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Morphometric Study of Sub Axial Cervical Spine Pedicles in Nepalese Population

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ABSTRACT

Background: Mal-positioning of cervical screws risks neurovascular injury so, it is necessary to understand cervical pedicle morphology for pedicle screw fixation in the region. The risks of pedicle screw insertion in the cervical spine can be mitigated by a three-dimensional appreciation of pedicle anatomy. The study aims to determine the morphology of the sub axial cervical spine pedicles in Nepalese Population based on computerized tomography.

Methods: A cross-sectional study using computerized tomography scans of the spine was made among the randomly selected 87 patients who had visited National Trauma center, Kathmandu, Nepal with vertebral fracture other than cervical vertebrae. Patient was examined as per Advanced Trauma Life support protocol and neurological assessment. Measurement was done from the third cervical vertebra down to the seventh cervical vertebra in computer with standard software in the department of radiology from where all the computerized tomography scan reporting are done.

Results: The mean pedicle length ranged from 4.41 mm at C3 to 4.96 mm at C7 where mean pedicle height ranged from 4.64 at C3 to 5.12 at C7. Pedicle length, pedicle height and pedicle width were observed to be statistically significant with gender. The pedicle axial length of C3 and C7 vertebra were found significant with gender. All parameters were found to be greater in male compared to female.

Conclusions: The study revealed that pedicle length, pedicle height, pedicle width, pedicle axial length increased from third to seventh cervical however, transverse angulation increased up to fifth vertebra and decreased to seventh vertebra.

Keywords: Morphology; sub-axial cervical spine; tomography.

INTRODUCTION

The common stabilization techniques for cervical vertebrae are posterior wiring techniques, lateral mass screw or transpedicular screw fixation.[1,2] Transpedicular approaches are widely used in various surgical interventions like pedicle screw fixation, vertebroplasty and kyphoplasty.[3] Cervical pedicle screw (CPS) fixation is found to be superior compared with lateral mass screws as it provides more axial, bending, and torsion stability, with higher pull out strength, and has a low risk of loosening with cyclical loading.[4-6] Inherent variability in pedicles at each level and lack of consistent suitable landmarks for CPS placement add to the technical challenge, for this 3-dimensional pedicle geometry by calculating variables like pedicle length, pedicle height , pedicle width , pedicle axis length , pedicle transverse angulation will be of great help.[7,8]

Morphology of Nepalese population may vary significantly from Indian, American and European population.[9,10] The study aims to determine the morphology of the sub axial cervical spine pedicles in Nepalese Population based on computerized tomography (CT).

METHODS

A cross-sectional study using CT scans of the spine was made among the randomly selected eighty-seven

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patients who had visited National Trauma center, Kathmandu, Nepal with vertebral fracture other than cervical vertebrae. Patient was examined as per Advanced trauma life support protocol and neurological assessment was done. Measurement was done from the third cervical vertebra (C3) down to the seventh cervical vertebra (C7) in computer with standard software in the department of radiology from where all the CT scan reporting are done. On axial CT scans, the parameters pedicle width (PW), pedicle axial length (PAL), pedicle transverse angulation (PTA) were measured. On sagittal CT scan images, pedicle height (PH), pedicle length (PL) were measured.

Once the patient met inclusion criteria in the study, patients was explained regarding the possible radiation hazard of the computed tomography and informed written consent was taken, a short demographic history was taken, patient was examined as per ATLS protocol and neurological assessment was done. As per ATLS protocol computed tomographic screening of whole spine was done using the machine Siemens Somatom 16 slices helical. A preliminary lateral scout scan was done, followed by (3.0-mm) helical scans of the cervical spine and sagittal and coronal reconstructions at (0.75-mm). Measurements were made from the third cervical vertebra (C3) down to the seventh cervical vertebra (C7) in computer with standard software in the department of radiology from where all the CT scan Reporting are done. On axial CT scans, the parameters PW, PAL, PTA was measured. On sagittal PH, PL was measured. The Linear parameters was measured in millimeters. Angular parameters were measured to one tenth of a degree. All the paired cervical pedicle parameters were measured individually, using same digital measurement software. The measurements were done independently by an observer and cross checked by a consultant spine surgeon. The required information was recorded in the prepared format. Ethical approval was obtained from institutional review board of National academy of medical sciences.

Data was entered and analyzed in SPSS version 20. Independent T test and analysis of variance was used for comparison between two groups for continuous variables. P value <0.05 was used for determining level of statistical significance.

RESULTS

We analyzed 87 sub-axial cervical vertebrae of respondents. The mean age (+SD) of the respondents was 48.29 + 13.5 years where mean age of a male was 48.35 + 13.33 years and females was 48.23 + 13.94 years. One in four (25.3%) respondents were aged 30-40 years. About half (50.6%) of the respondents were females. (Table 1)

Table 1. Sociodemographic characteristics of the respondents.

Characteristics	Number	Frequency
Age		
20-30	7	8.0
30-40	22	25.3
40-50	20	23.0
50-60	17	19.5
60-70	21	24.1
Mean age and standard deviation of the respondents = 48.29 + 13.5, Min 26 and Max 70		
Sex		
Male	43	49.4
Female	44	50.6

Table 2. Pedicle length, height and width with sex.

Spine level	Pedicle length(mm)		P value	Pedicle height (mm)		P value	Pedicle width(mm)		P value
	Male	Female		Male	Female		Male	Female	
C3	4.68 + 0.59	4.14+ 0.44	<0.001**	4.72 + 0.49	4.57 + 0.26	0.08*	4.26 + 0.56	4.01 + 0.25	0.009**
C4	4.82 + 0.57	4.29 +0.44	<0.001**	4.80 + 0.46	4.63 + 0.24	0.038*	4.37 + 0.59	4.10 + 0.27	0.008**
C5	4.90 + 0.53	4.40 + 0.40	<0.001**	5.01 + 0.48	4.84 + 0.28	0.041*	4.46 + 0.48	4.25 + 0.24	0.015*
C6	4.99+ 0.53	4.52 + 0.38	<0.001**	5.08 + 0.34	4.93 + 0.25	0.028*	4.56 + 0.45	4.37 + 0.21	0.016*
C7	5.08 + 0.48	4.65 + 0.37	<0.001**	5.19 + 0.32	5.05 + 0.27	0.03*	4.75 + 0.54	4.52 + 0.28	0.015*

Table 2 revealed association between pedicle length, height and width with sex. The result showed statistically significant between the sex in all spinal level ($p<0.001$) in pedicle length. The pedicle height is significantly higher in males than females in all spinal level.

Table 3. Pedicle axial length and Transverse angulation with sex.

Spinal level	Pedicle axial length (mm)		P value	Transverse angulation (degree)		P value
	Male	Female		Male	Female	
C3	30.60 + 0.88	30.12 + 0.57	0.003**	38.50 + 1.51	38.50 + 1.45	0.954
C4	31.44 + 0.60	31.36 + 0.41	0.455	39.93 + 1.65	39.80 + 1.47	0.565
C5	32.68 + 1.27	32..45 + 1.32	0.408	42.50 + 2.24	42.11+ 2.02	0.498
C6	32.98 + 1.40	32.60 + 1.02	0.159	41.12 + 1.60	41.45 + 1.24	0.072
C7	34.45 + 1.51	33.63 + 0.91	0.003**	40.60 + 3.48	40.66 + 2.76	0.281

Table 4 shows age wise distribution of pedicle length which was found statistical significant with all age groups.

Table 4. Age wise distribution of pedicle length and Transverse angulation.

Age group Vertebral level	20-30	30-40	40-50	50-60	60-70	P value
Pedicle length (mm)						
C3	3.77 + 0.23	4.39 + 0.35	4.72 + 0.80	4.29 + 0.57	4.44 + 0.41	0.003**
C4	3.92 + 0.21	4.52 + 0.37	4.85 + 0.77	4.42 + 0.58	4.60 + 0.42	0.004**
C5	4.12 + 0.17	4.62 + 0.42	4.91 + 0.72	4.52 + 0.46	4.69 + 0.43	0.010*
C6	4.31 + 0.20	4.70 + 0.41	5.02 + 0.70	4.65 + 0.42	4.75 + 0.51	0.019*
C7	4.42+ 0.23	4.84 + 0.37	5.70 + 0.66	4.89 + 0.44	4.86 + 0.47	0.038*
Transverse angulation (Degree)						
C3	38.0 + 0.11	37.95 + 2.05	38.85 + 0.58	38.71+ 0.47	38.74 + 1.94	0.212
C4	39.0 + 0.13	39.50 + 2.24	40.35 + 0.81	39.82 + 0.63	40.10 + 1.86	0.213
C5	41.14 + 1.95	41.77 + 2.15	43.35 + 2.27	41.76 + 1.71	41.73 + 1.85	0.034*
C6	42.0 + 0.11	40.36 + 2.27	41.10 +1.16	41.76 + 0.66	41.49 + 1.36	0.020*
C7	40.0 + 0.12	38.36 + 3.88	42.45 + 2.87	40.82 + 2.45	39.76 + 2.46	0.001**

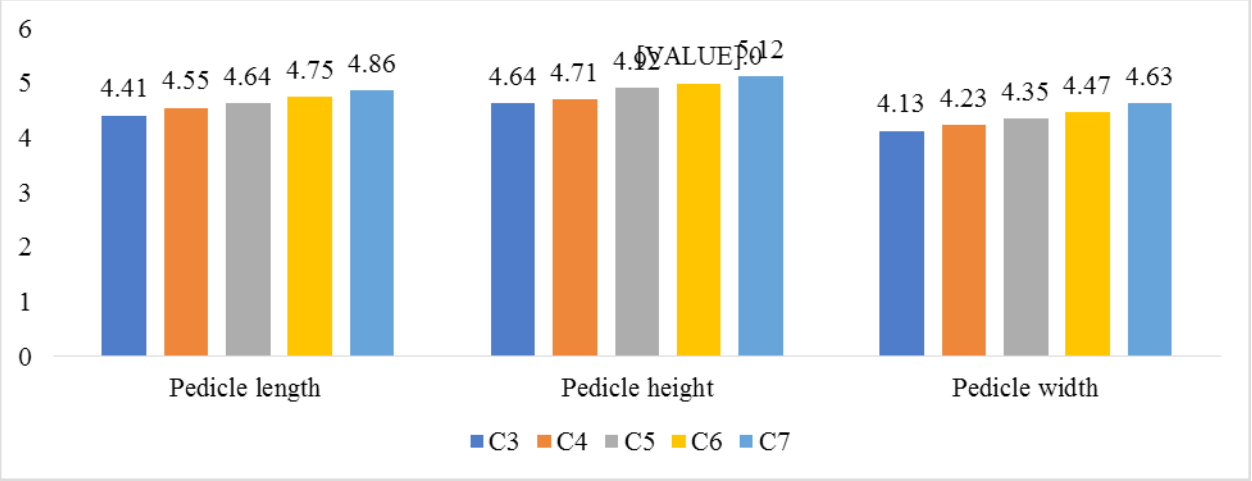

Figure 1. Overall Mean of pedicle length, height and width.

Pedicle axial length is significantly higher in males than females in C3 and C7 whereas differences in transverse angulation between the sex was found to be statistically insignificant is shown in Table 3.

The mean pedicle length ranged from 4.41 mm at C3 to 4.96 mm at C7 where mean pedicle height ranged from 4.64 at C3 to 5.12 at C7. Mean pedicle width was 4.13 mm at C3 which increases to 4.63 at C7. The mean pedicle length was found to increases from 4.68 mm at C3 to 5.08 at C7 in male, and from 4.14 mm at C3 to 4.65 mm at C7 in female. The mean pedicle length was higher in 40-50 aged group which ranged from 4.72 mm at C3 to 5.70 at C7. Among the spine level, the mean pedicle length is higher at C7 compared to others spine level at all aged group. (Figure 1)

The mean pedicle axial length from 30.36 mm at C3 to 34.04 mm at C7. Mean transverse angulation was 38.50^{O} at C3 and highest at C5 which was 42.07^{O}.The mean shortest PAL was found to be 30.60 mm at C3 in male, 30.12mm at C3 in female. The longest PAL was found at C7 which is 34.45 mm at C7 in male and 33.63 mm at C7 in female. The mean transverse angulation is higher at C5 compared to other spine level at all aged group, and maximum among aged group 40-50 compared to other ages. (Figure 2)

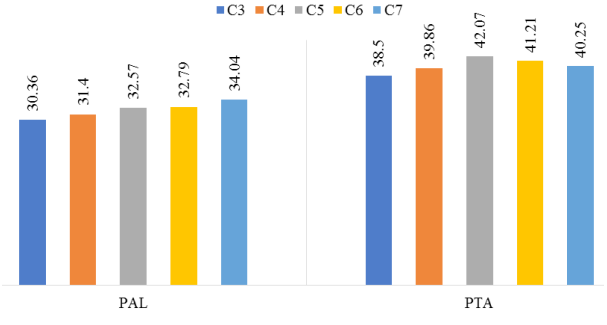

Figure 2. Mean pedicle axial length and Transverse angulation.

DISCUSSION

Different study was conducted for morphometric analysis of sub axial cervical spine in various countries. Study done among Indian population by Farooque K et al.[8] found morphometric parameters were significantly larger in male compared with female; which is similar to our findings. The mean transverse angulation was found equal among male and female at C3.

In our study the mean pedicle length in males was 4.68 mm at C3 to 5.08 mm at C7 and in females 4.14 mm at C3 to 4.65 mm at C7; whereas the study done by Farooque et al[8] found mean pedicle length 5.2 mm, 5.1 mm at C3 to 5.8 mm, 5.7 mm at C7 among male and female respectively. In our study mean pedicle width ranges 4.26 mm at C3 to 4.75 mm at C7 in males and 4.01 mm at C3 to 4.52 mm at C7 in females whereas another study has higher mean pedicle width in males and females which shows 4.7 mm, 4.3 mm at C3 to 6 mm, 5.4 mm at C7 among males and females. The mean pedicle height among the Indian population was also found higher than the Nepalese population; where the mean PH is ranged from 4.72 mm to 5.19 mm from C2 to C7 among males and 4.57 mm to 5.05 mm from C3 to C7 among females.[8] The transverse angulation was 38.50 at C3 to 40.60 at C7 in males in our study which is lower at C3 and higher in C7 than the study done by Farooque et.al which shows 45.02 at C3 to 37.66 mm at C7. Similar finding was found among the females. In comparison to the indian population, the pedicle length, pedicle width, pedicle height was found to be smaller in Nepalese people in both male and female groups. Similar finding was observed in a study done in Thai people by Mahiphot J et al [2] which found that the mean of PW, PL, PH, PAL and PTA were significantly higher in male than female excepted for PL (C7) and PTA (C3, C5).

In our study the pedicle length, pedicle height and pedicle width were significantly associated (P< 0.05) on sex which is similar to the study done by Farooque et al. Another study done by Mahiphot J et al contradicts with our findings which shows no significant differences of the cervical pedicle between males and females in pedicle width, height and pedicle axial length. The study shows significant differences in C6 PW, C3 PL and C4-C5-C7 PTA. This might be due to the differences in the measurement procedure which was done by using Image J software.

CONCLUSIONS

The study concludes pedicle length, pedicle height, pedicle width, pedicle axial length increased from third to seventh cervical vertebra however, transverse angulation increased up to fifth vertebra and decreased to seventh vertebra. The pedicle morphology varies with sex and different age groups. The factors should be considered for pedicle screw fixation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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