Morphometry Study on Thoracic Vertebrae Pedicle with Computed Tomography Scan in Population of Surabaya, Indonesia

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Abstract

The fixation technique with pedicle screw is widely used for stabilization as well as deformity correction. However, data on vertebral morphometry have not been obtained. Most previous studies were conducted on the Caucasian race and slightly in the Asian race considering that there was a significant difference in pedicle morphometry of vertebrae between races and age. The objective to examine the morphometry of the thoracic vertebral pedicle in young adult population of Surabaya, comparing with the pedicle morphometry in the overseas population. The method we collected patients' data of thorax CT Scan in Dr. Soetomo Teaching Hospital and Airlangga Hospital Surabaya. Patients with spinal deformities including congenital abnormalities, trauma, infection, and tumors were excluded. The variables to be measured were pedicle diameter (Pedicle width), pedicle depth to anterior cortex corpus vertebrae (Cord Length), and transverse pedicle angle. The result CT scan data collected was 123 consisting of 56 males and 67 females with an average age of 18.1 years old. The average pedicle width, cord length, and transverse pedicle angle in Surabaya population differed significantly from the Caucasian population of the previous study. Conclusion there were no significant differences in transverse pedicle angle between males and females. There was no significant difference in morphometric data compared to the Asian population.

Keywords: *Thoracic Vertebrae, Pedicle Screw, Pedicle Morphometry, Surabaya Population*

Introduction

The use of pedicle screw as a fixation tool on spine surgery has become popular all over the world. This procedure is the only system that can provide fixation on three vertebral columns and restrain movement in all dimensions [1]**.** Accurate and comprehensive antopometric data for the spine (vertebrae) is not available at this time. Information about the dimensions of the vertebrae is essential for the development and design of rational spinal implants such as pedicle screw. Previous studies have measured this with X-ray modalities, and computed tomography (CT) scan[2]. Several studies also performed analysis on cadaveric specimens [3]

The thoracic vertebrae have unique characteristics and these characteristics are associated with potential complications of injury to the neural structure. The magnitude of this potential complication that causes the use of pedicle screw on the thoracic vertebrae is very limited. The pedicle diameter of the thoracic vertebrae is sometimes smaller than the available pedicle screw diameter [4]. The lateral aspect of the dural sac is directly adjacent and attached to the medial wall of the pedicle. Therefore, misalignment of screw mounting in the medial direction may cause injury to the dural sac and spinal cord [5], and lateral errors can cause injury to the blood vessels [6]

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A study in Asian populations and using CT scans showed that the data is not applicable for the Caucasian population [7].Recently, the development of digital imaging and computer usage has led us to a new generation of X-ray imaging that enables the manipulation and improvement of the resulting image quality, and allows precision measurements in different areas of the vertebrae. These data can produce basic antopometric models for the study of spinal implant design [8]

Most of the anatomical studies of vertebrae pedicle morphology were conducted in the Caucasian population, and a small percentage in the Asian population. Several studies reported no statistically significant difference between the data examined on CT scans and on cadavers. Previous studies have also shown significant differences in pedicle size between human races [9]. Therefore, we aimed to examinethe morphometry of the thoracic vertebral pedicle in young adult population of Surabaya, comparing with the pedicle morphometry in the overseas population.

Method

The subjects of this study were patients of Dr. Soetomo Teaching Hospital and Universitas Airlangga Hospital Surabaya. Indonesia that fulfilled the criteria of inclusion and exclusion. The inclusion criteria of the subjects included patients aged 16-25 years old and patients underwent thoracic CT scan with all indications. The exclusion criteria included patients with spinal deformities including congenital abnormalities, trauma, infections, and tumors. Subjects who were willing to participate to the research filled out the informed consent sheet.

This study used cross-sectional observational design that described the average morphometry of young adult vertebrae pedicle in population of Surabaya, Indonesia and compared morphometry of vertebrae pedicle among young adult population in Surabaya, Indonesia and overseas population whose data obtained from previous study. The process of determining the number of subjects included identification according to the inclusion and exclusion criteria in which the subjects obtained 123 patients consisting of 56 male patients and 67 female patients. The number of thoracic vertebrae examined was 1476 pieces consisting of 672 pieces of male vertebrae and 804 pieces of female vertebrae.

The research procedure was performed based on the results of 16 slices of thorax CT Scans (Siemens Ltd, Berlin and Munich, Germany) on the subjects. The CT-Scan data was a opened with the application of Osirix version 6.5. Furthermore, by using the application, the file of CT-Scan can be opened, re-formatted, and measured the variables needed. Measurements were performed on the vertebral pedicle T1 to T12. The variables to be measured were pedicle diameter (mm), pedicle to anterior cortex corpus vertebrae (mm), and pedicle transversal angle(°).The pedicle width was determined by measuring the shortest distance between the pedicle walls. The transverse angle pedicle was determined by measuring the angle formed between the central axis of the pedicle and the perpendicular line from the pedicle width line passing through the pedicle. Chord length was measured from the posterior and anterior cortical ends of a line perpendicular to the pedicle width used in the transverse pedicle angle measurement. All measurements used axial piece of CT scan.

Measurable structures in the vertebrae included (1) chord length of the pedicle, measured from the posterior cortex (entry point) pedicle to the anterior cortex of the vertebrae in line with the pedicle axis, (2) length of the pedicle, measured from the pedicle posterior cortex to the posterior longitudinal ligament along the pedicle axis, (3) transverse pedicle diameter, measured at isthmus horizontal orientation,(4) the pedicle insertion angle, measured from the midline towards the pedicle mid-axis, (5) the height of the pedicle, measured in the vertical orientation isthmus, (6) the length or width of the vertebral corpus, measured from the posterior to the anterior longitudinal ligaments on the mid-sagittal pieces (measurements were made on both end plates, and the average value was calculated), (7) the pedicle offset, calculated from the spinous processus to the medial and lateral walls of the pedicle, and from the inferior facet to the inferior extent of the outer wall of the pedicle, and (8) the pedicle's entry point (central axis), measured at the confluence between the tranversus processus and the nearest facet joint [10]

After all variables were obtained, the mean and standard deviation measurements were performed on each variable. The measurement were differentiated between males and females at each vertebral level to look for significant differences. Due to the absence of gender discrimination in previous studies defined as comparative studies, measurements of mean and standard deviations of all samples were devided regardless of

gender. Furthermore,

these data were compared with previous research.

Results

In both males and females, the average pedicle width was highest at T12 level with a magnitude of 9.05 mm and 7.63 mm respectively. The diameter of the pedicle gradually decreased from T1 until it reached to the smallest diameter in T4, and gradually enlarged again. The narrowest diameter was at T4 (male: 4.75 mm; female: 3.98 mm). The diameter of the vertebra pedicle was significantly larger in males compared with females at all levels.

Pedicle chord length was significantly shorter in females than in males at all vertebral levels. The pedicle chord length ranged from 27.28 mm to 50.98 mm in males and from 25.88 mm to 43.84 mm in females. The longest pedicle chord length was at 50.98 mm and the shortest was at 25.88 mm in males and females. The length of the pedicle chord increased from T1 to T9, and shortened from T10 to T12. Compared with previous research data, the trend was found similar.

The level with the widest transverse pedicle angle was T1 (36.29º) in males and also T1 (35.71º) in females. The transversal pedicle angle gradually narrowed to its level from T1 to T12, and the narrowest at T12 (male: -4.08º; female: -6.26º). No significant difference was found between the transverse pedicle angle of male and female subjects. Compared with other studies, no significant difference was found in the transverse pedicle angle, but had similar trends in the pattern.

Tabel 1: Comparison of pedicle width, cord length, and transverse pedicle angle in males and females

level	pedicle width			cord length			transverse pedicle angle		
	Male	Female	p	Male	Female	p	Male	Female	p
T1	7.25±0.68	6.68±0.69	0.000	35.50±2.19	32.50±1.96	0.000	31.23±2.52	30.65±2.54	0.208
T2	7.04±0.73	5.60±0.92	0.000	36.14±2.50	32.87±2.12	0.000	20.78±2.31	20.90±2.65	0.791
T3	5.38±0.84	4.33±0.83	0.000	35.97±3.16	32.82±2.65	0.000	12.97±2.42	12.90±2.56	0.877
T4	4.75±0.53	3.99±0.74	0.000	35.07±2.75	33.36±3.11	0.000	10.29±2.17	10.13±2.11	0.680
T5	4.83±0.67	4.08±0.87	0.000	37.28±2.90	33.70±2.73	0.000	8.52±2.03	7.82±2.24	0.074
T6	5.11±0.94	4.12±0.78	0.000	38.11±2.44	34.74±2.47	0.000	6.95±1.93	6.71±2.25	0.531
T7	5.15±0.86	4.33±0.85	0.000	40.84±2.43	35.95±2.86	0.000	5.34±1.94	5.37±2.68	0.944
T8	5.67±0.82	4.53±0.81	0.000	41.04±2.76	36.64±2.35	0.000	3.88±2.50	4.43±2.54	0.230
T9	5.87±0.73	4.77±0.89	0.000	41.15±3.54	37.13±2.83	0.000	2.51±2.08	3.50±2.28	0.013
T10	6.79±1.13	5.82±1.16	0.000	40.79±3.88	35.80±2.88	0.000	1.25±1.78	1.51±2.34	0.496
T11	8.28±1.13	7.32±1.46	0.000	40.30±3.14	35.45±2.46	0.000	-0.71±2.04	-0.28±1.80	0.216
T12	9.05±1.69	7.63±1.17	0.000	39.14±3.34	35.13±2.43	0.000	-1.66±1.16	-1.33±1.99	0.275

Discussion

In the caucasian population, previous research xamined the morphometry of the thoracic vertebrae pedicle using a CT scan by measuring several parameters. When compared with the results the morphometric size of previous the thoracic vertebral pedicle in the Surabaya population is proved to be significantly smaller. These size differences may be associated with a smaller body size in Asians [4]. Asians have a smaller body mass index, but have a greater percentage of body fat when compared to Caucasians [11].Therefore, height and body mass index size may provide good predictive value for pedicle size of the vertebrae. Measurement of pedicle size of the vertebrae using a pre-operative CT scan may also provide precision vertical pedicle dimension precision data, and improves the accuracy of pedicle screw mounting on the thoracic vertebrae; thus, the complications can be avoided.

The comparison of mean pedicle width between Kai et al's study(19) study and some revious studies in Table. It appears that the large pedicle width in the Surabaya population is smaller when compared with the Caucasian population and has similarities with the Asian population. Comparison between Kim et al's study(5) and the current study chord length pedicle of Surabaya population with other research. It appears that the chord length pedicle in Surabaya population is smaller than the Caucasian population and similar to other Asian populations. The Comparison between Panjabi et al's study(6)and the current study appears that the large mean transverse pedicle angle in Surabaya population is also smaller than the Caucasian population and similar to other Asian populations.

Researcher performed a comparison between pedicle morphometry in Surabaya population and pedicle morphometry in the Asian population[12]. From these comparisons, it is evident that pedicle morphometry in Surabaya populations does not differ significantly with other Asian populations. There was a comparison of pedicle morphometry between Surabaya population and Caucasian population [13]. From the comparison, the morphometry of pedicle of Caucasian population is significantly greater than Surabaya population.

The Malaysian population compared with our study on the population of Surabaya using two sample T-tests, it was found that both the comparison of pedicle width, cord length, and transverse pedicle angle showed no significant difference. Kai et al. conducted a cross-sectional study of pedicle morphometry in 180 patients of Malaysian Malay race with ages ranging from 18 to 80 years. Kai's research concludes that the existing pedicle screw system is incompatible with the majority of the Malay population, especially at the midthoracic level. Kai also stated that the smaller pedicle size of the Malay race examined may be related to the Malay race body that is shorter than Caucasian races [12]

Conclusion

CT scan evaluation of the thoracic vertebrae can provide morphometric data which is very useful in determining the length and length of the pedicle screw, and determining the direction of the pedicle screw on transpedicle spinal surgery. The size of the pedicle's morphometry in humans varies from one to another. In this study, it appears that the morphometry of the human pedicle differs from one population to another. Smaller thoracic vertebrae pedicle dimensions in Surabaya population compared with Caucasian population can be associated with smaller body size in Asian populations. Many factors that cause this difference are: race, weight, height, and body mass index. Therefore, in carrying out the transpedicle instrumentation action, it is necessary to consider these factors and, if possible, CT scan can be performed before the surgery to estimate the pedicle dimensions of patients.

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