ABSTRACT

Objective: To determine the entry for the dorsal pedicular screw in relation to the notch present at the junction of base of the lateral margin of superior articular process with superior border of transverse process in dorsal spine. The advantage of this technique is a constant and easily identifiable entry point which does not involve partial resection of the inferior facet, thus maintaining stability and maintaining the well defined transverse and sagittal screw angles and decreasing the incidence of medial and inferior pedicle violation.

Materials and Methods: The study was carried out using ten cadavers (four male and six female). Spinal column was dissected completely from cadavers. Before the experiment, normal anatomy was confirmed on all cadavers excluding cases of spinal deformity. Dissection was done by the spine surgeons taking care to preserve all the bony landmarks near the entry point. This study was carried out bilaterally on pedicles between the first and twelfth thoracic (T) vertebrae.

Results: The relation of the superior articular notch and transverse process to the thoracic spine pedicles was studied. It was found that superior third of the pedicle was related to the superior articular notch and the transverse process in the first five thoracic vertebrae. The relation of these structures to the pedicle of the sixth thoracic vertebra was somewhat equally distributed between the superior and middle third of the pedicle. From the 7th to 12th thoracic vertebrae the superior articular process and transverse process were related to the middle third of the pedicle in almost all the cases. It is important to note that the inferior 1/3rd of the pedicle was not related to these landmarks at any of the levels.

Conclusion: We conclude that the ideal pedicle entry point described here should be considered by surgeons during thoracic pedicle screw instrumentation. The notch at the base of the superior articular process will always remain constant and therefore an important anatomical landmark in guiding the screw toward the entry of the pedicle.

Keywords: Cadaveric study, dorsal vertebra, notch, pedicular screw, transverse process

INTRODUCTION

Thoracic pedicle screws provide a number of advantages over other methods of fixation in the dorsal spine in treating a variety of conditions including better pull-out strength\(^1\) and greater control in the sagittal, coronal, and rotational planes due to increased stability to axial, bending, and rotational forces by three-column fixation,\(^2,3\) fewer vertebral motion segments fusion,\(^4,9\) reduction in the duration of postoperative bracing,\(^10\) and secure fixation after laminectomy or in the absence of the posterior elements.\(^11\) In patients with spinal deformity, segmental pedicle fixation has revealed greater three-dimensional correction with decreased rates of curve progression and higher fusion rates,\(^12-15\) the ability to treat the rigid scoliosis between 70° and 100° curves without anterior release\(^15\) and direct apical vertebral derotation to enhance correction and potentially obviate the need for a thoracoplasty.\(^16-18\)

Thoracic pedicle screw fixation is a difficult procedure to master and can cause serious complications due to screw
misplacement. In the thoracic spine, the benefits of pedicle screws have been associated with its potential risks, such as spinal canal violation, pedicle fracture, nerve root compression, and vascular lesions.\textsuperscript{[14,19‑24]} Furthermore, the narrow and inconsistent shape of the thoracic pedicles, especially in spinal deformity, makes their placement technically challenging. Several techniques have been proposed to decrease the incidence of screw malposition and enhance safety. One of these, the free hand technique, relies on an accurate entry point, correct screw trajectories in the transverse and sagittal plane, and palpation of all walls of the pedicles during each step of insertion. However, in spite of the entry points for dorsal pedicle screws being well described in the literature, there is a variability among the spine surgeons in interpretation of these entry points. This was well documented by our survey carried out to prove this. We conducted a survey among 31 spine surgeons for ideal pedicle entry point in D2 and D10 vertebra [Figure 1].

Only the entry point was to be drawn and the screw angulation and the trajectory were excluded.

Tables 1 and 2 show incidence of entry points in different marked areas in D10 and D2 vertebrae, respectively.

We observed a wide variability in deciding entry point while passing pedicular screws. Hence, there need to standardize entry point in relation to fixed bony landmark to decrease interobserver variability in deciding entry point for dorsal pedicular screws.

The purpose of this study is to delineate the ideal entry point for “freehand” thoracic pedicle screw placement with respect to the pertinent anatomy.

### MATERIAL AND METHODS

The study was carried out using ten cadavers (four male and six female). Spinal column was dissected completely from cadavers. Before the experiment, normal anatomy was confirmed on all cadavers excluding cases of spinal deformity. Dissection was done by the spine surgeons taking care to preserve all the bony landmarks near the entry point. This study was carried out bilaterally on pedicles between the first and twelfth thoracic (T) vertebrae.

The entire spinal column was dissected free from soft tissue and bones. Facet joint was exposed. Only the inferolateral part of inferior articular process which overhangs superior articular process was osteotomized. The lateral extent of facet joint and notch at the base of superior articular process was defined. Since the entire spinal column was dissected including excision of the ribs, the relation of notch and superior border of transverse process was defined with respect to pedicle on sagittal view in all 12 thoracic vertebrae. Pedicle was divided into three zones, i.e., superior, middle, and inferior one-third. For all practical purposes, entry point in coronal plane was 5 mm medial to the notch [Figures 2-4].

### RESULTS

Table 3 shows relation of superior articular notch with pedicle.

Table 4 shows relation of superior border of transverse process with pedicle.
DISCUSSION

Rampersaud et al.\textsuperscript{[25]} showed that the maximal permissible translational error at the midthoracic and thoracolumbar junction is $< 1$ mm and the permissible rotation error is $< 5^\circ$. Parent et al. and Zindrick et al. showed in morphometric studies that the transverse diameter of the pedicle is $< 5$ mm in some normal and scoliotic spines at the midthoracic level\textsuperscript{[26,27]} Hence, it is important to have a constant entry point that is easy to identify and that the transverse and sagittal angles be calculated from this entry point.

Chung et al. in its cadaveric study showed that entry point is situated at the base of the superior facet at the junction of the lateral one-third and medial two-thirds.\textsuperscript{[28]} The superior distance of the ideal pedicular entry point from the center of the pedicle was greater at the upper thoracic spine (T1) and lower thoracic spine T10–T12 and fairly constant between T2 and T9. This means that the point lies close to the center of the pedicle in the middle thoracic spine and farther away toward the transition vertebrae. However, sagittal screw angles were at a maximum angle at the upper thoracic spine (T1 and T2) and showed a decreasing trend in the direction of T12.\textsuperscript{[28]} By this technique, 1.6% of the screws showed superior violation while no screws showed inferior violation; 1.6% screws showed a lateral or medial violation of $< 2$ mm each, while 1.6% showed a lateral violation of 2–4 mm and 0.8% showed a lateral violation of $> 4$ mm. There

![Figure 2: Division of pedicle in three zones, i.e., superior, middle, and inferior one-third](image)

![Figure 3: Relation of notch (marked blue) at superior articular facet base with pedicle of D10 vertebra](image)

![Figure 4: Relation of notch (marked blue) at superior articular facet base with pedicle of D10 vertebra](image)

Table 3: Relation of superior articular notch with pedicle

|        | Superior one-third | Middle one-third | Inferior one-third |
|--------|-------------------|-----------------|-------------------|
| D1     | 20                | 0               | 0                 |
| D2     | 20                | 0               | 0                 |
| D3     | 20                | 0               | 0                 |
| D4     | 20                | 0               | 0                 |
| D5     | 20                | 0               | 0                 |
| D6     | 11                | 9               | 0                 |
| D7     | 3                 | 17              | 0                 |
| D8     | 1                 | 19              | 0                 |
| D9     | 1                 | 19              | 0                 |
| D10    | 0                 | 20              | 0                 |
| D11    | 0                 | 20              | 0                 |
| D12    | 3                 | 17              | 0                 |

![Chart showing relation of superior articular notch with pedicle](chart)
were no medial violations >2 mm. Most of the violations were at the midthoracic level.

In a cadaveric study by Cinotti et al.,[11] that used the junction of the superior border of the transverse process and lateral one-third of the base of the transverse process as the entry point, the incidence of medial screw violation was 2% and that of the lateral cortex 10%. This study also mentioned that the bottom of the superior facet was located proximal to the center of the pedicle at T4 but that it moved caudally from T4 to T12 where it was situated 2 mm below the center of the pedicle. This discrepancy in the study by Kook and Cinotti may be because Cinotti projected the pedicle onto the posterior surface of the lamina, while Kook used radiographs to determine the center of the pedicle.

Vaccaro et al.[29] reported the entry point for T11 and T12 to be the junction of the middle of the transverse process and the middle of the superior facet, and for T4–T9 to be the vertebrae junction of the superior border of transverse process and the middle of the superior facet. However, 41% of the pedicle screws were outside the boundaries of pedicle.

Cinotti et al.[11] reported that choosing the entry point along the center of the superior facet will increase the incidence of medial wall violation. Hence, a line along the midpoint of the superior facet should not be considered. Disadvantage of a superior entry point is that the screw has to be directed more caudally; hence, it is not parallel to the end plate which leads to a slightly lower pull-out strength. However, the screw still has a much higher pull-out strength than hooks.[30]

CONCLUSION

We conclude that the ideal pedicle entry point described here should be considered by surgeons during thoracic pedicle screw instrumentation. The notch at the base of the superior articular process will always remain constant and therefore an important anatomical landmark in guiding the screw toward the entry of the pedicle. Most surgeons should bear in mind that the results of our study may not be applicable to all patients worldwide in terms of ethnicity. Furthermore, if the surgeon is not fully experienced in the method reported here, it will be necessary to combine it with another technique.

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Conflicts of interest
There are no conflicts of interest.

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