Morphometric Analysis of Cervical Spine Pedicles in an Indian Population

1Sarvdeep S Dhatt, 2Vishal Kumar, 3Sajeel Rijal, 4Mahesh Prakash

ABSTRACT

Introduction: The quantitative understanding of cervical pedicle morphology minimizes the injury to the neurovascular structure and improves the surgical outcome. The aim of this study was to investigate the morphometry of the cervical pedicle using computed tomography (CT) scans.

Materials and methods: The CT scan was performed in eleven cervical spine injury patients and the axial and sagittal images were used to calculate the four linear parameters—outer pedicle width (OPW), inner pedicle width (IPW), pedicle height (PH), pedicle axis length (PAL), and the pedicle transverse angle (PTA).

Results: A total of 110 pedicles were measured and studied. The mean OPW, IPW, and PH showed gradual increase of the value from C3 to C7. The PTA showed maximum value at C4 vertebra and minimum value at C7 vertebra.

Conclusion: The study demonstrated that pedicle dimensions were small in comparison to European and other Asian populations. To enhance the safety of cervical pedicle screw insertion, the pedicle dimensions and trajectories should be determined individually. The screw diameter should also be optimal to avoid pedicle violations because of narrow OPW in our study population.

Keywords: Cervical pedicle, Cervical pedicle screw, Pedicle morphometry.

INTRODUCTION

The upper cervical spine includes the atlas C1 and axis C2. The lower cervical spine is known as the subaxial cervical spine and it includes vertebrae from C3 to C7. The anatomy of upper two vertebrae is unique from each other but the subaxial cervical spine has relatively uniform anatomical configuration. The cervical pedicle projects from the vertebral body in posterolateral to anteromedial orientation and they form the posteromedial border of the vertebral artery foramina. The internal morphology of the cervical pedicles including medial and lateral cortical thickness varies substantially between vertebral levels between men and women. 

The subaxial pedicle screw fixation is an alternative to lateral mass screw fixation for posterior cervical spine stabilization. Abumi et al. and Jeanneret et al. were the first to introduce the pedicle fixation in the lower cervical spine. The pedicle screw fixation system provides the three-point fixation for flexion, extension, torsion, and compression in the posterior column and for three-column instabilities. 

As compared with bicortical lateral mass screw fixation, pedicle screws have 4 times the pull-out strength and thus have lower risk of loosening during cyclic loading. 

The knowledge of the cervical pedicle morphology is of utmost importance to avoid damage to the vertebral artery, spine, or nerve root during surgical intervention involving the posterior cervical spine. The differences in the cervical spine morphometries have been reported across different populations and ethnic groups. These differences have got implications during the surgery to avoid the pedicle breach and other complications. Thus, knowing the cervical pedicle morphology among the sample of Indian population would help in the surgical technique in the cervical pedicle screw fixation.

MATERIALS AND METHODS

Computed tomography of the cervical spine was performed in 11 patients of cervical injury from July 2014 to June 2015. These patients also underwent pedicle screw fixation. The axial and sagittal cuts were studied. These images were obtained in the RADIANT DIACOM VIEWER and were used to analyze the five parameters—OPW, IPW, PAL, PH, and PTA. The mean value and standard deviation of these parameters were compared with data obtained from other studies and other ethnic populations (Fig. 1).

RESULTS

Pedicle Axis Length

The PAL was found to be lowest at the level of C3 and C4, which showed progressively increasing value and
was maximum at the C7 level. There was no statistical difference in the PAL of the right side and left side (p = 0.95) (Table 1).

**Pedicle Width**

The OPW and IPW also showed a similar trend with minimum OPW at C4 vertebra and a gradually increasing value and maximum at C7 vertebra. There was no statistical difference in the OPW dimension comparing left side and right side (p = 0.45) (Table 2).

The IPW had minimum value at C3 vertebra and maximum at C7 vertebra with no statistically significant value of right side and left side (p = 0.66) (Table 3).

**Pedicle Transverse Angle**

The mean value of the PTA also showed the highest value of PTA at the level of C4 vertebra and the lowest value at C7 (Table 4). There was no significant difference in the right side and the left side measurements (p = 0.95).

**Pedicle Height**

This showed a decreasing trend with minimum height at C4 and maximum height at C7. A total of 110 cervical pedicles were evaluated using axial and sagittal CT scans. The cervical morphometries were calculated and their mean value and standard deviation value were obtained. These morphometric parameters were calculated using RADIANT DIACOM software. The independent t-test and Z-test were used with significance set at 95% confidence interval to identify whether there was a statistically significant difference with the cervical pedicle dimension on the right and left sides. The calculated morphometry of the pedicle was also compared with the pedicle dimension of the Indian population.

**DISCUSSION**

Posterior transpedicular screw fixation provides an effective stabilization in the spine complex in various conditions. There are multiple cadaveric and radiographic studies to determine the anatomy of the cervical pedicle. The study by Karaikovic et al has shown no statistically significant differences in the anatomical dimension measured directly or by radiography. The technique of the transpedicular fixation was not widespread because of the safety risk. The ability to measure the pedicle dimension accurately allows accurate assessment for the screw insertion.

The measurement of pedicle dimension in our study reveals the characteristic trends compared with the previous studies in Asian population. This study...
showed that C7 had the maximum OPW and IPW and there was an increasing value from C3 to C7. The PH was also greater than the pedicle width in all vertebrae. This measurement is also similar to other studies. The pedicle width is a determinant of feasibility and safety of pedicle screw fixation.

Each cervical vertebra has its unique morphology, so each vertebra was measured independently. In our study, there was no significant difference in the morphometric parameter on the right side and left side, which is similar as reported in literature. The angular parameter measured PTA also had a wide angle at the upper subaxial cervical spine C4 and C5 level and the lowest value at the C7 level, and there was no significant difference in the measurement in the right side and left side, which is similar to other studies.

Comparing our data at all subaxial cervical spine with other similar studies on Asian population, the mean OPW and PH were smaller than other Asian population and were statistically significant as shown in Table 5. The mean PAL and PTA are smaller but were not statistically significant. The relatively small pedicle dimension of cervical pedicles in our study suggests that we need an accurate preoperative planning and CT-based measurement before we proceed to pedicle screw fixation.

Comparing our data with similar studies on European CT measurements, the mean OPW, PH, PAL are smaller in our study and were statistically significant (p < 0.05), but PTA is not significant (p > 0.05). This showed that the pedicle morphology of the Indian population is smaller than that of the European population; thus, the planning and execution of the pedicle screw fixation should be race-specific.

CONCLUSION

The findings of the cervical pedicle angular and linear parameter dimensions in the study reveal the characteristic trend comparable to the previous studies. The placement of the transpedicular screw should be individualized for each patient. The preoperative CT scans and their morphometric study help the surgeon in identifying the screw diameter and length that would avoid intraoperative complications.

REFERENCES


Table 5: Comparison of mean subaxial cervical pedicle morphology parameter between the present study, Asian population, and European/American population

<table>
<thead>
<tr>
<th></th>
<th>Study</th>
<th>Asian population</th>
<th>Asian study vs our study</th>
<th>European study vs our study</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPW</td>
<td>C3</td>
<td>4.913</td>
<td>5.26</td>
<td>p = 0.019</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>4.405</td>
<td>5.468</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>4.755</td>
<td>5.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6</td>
<td>4.823</td>
<td>5.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>5.59</td>
<td>6.63</td>
<td></td>
</tr>
<tr>
<td>PAL</td>
<td>C3</td>
<td>30.195</td>
<td>29.17</td>
<td>p = 0.35</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>30.1845</td>
<td>28.90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>31.323</td>
<td>30.82</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6</td>
<td>31.85</td>
<td>31.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>32.75</td>
<td>31.87</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>C3</td>
<td>4.63</td>
<td>6.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>4.46</td>
<td>6.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>4.59</td>
<td>6.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6</td>
<td>4.76</td>
<td>7.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>5.32</td>
<td>7.63</td>
<td></td>
</tr>
<tr>
<td>PTA</td>
<td>C3</td>
<td>43.73</td>
<td>48.41</td>
<td>p = 0.53</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>45.15</td>
<td>50.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>43.68</td>
<td>48.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6</td>
<td>40.917</td>
<td>44.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>37.415</td>
<td>37.05</td>
<td></td>
</tr>
</tbody>
</table>


