

## Computed Tomographic Measurement of Cervical Pedicle Morphology in Filipino Patients

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Studies have shown that Asian cervical pedicles are significantly smaller, thus increasing the technical difficulty of screw insertion when using standard 3.5 mm pedicle screws. Cervical pedicle morphology of a sample of Filipino patients was assessed using computed tomographic measurements.

**Objective:** The study was carried out to measure the cervical pedicles and assess the feasibility of transpedicular screw fixation in the local setting.

**Methods:** CT scans of bilateral C2 to C7 pedicles of 94 Filipinos with a mean age 52.9 years old (range: 18 to 82) composed of 37 females and 57 males were evaluated for inner diameter, lateral wall, and medial wall thickness.

**Results:** The inner diameter of male pedicles was significantly wider compared to females. The medial wall and lateral wall thickness of males was also significantly greater except for C2-C5 and C2 & C6 respectively. C3 to C5 of male pedicles had a mean inner diameter of < 3.1 mm compared to C2 to C6 in females. For mean lateral wall thickness, only the right C4 and C5 lateral wall thickness in females was < 1.0 mm. All cervical spine levels in both males and females had a mean medial wall thickness of > 1.0 mm (range 1.47 to 1.89mm).

**Conclusion:** The cervical pedicles of Filipinos are smaller than those reported in Euro-American populations and may be too small to adequately accommodate transpedicular screw fixation using 3.5 mm screws. It is recommended that pre-operative imaging for all levels should be performed when transpedicular screw insertion is indicated.

**Key words:** cervical spine, morphometry, transpedicular fixation, computed tomography

Transpedicular screw instrumentation of the cervical spine provides superior fixation in patients who require

multisegmental stabilization or deformity correction of the cervical spine. In biomechanical studies, cervical transpedicular screw constructs showed almost twice the resistance to pull-out (677 N vs. 355 N) compared to lateral mass screws.<sup>1</sup> In addition, cyclic loading of pedicle screw cadaver constructs had lesser loss of stability in flexion/extension and lateral bending after 1000 cycles than lateral mass screw constructs.<sup>2</sup> The typical mode of failure of lateral mass screws is loosening or avulsion, particularly at the lower end of the instrumentation.

Pedicle screw instrumentation provides a stronger mode of fixation in patients with poor bone quality, destruction of a lateral mass or in patients undergoing correction of a cervical kyphosis. However, cervical transpedicular screw fixation is more technically demanding compared to same fixation of the thoracic and lumbar spine due to the complexity and variability of cervical spine morphology.<sup>1,3,4,5</sup> The cervical spine pedicle is surrounded by important anatomic structures: above and below are the nerve roots, medially lies the spinal cord and laterally lies the vertebral artery. Abumi et. al. reported that 6.7% of their 669 cervical pedicle screws inserted during surgery penetrated the pedicle on CT scan.<sup>6</sup> Even with the aid of computer navigation, there is still a 24% risk of screw misplacement.<sup>7</sup>

The mean outer pedicle diameter ranges from 5.5 to 7.7mm among Caucasians<sup>11</sup>. Asian pedicle diameters are smaller. A Medline search showed four papers

noting significantly smaller measurements for Asian cervical pedicles.<sup>5,8,9</sup> The smaller size of cervical pedicles would increase the technical difficulty of screw insertion, especially when using standard 3.5 mm pedicle screws. Morphometric measurements of Filipino cervical spine pedicles would guide surgeons in preparing proper screw sizes for local patients if cervical transpedicular screw fixation is warranted. Knowledge of the internal diameter and wall thickness could also increase accuracy of screw placement.<sup>9</sup>

The objective of this study was to measure the internal diameter, medial and lateral wall thickness of cervical spine pedicles (C2 to C7) in a Filipino patient population seen at the Philippine General Hospital.

## Methods

A manual search of the Department of Radiology database for all cervical CT scans performed from December 2008 to November 2009 was done. All radiographically normal cervical vertebrae were included in the study. Scans with radiographic findings of infection, malignancy, congenital anomalies, fractures or dislocations were excluded. This study is exempt from ethics review consistent with the General Ethical Guidelines for Health Research (2011) of the Philippine Health Research Ethics Board.

The images used consisted of 2.0 mm axial images acquired directly using Siemens SOMATOM Emotion 16 and SOMATOM Spirit 2 multislice scanners (Siemens Medical Solutions, Erlangen, Germany). The narrowest inner diameter (isthmus), medial wall thickness, and lateral wall thickness of the bilateral C2 to C7 pedicles were measured (Fig 1). All measurements were performed using electronic calipers on a Sienet MagicView VE 42 Siemens PACS station capable of multiplanar digital reconstruction. The digital images were viewed full-screen on a 3-megapixel, 20.8-inch diagonal grayscale flat panel screen with 1536 x 2048 resolution. To standardize measurements, the images were viewed with the preconfigured osseous window setting of the Sienet MagicView VE 42 Siemens PACS station (window width of 1500 and window level of 450). The measurements acquired were tabulated using Microsoft Excel for Mac 2011 Version 14.0.0. The

differences in the means of the measurements in the male and female populations were analyzed using a one-tailed z-test at  $\alpha = 0.05$ .

## Results

A total of 252 cervical CT scans were performed by the Department of Radiology in the study period. Only 94 scans had normal radiographic findings of the cervical spine and were included in this study. These 94 patients had a mean age of 52.9 years old (range: 18 to 82). There were 57 males and 37 females. All the patients were Filipinos, as indicated in their hospital data. A total of 1316 pedicles were measured.

Table 1 summarizes the inner diameter, mean medial wall thickness and the lateral wall thickness measurements taken from this sample of patients.

The mean inner diameters were significantly different across all levels between males and females ( $\alpha = 0.05$ ). Mean lateral wall thickness was also significantly different between males and females except for C2 and C6 levels on the right side. Mean medial wall thickness was consistently larger between males and females except for C2 to C5 levels on the right side. There was no significant difference between the left and right pedicle measurements at each level for either sex (Table 1).

C3 to C5 of male pedicles had a mean inner diameter of  $< 3.1$  mm compared to C2 to C7 in females. For mean lateral wall thickness, only the right C4 & C5 lateral wall thickness in females was  $< 1.0$  mm. All cervical spine levels in both males and females had a mean medial wall thickness of  $> 1.0$  mm (range 1.47 to 1.89 mm).

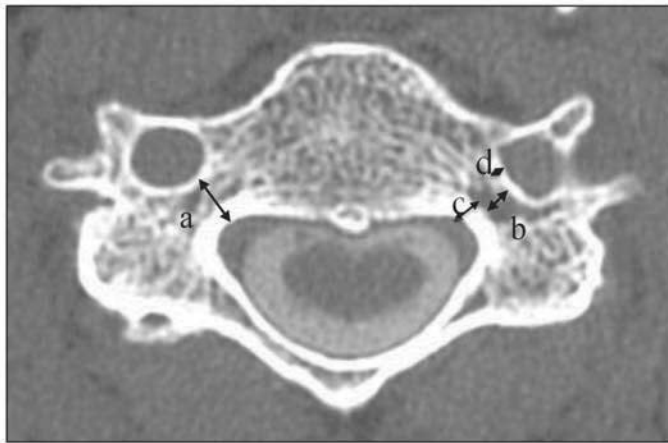
## Discussion

Results of this study show that the cervical spine pedicle inner diameter of  $< 3.0$  mm in Filipino males and females is smaller than the standard 3.5 mm pedicle screws being used.

There are various morphologic studies on human cervical pedicles to assess the appropriateness of transpedicular screw fixation in this region.<sup>4,9,10,11,12</sup> All studies were performed in European or American centers and two of them specified that their specimens were

**Table 1.** The inner diameters, medial and lateral wall thicknesses of cervical pedicles of 94 Filipinos.

Level	Inner Diameter mm (SD)			Medial Wall Thickness mm (SD)			Lateral Wall Thickness mm (SD)		
	Males	Females	P value	Males	Females	P value	Males	Females	P value
C2	3.44 ( $\pm 1.07$ )	2.88 ( $\pm 0.98$ )	0.012	1.88 ( $\pm 0.04$ )	1.73 ( $\pm 0.48$ )	0.097	1.34 ( $\pm 0.37$ )	1.18 ( $\pm 0.36$ )	0.036
C3	3.00 ( $\pm 0.77$ )	2.49 ( $\pm 0.85$ )	0.004	1.70 ( $\pm 0.38$ )	1.56 ( $\pm 0.35$ )	0.092	1.24 ( $\pm 0.36$ )	1.05 ( $\pm 0.33$ )	0.012
C4	2.76 ( $\pm 0.73$ )	2.24 ( $\pm 0.65$ )	0.001	1.58 ( $\pm 0.34$ )	1.47 ( $\pm 0.36$ )	0.147	1.17 ( $\pm 0.37$ )	0.98 ( $\pm 0.28$ )	0.007
C5	2.91 ( $\pm 0.73$ )	2.52 ( $\pm 0.72$ )	0.011	1.60 ( $\pm 0.34$ )	1.52 ( $\pm 0.40$ )	0.336	1.18 ( $\pm 0.38$ )	1.17 ( $\pm 0.74$ )	0.944
C6	3.13 ( $\pm 0.74$ )	2.56 ( $\pm 0.70$ )	0.000	1.71 ( $\pm 0.41$ )	1.53 ( $\pm 0.38$ )	0.042	1.34 ( $\pm 0.65$ )	1.20 ( $\pm 0.72$ )	0.323
C7	3.64 ( $\pm 0.91$ )	3.00 ( $\pm 0.89$ )	0.001	1.87 ( $\pm 0.48$ )	1.63 ( $\pm 0.45$ )	0.016	1.38 ( $\pm 0.48$ )	1.15 ( $\pm 0.34$ )	0.013

**Figure 1.** Cervical spine pedicle measurements. a = outer diameter; b = inner diameter; c = medial wall thickness; d = lateral wall thickness

obtained from spinal columns of Euro-American origin.<sup>8,10</sup> All agreed that morphometric measurements vary from one cervical level to another. Two centers studied the internal morphology of cervical pedicles and agreed that a significant number of pedicles had an inner diameter of 2 mm or less.<sup>4,11</sup> Measurement of pedicle width and height showed that a 3.5 mm screw can be accommodated in all subaxial cervical levels of 98% of healthy young North American volunteers.<sup>13</sup> However, controversies

still exist regarding the use of 3.5mm pedicle screws for cervical transpedicular fixation in the Asian population.<sup>5,8,9</sup>

Inner diameters of <3.0 mm is considered insufficient to accommodate 3.5 mm screws.<sup>6</sup> Wall thickness of <1.0 mm may not be sufficient to prevent cortical perforation.<sup>6</sup> Inner diameters ranging from 1.94 mm to 3.37 mm in males and 1.52 mm to 2.46 mm in females measured radiographically in a Malay population could theoretically risk cortical penetration and injury to adjacent vital structures.<sup>6</sup> A medial perforation can injure the spinal cord while a lateral perforation can damage the vertebral artery. These findings were consistent with cadaveric measurements done on a Chinese Singaporean population.<sup>5</sup> In this study of Filipino cervical spines, measurements across the various cervical spine levels were consistent with published literature.<sup>3,4,5,6,7,8,9,10</sup> Females had smaller measurements than males in most levels. In general, pedicle dimensions tend to be smaller in females in all populations.<sup>11</sup> Medial walls were consistently thicker than lateral walls. This implies that the vertebral artery is more prone to injury than the spinal cord in screw perforations. Though the mean inner diameters were not as small as that observed in the Malay population, most of the measurements were still too small to safely accommodate a 3.5 mm pedicle screw in inexperienced hands. The authors agree with published

recommendations to perform pre-operative imaging for all levels when transpedicular screw insertion is indicated.

The use of smaller diameter screws can be an alternative in patients with reduced pedicle diameters but there is a concern that it may provide a weaker form of fixation. However, Heller<sup>1</sup> demonstrated that the pull-out strength of a 3.5 mm screw is not significantly different from that of a 2.7 mm screw. He attributed this to the fact that the cortical purchase of a 2.7 mm screw in a narrow pedicle may be equivalent to the cortical purchase of a 3.5 mm screw in a wider pedicle. Hence, the use of smaller diameter 2.7 mm pedicle screws is feasible in Filipino patients requiring transpedicular fixation of the cervical spine.

## Conclusion

The inner diameter, lateral and medial wall thickness of typical Filipino cervical spine pedicles are smaller than those reported in Euro-American populations. Pre-operative imaging is recommended, especially in female patients, to determine if standard 3.5 mm. pedicle screws can be safely inserted. If not, the use of smaller diameter pedicle screws may be considered.

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