Original Article



# Morphometric Analysis of Sub-Axial Cervical Spine Pedicle Based on Computed Tomography Scan in Pakistani Population

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## ABSTRACT

**Objective:** To analyze morphometric parameters of the pedicle of sub-axial cervical vertebrae using a Computerized Tomographic scan of the Pakistani population to help spine surgeons import appropriate size screws and prevent perioperative complications.

**Study Design:** Cross-Sectional study.

**Place and Duration of Study:** This study was conducted at the Ziauddin University and National Medical Center, Karachi from October 2021 to April 2022.

**Materials and Methods:** A total of 100 patients including 50 males and 50 females presenting to the neurosurgical setting were included in the study. The pedicle width, height, length, and axis length were measured on all sub-axial vertebrae on both sides.

**Results:** All parameters were found to be greater in men compared to women at each spinal level. A slight difference was found in the pedicle parameters measurements on both sides. The pedicle width and axis length were found to be increasing craniocaudally in contrast with pedicle length which was decreasing craniocaudally in both male and female patients. However, the pedicle height remains almost the same at all levels in both genders.

**Conclusion:** This study provides references for common screw sizes to be used in our population. It also suggests a larger screw size in males. We also recommend the use of the same screw size on both sides of the same individual where required.

**Key Words:** Cervical spine, morphometric analysis, pedicle screw fixation, surgical anatomy.

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## INTRODUCTION

Cervical Pedicle Screw (CPS) fixation is by far the most superior treatment modality to treat cervical instability secondary to degenerative, traumatic, neoplastic, and inflammatory causes[1]. While performing three-column fixation of the cervical spine, CPS has proved to offer increased stability as compared to other conventional cervical fixation strategies[2]. However, the perioperative complications are commonly associated with the said procedure due to damage to surrounding neuro-vasculature[3,4,5]. Due to its challenging nature, lateral mass screws are usually preferred in place of CPS. However, to find out the feasibility of performing CPS, it is vital to understand the surgical anatomy and instrument to plan the procedure pre-operatively resulting in decreased incidence of the aforementioned complications, especially in the low-budget settings in Pakistan where CT scan and intraoperative imaging is not readily available. With the advent of computer and robot-assisted surgeries, the use of CPS is likely to increase.

Several studies have highlighted the pedicle morphometric parameters of sub-axial cervical vertebrae on cadavers and based on different radiological modalities[6-8]. It has been observed that there is a significant difference between the said parameters measured on cadavers compared to those measured based on CT scans because of the tendency of the preservative to cause postmortem changes[9].

Currently, there is a lack of data on morphometric parameters of the pedicle of cervical vertebrae of the

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Pakistani population. Therefore, this study was undertaken to analyze such parameters including Pedicle Height (PH), Pedicle Width (PW), Pedicle Length (PL), and Pedicle Axis Length (PAL). Such data will provide a better understanding of cervical pedicle anatomy allowing spine surgeons to pre-plan a safer approach. It will also help the implant companies to arrange and stock more common sizes.

# MATERIALS AND METHODS

This was a cross-sectional study carried out collaboratively at National Medical Center (NMC) and Ziauddin University (ZU). The study was approved by the Ethics Review Committee, ZU.

In total, 500 sub-axial cervical vertebrae were observed in 100 patients (50 males and 50 females) presenting to the neurosurgical setting at NMC. Individuals with a history of congenital spine deformity, trauma, infection, neoplasm, and surgery of the cervical spine were excluded.

A CT scan of the cervical spine was performed. All parameters were measured individually from C3 to C7. The parameters measured on the transverse section included PW and PAL (Figure 1) while PH and PL were measured on the sagittal plane (Figure 2).

**Statistical Analysis:** SPSS v20 was used for data entry and analysis. All quantitative measures were expressed as mean and standard deviation. One sample t-test was applied to analyze the parameters of the general population. For comparison between the male and female groups individual sample t-test was applied. P-value <0.05 was considered statistically significant.

# RESULTS

The mean age of male subjects was 41.86±11 years while that of women was 43.94±13 years. PW, PL, and PAL were significantly dependent upon gender except for PH. All parameters were found to be greater in men compared to women at each spinal level. There was a slight difference found in the measurements of pedicle parameters when compared with both sides.

The PW and PAL were found to be increasing craniocaudally in contrast with PL which are decreasing craniocaudally in both male and female patients. However, PH remains almost the same at all levels in both genders.

The mean PW in male patients on the right side was found to be 5.78±0.89 mm at C3 and 7.22±1.02 mm at C7. When compared to the left side, PW at C3 was found to be 5.37±1.14 mm and 7.05 mm at C7. In female patients, PW on the right and left sides were found to be 5.23±0.87 mm and 4.87±0.83 mm at C3 respectively whereas at the C7 level was observed to be 6.66±1.01 mm on the right side and 7.86±9.7 mm on the left. None of the PW in both genders were found to be less than 4 mm.

**Table No.1: Pedicle Width, Pedicle Height, Pedicle Length, and Pedicle Axis Length, comparing both sides in both genders**

| Vertebral Level | Pedicle Width (mm) | | | Pedicle Height (mm) | | | Pedicle Length (mm) | | | Pedicle Axis Length (mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male (Mean ± SD) | Female (Mean ± SD) | p-Value | Male (Mean ± SD) | Female (Mean ± SD) | p-Value | Male (Mean ± SD) | Female (Mean ± SD) | p-Value | Male (Mean ± SD) | Female (Mean ± SD) | p-Value |
| C3 | | | | | | | | | | | | |
| Right | 5.78 ± 0.89 | 5.23 ± 0.87 | 0.002 | 7.32 ± 0.96 | 6.21 ± 0.84 | 0.001 | 7.08 ± 1.87 | 6.76 ± 1.31 | 0.322 | 31.68 ± 2.11 | 29.89 ± 1.64 | 0.001 |
| Left | 5.37 ± 1.14 | 4.87 ± 0.83 | 0.014 | 7.16 ± 1.31 | 6.08 ± 0.81 | 0.001 | 6.75 ± 1.63 | 6.73 ± 1.36 | 0.951 | 31.42 ± 2.13 | 29.21 ± 4.25 | 0.001 |
| C4 | | | | | | | | | | | | |
| Right | 5.80 ± 0.94 | 5.17 ± 1.03 | 0.003 | 7.80 ± 0.73 | 6.42 ± 0.75 | 0.001 | 6.62 ± 1.62 | 6.78 ± 1.29 | 0.001 | 31.51 ± 1.56 | 29.90 ± 1.64 | 0.001 |
| Left | 5.72 ± 0.91 | 5.31 ± 1.18 | 0.054 | 7.57 ± 1.02 | 6.22 ± 0.67 | 0.001 | 6.55 ± 1.42 | 6.86 ± 1.34 | 0.268 | 31.45 ± 2.00 | 29.43 ± 1.77 | 0.001 |
| C5 | | | | | | | | | | | | |
| Right | 6.21 ± 0.95 | 5.61 ± 0.86 | 0.001 | 6.96 ± 0.93 | 6.13 ± 0.95 | 0.001 | 6.68 ± 1.42 | 6.59 ± 1.23 | 0.724 | 32.70 ± 2.16 | 30.98 ± 1.67 | 0.001 |
| Left | 6.09 ± 0.77 | 5.67 ± 0.79 | 0.009 | 7.16 ± 0.97 | 5.98 ± 0.71 | 0.001 | 6.50 ± 1.46 | 6.77 ± 1.23 | 0.327 | 32.42 ± 1.97 | 29.72 ± 4.23 | 0.001 |
| C6 | | | | | | | | | | | | |
| Right | 6.37 ± 0.95 | 5.67 ± 0.80 | 0.001 | 7.21 ± 0.98 | 6.23 ± 1.20 | 0.001 | 6.87 ± 1.46 | 6.60 ± 0.86 | 0.268 | 32.72 ± 7.13 | 31.98 ± 1.87 | 0.481 |
| Left | 6.21 ± 0.91 | 5.53 ± 0.73 | 0.001 | 6.24 ± 1.81 | 6.47 ± 1.13 | 0.001 | 6.24 ± 1.81 | 6.47 ± 1.13 | 0.446 | 33.94 ± 2.09 | 31.46 ± 2.29 | 0.001 |
| C7 | | | | | | | | | | | | |
| Right | 7.22 ± 1.20 | 6.66 ± 1.01 | 0.013 | 7.87 ± 1.03 | 6.68 ± 1.05 | 0.001 | 6.55 ± 1.33 | 6.44 ± 1.40 | 0.697 | 34.72 ± 2.76 | 32.04 ± 1.96 | 0.001 |
| Left | 7.05 ± 1.09 | 7.86 ± 9.7 | 0.56 | 7.92 ± 1.08 | 8.18 ± 9.3 | 0.84 | 6.50 ± 1.34 | 7.95 ± 12.01 | 0.396 | 34.45 ± 3.03 | 31.38 ± 2.09 | 0.001 |

The PH in male patients on both sides was found to be more or less the same ranging from 6.96±0.93 mm to 7.92±1.08 mm. A similar pattern was seen in PH in female patients on both sides ranging from 5.98±0.71 mm to 8.18±9.3 mm. The PL was not found to be significantly different between genders. In men, maximum PL was found to be 7.08±1.87 mm on the right and 6.75±1.63 mm on the left at C3 while 6.55±1.33 mm on the right and 6.5±1.34 mm on the left were the minimum values noted at C7. In the female group, the highest measurement was found to be 7.95±12.01 mm on the left at C7 compared to 6.78±1.29 mm on the right at C5. The PAL on the other hand was found to be slightly increasing craniocaudally in both genders ranging from 31.42±2.13 mm to 34.72±2.76 mm in males and 29.21±4.25 mm to 32.04±1.96 mm in females (Table 1).

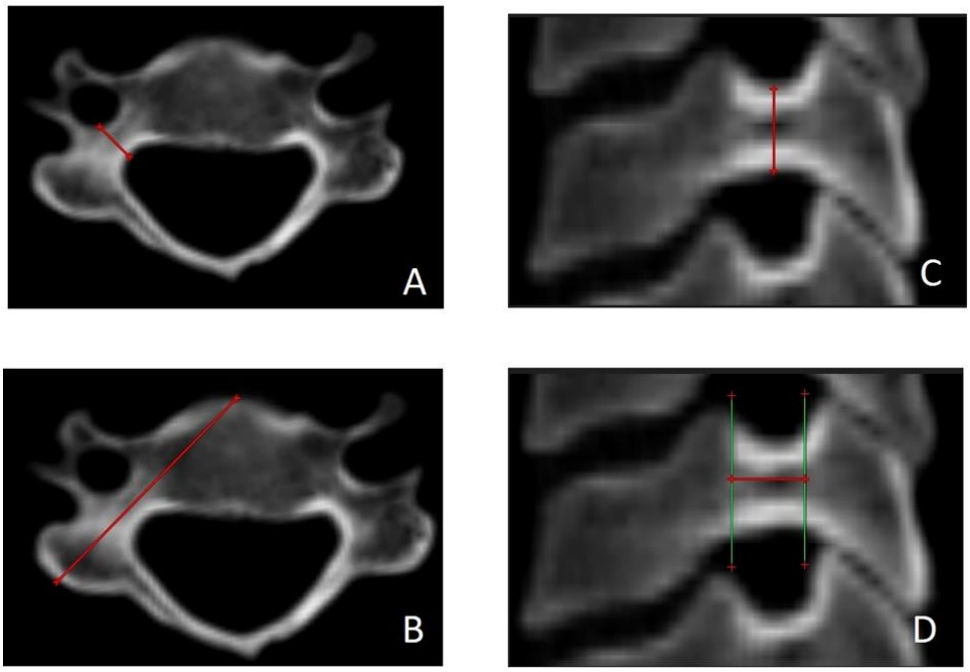


**Figure 1: A –** Transverse section of cervical vertebrae showing **Pedicle Width (PW)** which is defined as the mediolateral outer diameter of the pedicle at its isthmus, **B -** Transverse section of cervical vertebrae showing **Pedicle Axis Length (PAL)** which is defined as the length of the pedicle axis from its projection on the dorsal surface of the lateral mass to the anterior vertebral body surface, **C –** Sagittal view of cervical vertebrae showing **Pedicle Height (PH)** which is defined as the superoinferior outer diameter of the pedicle at its isthmus, and **D –** Sagittal view of cervical vertebrae showing **Pedicle Length (PL)** which is defined as the distance between the pedicle lateral mass junction and pedicle vertebral body junction [(13)].

# DISCUSSION

Several studies have been done on both cadavers[10,11] and the basis of computed tomography[13-19] to analyze the morphometry of the sub-axial cervical vertebrae in different population. In 1991, Panjabi et al were the first to study the geometry of sub-axial cervical vertebrae on cadavers [(10)]. Later several studies were done based on CT-scan which showed significant differences between the values studied on cadavers. This is because long-time use of preservatives brings about changes in the morphology of the cervical spine in the cadaveric specimen.

In our study, all parameters of cervical pedicle measured on CT scan were greater in males than females which is consistent with studies on Indian, Japanese and American populations[13,14,17]. Furthermore, we noted a difference in measurements between pedicle parameters on both sides. This is consistent with a study on the Thai population.

PW and PH in our population were found to be greater than that of Brazilian, Kuwaiti, Turkish, American, and Thai populations.

The PH in our study was found in both genders and on both sides to be larger than that found in the Brazilian, Kuwaiti, Turkish, and Thai populations [(15), (16), (11), (19)]. Furthermore, the PW measurement found in our population increases as the vertebral level goes down which is consistent with other mentioned populations. The mean PW in our study was found to be smaller in both males and females and on both sides than that in the Japanese population and American males. However, the PW in the American female population was slightly larger than in our population[10,17]. Whereas the PW mentioned in studies done on populations in Kuwait, Thailand and Turkey were found to be smaller[16,19,11].

PW of more than 4.5 mm is considered optimum for pedicle screw insertion with greater resistance to pull-out forces[21-22]. As mentioned in our study most of the population has PW more than optimal (4.5mm), therefore it is feasible to insert a pedicle screw in the Pakistani population without risking the complication. However, a study done on the Indian population states that the PW at the C3 level in females is less than 4.5 mm, therefore it is feasible to perform CPS fixation at any level in both males and females except C3 in females [(13)]. In contrast with other populations, there is a significant difference between the PH and PW on both sides which is a unique finding in our population.

There are many ways recommended to decide the point of entry for the pedicle screw in vertebrae from C3-C7. Knowledge about PL and PAL is essential to selecting the appropriate screw size. The PL and PAL in our population are found to be decreasing craniocaudally in both genders except for C7 for PL. In our study, the PAL in the male population is found to be similar to that in Americans, Kuwaitis, Thai, and Indians[16,17,13,19]. However, in the Brazilian population PAL is found to be lesser than the other populations[15].

# CONCLUSION

Through this study, we have extracted the data on morphometry of the cervical vertebrae in a subset of the normative or disease-free Pakistani population. This data can be used as a reference for the selection of common screw sizes to be used in our population. Furthermore, this study suggests that usage of larger-sized screws in males will provide better surgical outcomes. We also suggest the surgeons to use similar-sized screws on both sides of the same individual where required. Furthermore, we recommend that the spine surgeon should do the preoperative measurement based on a CT scan to take individual variations into account for better understanding.

**Author's Contribution:**

| | |
|---|---|
| Concept & Design of Study: | Qamber Haider Kazmi |
| Drafting: | Kevin Joseph Jerome Borges, Mohsin Qadeer |
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| Revisiting Critically: | Qamber Haider Kazmi, Kevin Joseph Jerome Borges |
| Final Approval of version: | Qamber Haider Kazmi |

**Conflict of Interest:** The study has no conflict of interest to declare by any author.

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