]. In the present study, pedicular depth is also measured in medial direction between lateral edges of superior articular facets of first sacral vertebra to the anterolateral edges of S1 vertebral body. Pedicular depth is important to know maximum safe length of screw. If length of screw is less than this distance, it may not produce harm to related structures [6].

In present study, pedicle depth of first sacral vertebra is higher on left side and resembles on right side on comparing with the study by Sinha M B et al [6].

Conclusion

Various studies have been carried out in India and abroad by anatomists, anesthetists and radiologists about the parameters of sacrum. Most of these studies are focused on sacral hiatus. There is less number of studies done on Indian population for measurements of parameters of pedicles of first sacral vertebra. Hence, it is hoped that the present study will be useful for clinicians; especially spine surgeons as it gives comprehensive data about different parameters of first sacral vertebra in Indian population. This data will be useful for pedicle screw fixation and for formation of screws. This study will also help to avoid the neurovascular injuries during spinal procedures.

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