Original article:

Morphometry of first pedicle of sacrum and its clinical relevance

Sinha Manisha B, Rathore Mrithunjay, Trivedi Soumitra, Siddiqui A U

Department of Anatomy, All India Institute of Medical Sciences (AIIMS), Raipur, Chhattisgarh, India-492099
Corresponding Author: Dr Manisha B Sinha; E-Mail id: manishab80@gmail.com

Abstract

Background: Pedicular screw fixation in S1 segment of sacrum is associated with potential risk of injury to nearby structures as well as to sacral ala and sacral wing. The aim of present study was to provide dimension of pedicle and related bony structures so as to facilitate screw fixations without any complications.

Materials & Methods: Study was conducted on fifty adult sacra. Bones were classified on the basis of sacral index in male and female sacrum. Pedicular dimensions of S1 vertebra were noted, analyzed and charted. These dimensions are of immense use in various surgical procedures.

Observations & Results: Significant difference in sacral height, sacral breath and sacral canal width were observed. The measurements of parameters of right and left pedicle were having insignificant side and gender difference.

Conclusion: Detailed knowledge of pedicular dimensions is important to enhance the success rate of screw fixation and to prevent intra-operative and post-operative complications.

Keywords: sacrum, pedicle, sacral ala, pedicular screw fixation

Introduction: The pedicle screw system represents difficult surgical technique. A thorough knowledge of the anatomy of pedicles is an important pre-requisite for the pedicle fixation. The pedicle connects the posterior elements to the vertebral body. Medial to the pedicle lies the epidural space, nerve root, and dural sac. The existing nerve root at the level of the pedicle is close to the medial and caudal cortex of pedicle. Close to the lateral and superior aspects of the pedicle cortex is the nerve root from the level above. In the sacral region, the great vessels and their branches lie laterally along sacral ala. In the midline of the sacrum, a variable middle sacral artery can lie directly anterior to the S1 vertebral body. Anterior penetration of a vertebral body can occur without being noticeable on the radiograph unless a “near – approach view” is obtained. A medially directed sacral screw reduces the possibility of injury to anterior structures if the screw penetrates the anterior cortex. Abnormal vasculature, like middle sacral artery is present in anatomical safe zone. Injury to this vasculature would occur when bicortical S1 screw placement is desirable. Present study was undertaken because scarcity of data amongst Indian population; especially dimensions related to pedicle and sacra.

The purpose of this study was to provide dimensions of sacrum and pedicle of S1 vertebral body for purpose of stabilization of spine near lumbosacral junction.
Materials and Methods: In this study fifty dry adult human sacral bones of Indian population were studied. These specimens were obtained from department of Anatomy, All India Institutes of Medical sciences, Raipur and Department of Anatomy and Forensic Medicine, Pt J N M Medical College Raipur, Chhattisgarh. Random samples were taken and were classified on the basis of sacral index. There were 38 male and 12 female specimens. Eroded and damaged bones were excluded from study. All parameters were measured by using Vernier caliper (Mitutoyo Corporation, Japan; accurate to 0.01mm) and mean were calculated. Measurements were focused on S1 vertebra. Following parameters as shown in fig.1 and fig.2 were measured:

Figure 1: Figure shows, a and b- anterior view of the sacrum, c and d- axial view of the sacrum.
SH; Sacral height,
SB; Sacral breath,
VBH; max anterior height of S1 body,
VBD; Maximum anteroposterior depth of S1 body,
VBW; Maximum transverse width of S1 body,
SCW; Spinal canal width

Figure 2: Figure shows, a- lateral view of the sacrum b- axial view of the sacrum.
PPH; Posterior pedicular height,
PW; Pedicular width,
PD; Pedicular depth

Linear parameters:
- Sacral height- Straight distance from base to apex (SH)
- Sacral breath- max distance between two ala (SB)
- S1 body
  Maximum anteroposterior depth (VBD)
  Maximum transverse width (VBW)
  Maximum anterior height (VBH)
- Spinal canal width (SCW)
- Posterior pedicular height (PPH)
- Pedicular width (PW)
- Pedicular depth (PD)
Observations:

Table 1: Measurements of various parameters in our study (*Foot notes: Rt-right, Lt-left*)

<table>
<thead>
<tr>
<th>SN</th>
<th>Parameters</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Mean±SD (mm)</td>
<td>Range (mm)</td>
<td>Mean±SD (mm)</td>
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<tr>
<td>1</td>
<td>Sacral height (SH)</td>
<td>100.07 ±7.90</td>
<td>85.64-111.3</td>
<td>102.94±6.85</td>
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<td>2</td>
<td>Sacral breadth (SB)</td>
<td>101.78 ±6.97</td>
<td>85.4-112.31</td>
<td>100.40±7.2</td>
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<tr>
<td>3</td>
<td>Vertebral body maximum width of S1 (VBW)</td>
<td>46.02 ±4.64</td>
<td>32.31-52.54</td>
<td>45.70±4.55</td>
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<td>4</td>
<td>Vertebral body mid-diameter of S1(VBD)</td>
<td>29.47±2.43</td>
<td>23.29-33.58</td>
<td>29.44±2.40</td>
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<td>5</td>
<td>Vertebral body height of S1 (VBH)</td>
<td>28.06 ±2.30</td>
<td>23.15-32.56</td>
<td>28.02±2.46</td>
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<td>6</td>
<td>Spinal canal width (SCW)</td>
<td>27.77 ±3.83</td>
<td>13.42-33.27</td>
<td>27.02±3.75</td>
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<td>7</td>
<td>Spinal canal mid diameter (SCD)</td>
<td>11.95±3.79</td>
<td>1.26-17.69</td>
<td>11.33±3.74</td>
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<td>Posterior Pedicle height (PPH)</td>
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<td></td>
<td></td>
<td>Lt 19.52+3.14</td>
<td>Lt 10.73-25.54</td>
<td>Lt 20.05±3.30</td>
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<td>Pedicle width(PW)</td>
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<td>Rt 12.25±2.36</td>
<td>Rt 5.76-17.6</td>
<td>Rt 12.41±2.46</td>
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<td>Lt 11.50±2.64</td>
<td>Lt 5.76-19.26</td>
<td>Lt 11.50±2.46</td>
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<td>10</td>
<td>Pedicle depth(PD)</td>
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<td></td>
<td></td>
<td>Rt 28.31±2.66</td>
<td>Rt 21.41-32.32</td>
<td>Rt28.31±2.66</td>
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<tr>
<td></td>
<td></td>
<td>Lt 28.55±2.54</td>
<td>Lt 22.66-33.1</td>
<td>Lt28.55±2.54</td>
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Table 2: Comparison of sacral parameters of present study with other study

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<tr>
<th>Researchers</th>
<th>Country</th>
<th>Specimen</th>
<th>SH (cm)</th>
<th>SB (cm)</th>
<th>VBW (cm)</th>
<th>VBD (cm)</th>
<th>VBH (cm)</th>
<th>SCW (cm)</th>
<th>SCD (cm)</th>
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<tr>
<td>Basaloglu et al⁵ (2005)</td>
<td>Turkey</td>
<td>60</td>
<td>10.43♂</td>
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<td>5.27♂</td>
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<td>10.08♂</td>
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<tr>
<td>Mazumdar et al³ (2012)</td>
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<td>250</td>
<td>10.08♂</td>
<td>9.63♂</td>
<td>4.16♂</td>
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<tr>
<td></td>
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<td>87.3♀</td>
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<td>Arman⁴ (2009)</td>
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<td>100</td>
<td>4.94♀</td>
<td>3.14♀</td>
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<td>2.97♀</td>
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<td>Xu et al⁵ (1995)</td>
<td>Toledo USA</td>
<td>50</td>
<td>4.54♂</td>
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<td>2.77♀</td>
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Table 3: Comparison of pedicular parameters of present study with other study

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<tr>
<th>Researchers</th>
<th>Country</th>
<th>Specimen</th>
<th>PPH (cm)</th>
<th>PW(cm)</th>
<th>PD (cm)</th>
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<td>60</td>
<td>2.09♂</td>
<td>1.43♂</td>
<td>2.26♂</td>
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<td></td>
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<td>2.09♀</td>
<td>1.42♀</td>
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<td>Arman et al⁴</td>
<td>Turkey</td>
<td>100</td>
<td>2.09♀</td>
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<td>Xu et al⁵</td>
<td>Toledo USA</td>
<td>50</td>
<td>1.09♀</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Present study</td>
<td>Indian</td>
<td>50</td>
<td>1.98♂</td>
<td>1.19♂</td>
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<td>1.82♀</td>
<td>1.19♀</td>
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**Results:** Based on these parameters, mean and standard deviation were calculated. Results of linear measurement were shown in the Table1. Sacral height and sacral breath of male were 102.94±6.85 and 100.40±7.2mm respectively. Same parameters in females were 90.92±2.24mm and 105.74±3.35mm. Both SH and SB was showing statistically significant gender difference. VBD, VBH values are more in female as compared to male but not statistically significant. The values of Sacral canal width SCW were 27.02±3.75 mm in males and 29.86 ± 3.18 mm in females, were showing statistical significant gender difference. The measurements of parameters of right and left pedicle were showing were having insignificant side and gender difference. Pedicle related parameters which were taken in to consideration were analysed and shown in Table 1.

**Discussion:** Achieving fusion at lumbosacral junction, difficulty is usually encountered in posterior pedicular screw fixation. However it is sometimes technically difficult in adult, especially in too fatty and too slim people and thus may be a cause of neurological compromise or pedicular fracture. Hence the detailed knowledge of morphometry of S1 pedicle and its surrounding structure is essential. In our study straight length of sacrum (SH) were 102.94± 6.85mm and 90.92± 2.24mm in male and female respectively whereas maximum breath of two wings of sacrum (SB) were 100.40 ± 7.2mm in male and 105.74± 3.35 mm in female. SH as well as SB have statistically significant sexual differences ( P value 0.0001 and 0.017 respectively). Basaloglu et al\(^2\) reported SH and SB were 104.3±12.4 and 102.0±10.2mm in male and 102.2± 7.0 and 108.4±6.0mm in female of western Anatolian population. These values are little higher side showing racial variation. Mazumdar S et al\(^3\) in 2012, SH and SB 100.8±11.5 and 96.3± 7.4mm in male and 87.3 ± 7.4mm and 95.6 ± 5.7mm in female in Indian population showing regional variation.

Basaloglu et al\(^2\) (2005) and Arman C et al\(^4\) (2009) found S1 vertebral body transverse diameter (VBW) 52.6±7.0mm and 49.40±5.89mm respectively in Turkey’s population. Mazumdar S et al\(^3\) reported 41.6±8.5mm male and 39.7 ± 5.2 mm in female in Indian population. In our study, VBW was 45.70 ± 4.55mm and 47.01± 4.89mm in male and female respectively. Our value little higher than Mazumdar et al and lower than Basaloglu et al and Arman C et al findings. In female our value was higher than male contrast to other study. For VBW, Xu et al\(^5\) found nearly same value in male but lower in female. Antero-posterior diameters of S1 in our study were 29.44 ± 2.40mm in male and 29.73±2.50mm in female (Table 1). Mazumdar S et al\(^3\) found 29.4 ± 3.8mm and 27.9± 2.7mm in male and female respectively. Basaloglu et al\(^2\) (2005) and Arman C et al\(^4\) found 31.0±3.0 mm (31.70± 3.0 mm in male and 30.3 ± 2.8mm in female ) and 31.42± 2.83mm respectively (Table 2). For this parameter our value is same as Mazumdar’s value in male but slightly higher in female. This parameter was again having low value than Basaloglu et al \(^3\) (2005) and Arman C et al\(^4\) showing racial variation. Vertebral body height (VBH) is anterior midline distance of superior and inferior limits of S1 vertebral body. VBH was 28.02 ± 2.46mm and 28.48 ±1.98 mm in male and female respectively. This finding was higher in study of Basaloglu et al\(^2\) (2005) and Arman C et al\(^4\) (Table 2). Xu et al\(^5\) finding was nearly same in male as our study.
Sacral canal width (SCW) was 27.02±3.75 mm in male and 29.86±3.18mm in female showing significant difference. SCW value was ranged from 13.42mm-33.27mm (Table 1). So 13.42mm minimum distance should be in between two laterals of posterior pedicular screw (PPS) of S1 Vertebra to avoid damage to sacral canal structures. This minimum distance is higher ie 25mm in Turkey population ² (Table 2).

S1 pedicle is fairly different from other the spinal pedicle. PPH is distance from upper notches of sacrum wings to upper corner of first dorsal sacral foramina. PW is perpendicular distance from lateral end of sacral canal to line joining to anterior notches of cortex to posterior notches of cortex at pedicle. This width helps to make bone stronger and helps the fixation of screw. These parameters are crucial because, these are minimum distance to occupy maximum width of PPS. Values of PPH are 19.33±2.72mm and 19.52±3.14mm on right and left side and PW are 12.25±2.36mm and 11.50±2.64mm on right and left side respectively (Table 1). Values of PPH and PW are lower in Indian population as compared to Turkey population (Table 3).

As described pedicle depth, first depth is parallel to midline from posterior cortex to anterior cortex and second depth is from posterior cortex to mid line along the pedicle⁶. We measured first pedicular depth (PD) ie maximum safe length of screw 28.31± 2.66 mm and 28.55 ± 2.54mm in male and female. If screw is less than this length may not produce any harm to related structures if it is inserted either anterior direction or anteriomedial direction. PD is higher in Indian population as compared to Turkey population (Table 3).

Extensive review of literature has revealed only a few studies reporting about Indian population. The present study and analysis reveals a very significant variation in the values, as regards the racial/ regional differences. Our study brings forth valuable data from this part of the world which can be of use for operating surgeons and interventionists. More similar study with valuable number of sample need to be taken.

Acknowledgement:
We would like to express our gratitude to departmental staff and colleagues of department of Anatomy and forensic of Pt JNM Medical College Raipur for providing us bones.

Abbreviations:
Sacral height- Straight distance from base to apex(SH)
Sacral breath- max distance between two ala (SB)
S1 body Maximum anteroposterior depth (VBD)
S1 body Maximum transverse width (VBW)
S1 body Maximum anterior height (VBH)
Spinal canal width (SCW)
Posterior pedicular height (PPH)
Pedicular width (PW)
Pedicular depth (PD)
References: