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ORIGINAL ARTICLE

Morphometric Analysis of Cervical Spine Pedicles in an Indian Population

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ABSTRACT

Introduction: The quantitative understanding of cervical pedicle morphology minimizes the injury to the neurovascular structure and improves the surgical outcome. This study aimed to investigate the morphometry of the cervical pedicle using Computerized CT scans.

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, inner pedicle width, pedicle height, pedicle axis length and the pedicle transverse angle.

Results: A total of 110 pedicles were measured and studied. The mean outer pedicle width, inner pedicle width, and pedicle height showed a gradual increase of the value from C3 to C7. The pedicle transverse angle showed maximum value at C4 vertebra and the minimum value at C7 vertebrae.

Conclusion: The study demonstrated that pedicle dimensions were small in comparison to the 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 outer pedicle widths in our study population.

Keywords: Cervical pedicle, Cervical pedicle screw, Pedicle morphometry

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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 the upper two vertebrae is unique from each other, but the subaxial cervical spine has a 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.[1,2] These characteristics make transpedicular fixation technically demanding.

The subaxial Pedicle screw fixation is an alternative to lateral mass screw fixation for posterior cervical spine stabilization. Abumini et al.[3] and Jeanneret et al.[4] 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.[5,6] As compared to bicortical lateral mass screw fixation, pedicle screw has four times the pull out strength and thus have a lower risk of loosening during cyclic loading.[7]

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.[8,9] The differences' in the cervical spine morphometries have been reported across the different population and ethnic groups.[10] These differences have got implications during the surgery to avoid the pedicle breach and other complication. Thus, knowing the cervical pedicle morphology among the sample of Indian population would help in the surgical technique in the cervical pedicle screw fixation.

METHODS

Computerized 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-outer pedicle width, inner pedicle width, pedicle axis length, pedicle height, and pedicle transverse angle. The mean value and standard deviation of these parameters were compared

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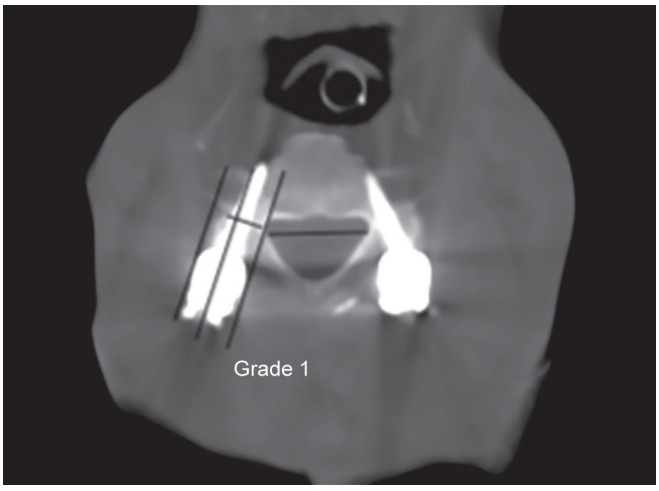

Fig. 1: Measurements of Grade to check accuracy for the placement of the pedicle screw.

with other data obtained from other study and other ethnic populations (Fig. 1).

RESULTS

Axial Pediclelength

The pedicle axis length was found to be lowest at the level of C3 and C4, which showed progressive 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 the similar trend with minimum OPW at C4 vertebrae and gradual increasing value and maximum at C7 vertebrae. There was no statistical difference in the OPW dimension comparing the left side and right side (p = 0.45) (Table 2).

Table 1: Axial Pedicle Length (APL)

Vertebrae	*Mean(mm)*		*Standard deviation*		
	Right	*left*	*Right*	*Left*	
C3	30.23	30.16	2.18	2.72	
C4	30.29	30.079	2.33	2.02	
C5	31.436	31.21	2.16	2.86	p = 0.95
C6	31.68	32.02	2.49	2.833	
C7	32.56	32.9445	2.45	2.71	

Table 2: OPW

Vertebrae	*Mean (mm)*		*Standard deviation*		
	Right	*left*	*Right*	*Left*	
C3	5.09	4.736	0.667	0.772	
C4	4.545	4.336	0.86	1.046	p = 0.45
C5	4.79	4.72	0.967	0.744	
C6	4.84	4.81	0.522	0.56	
C7	5.80	5.381	1.524	0.879	

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

Pedicle Transverse Angle (PTA)

The mean value of the pedicle transverse angle also showed the highest value of PTA at the level of C4 vertebrae and the lowest value at C7. Table 4. There was no significant difference on the right side and the left side measurement (P = 0.95).

Pedicle Height

This showed the 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 was used with significance set at 95% confidence interval to identify whether there was a statistical difference with the cervical pedicle dimension on the right and left side. The calculated morphometry of the pedicle was also compared with the pedicle dimension of pedicle dimension of the Indian population.

DISCUSSION

Posterior transpedicular screw fixation provides an effective stabilization of the spine complex in various condi-

Table 3: IPW

Vertebrae	*Mean(mm)*		*Standard deviation*		
	Right	*left*	*Right*	*Left*	
C3	2.46	2.02	0.600	0.21	
C4	2.53	2.58	0.632	0.33	p = 0.66
C5	2.59	2.33	0.49	0.45	
C6	2.53	2.45	0.4081	0.66	
C7	3.409	3.46	1.2453	0.740	

Table 4: PTA

Vertebrae	Mean		Standard deviation		
	Right	left	Right	Left	
C3	43.7	43.77	5.46	5.09	
C4	44.58	45.72	7.13	4.177	p = 0.95
C5	42.81	44.55	4.99	3.37	
C6	41.68	40.154	4.54	4.36	
C7	37.83	37	3.21	4.82	

Comparison of Mean Subaxial cervical Pedicle morphology Parameter between Present Study, Asian Population, European/ American Population

tions.[3,11] There are multiple cadaveric and radiographic studies to determine the anatomy of the cervical pedicle. The study by Karaikovic et al.[12] 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.[13] The ability to measure the pedicle dimension accurately allows accurate assessment of the screw insertion.[14,15]

The measurement of pedicle dimension in our study reveal the characteristics trend compared to the previous studies in Asian population.[16-18] This study showed C7 had the maximum OPW and IPW and there was an increasing value from C3 to C7. The pedicle height was also greater than the pedicle width in all vertebrae. This measurement is also similar to other studies.[17-19] Pedicle width is a determinant of feasibility and safety of Pedicle screw fixation.[16]

Each cervical vertebra has its unique morphology, so each vertebra was measured independently. In our study, there was no significant difference in the morphometrical parameter on the right and left side, which is similar as reported in the literature.[20] The angular parameter measured PTA also had a wide angle at upper subaxial cervical spine C4 and C5 level, and lowest value at the C7 level and there was no significant difference in measurement in the right and left side which is similar to other studies.

Table 5: Comparison of Mean subaxial cervical Pedicle morphology Parameter between Present Study, Asian Population, European/ American Population

	Study		*ASIAN Population*	*Study/s ASIAN*	*European*	*European v/s study*
OPW	C3	4.913	5.26	p = 0.019	5.17	p = 0.03
	C4	4.405	5.468		5.31	
	C5	4.755	5.68		5.66	
	C6	4.823	5.91		5.99	
	C7	5.59	6.63		6.64	
PAL	C3	30.195	29.17	p = 0.35	33.34	p = 0.0095
	C4	30.1845	28.90		32.81	
	C5	31.323	30.82		33.79	
	C6	31.85	31.67		34.23	
	C7	32.75	31.87		32.30	
PH	C3	4.63	6.70		6.89	
	C4	4.46	6.78		6.96	
	C5	4.59	6.95		6.74	
	C6	4.76	7.25		6.71	
	C7	5.32	7.63		6.93	
PTA	C3	43.73	48.41	p = 0.53	47.06	p = 0.61
	C4	45.15	50.58		48.78	
PTA	C5	43.68	48.95		48.35	
	C6	40.917	44.94		44.24	
	C7	37.415	37.05		38.68	

Comparing our data at all subaxial cervical spine with other similar studies on Asian Population,[15,16,18,2] the mean OPW, PH was smaller than other Asian population and was statistically significant as shown in Table 5. The mean PAL and PTA are smaller but was not statistically Significant. The relative small pedicle dimension of cervical pedicles in our study suggests that we need accurate preoperative planning and CT based measurement before we proceed to pedicle screw fixation.

Comparing our data with similar studies on European CT measurements,[7,14,21-24] the mean OPW, PH, PAL is smaller in our study and was 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 the European population thus planning and execution of the pedicle screw fixation should be race specific.

CONCLUSION

The findings of the cervical pedicle dimensions angular and linear parameter in the study reveal the characteristics 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 helps the surgeon in identifying screw diameter, the length that would avoid intraoperative complications.

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