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Morphometric Study of Dried Thoracic Vertebrae of the Human Cadavers

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ABSTRACT

Introduction: the aim of this anatomical investigation was to study the morphometry of the thoracic vertebrae and their foramen in cadaveric dried collections.

Material and Methods: this present descriptive cross-sectional study included 100 adult cadaveric dry thoracic vertebrae. The digital Vernier calipers was used to perform the measurements. The vertebral body height, antero-posterior length at superior and inferior borders, transverse length, interpedicular distance at the lateral ends, lamina length, height and thickness, superior and inferior articular facet height and width, mid sagittal and transverse diameter of vertebral foramen, pedicle width, thickness, length, chord length, length, width and thickness of transverse process were measured.

Results: the anteroposterior length of the vertebral body was more at the inferior border than at the superior border ($p < 0.001$). The length of lamina, width of inferior articular facet and thickness of transverse process were more on the right side than the left side ($p < 0.001$). The height of inferior articular facet, pedicle length, chord length and width of transverse process were greater for the left side than the right side ($p < 0.01$). The remaining parameters, which were compared on the right and left sides did not show the statistical significance ($p > 0.05$).

Conclusion: this investigation offered the measurements of important dimensions of thoracic vertebrae, which are essential in the clinical practice. The implants at the vertebrae need to be manufactured based on the anatomical dimensions of vertebrae of at particular sample population.

Key Words: Artificial Implants; Pedicle Screws; Spine; Thoracic Vertebrae.

Introduction

The morphometric data of the vertebrae are essential during the transpedicular screw fixation. This is important during the preoperative evaluation of the patient for choosing the accurate transplant. The dimensions of vertebra differ within several ancestries, ethnic and regional groups. The vertebral morphometry has been studied in the Western population in a great detail, especially with the usage of radiological measures. However, the direct anatomical measurements are considered as accurate in comparison to the radiological measurements. The dimensions of the vertebral pedicle are required during selection of the surgical screw[1]. The laminoplasty procedure requires the measurements of the lamina[2]. These data are essential to study the ossification of the posterior longitudinal ligament[3]. Recently, there has been a substantial improvement in the internal fixation techniques to stabilize the thoracic spine[4]. The patients of scoliosis, traumatic spine injury and collapse of the vertebrae due to infection are fixed by the posterior approach by using hooks, rods and wires[5]. Since the morphometric data of the thoracic vertebra are scarce from the Indian sample population, it will be of paramount importance to conduct a study in our geography to look for their morphological dimensions. This may be of great help to the orthopedic surgeons and spinal surgeons. The manufacturers may also get greater insight in designing the screws and implant. In this context, the aim of this study is to study the morphometry of the thoracic spine and its foramen in cadaveric dried specimens.

Materials and Methods

This present descriptive cross-sectional study included 100 adult cadaveric dry dorsal vertebrae. The sample size was determined based on previous study by Singh et. al.[6] The gender of the specimens was not taken into consideration. The damaged vertebrae and congenitally deformed thoracic vertebrae were excluded. The digital Vernier calipers was used to perform the measurements. The dimensions were measured in millimeters and tabulated as mean ± standard deviation. The details of included measurement in present study are being shown in Table-1 and Figure-1. The recent version of the SPSS software (version 26) was utilized for the statistical analysis. The paired 't' test was applied for the comparison between right and left sides. It was considered highly significant if the 'p' value is lesser

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than 0.001, moderately significant if lesser than 0.01 and significant if lesser than 0.05.

Table 1. Details of measurements of thoracic vertebrae (n=100) in the present study.

1	Height of the body (AB)
2	Antero-posterior length of body at superior border (CA)
3	Antero-posterior length of the body at inferior border (DB)
4	Transverse length of the body (EF)
5	Interpedicular distance at the lateral ends (GH)
6	Lamina length, right and left side (IJ)
7	Lamina height (KL) on both sides
8	Lamina thickness (MN) on both sides
9	Superior articular facet height (OP) and width (QR), right and left side
10	Inferior articular facet height (ST) and width (UV), right and left side
11	Mid sagittal diameter of vertebral foramen (WX)
12	Transverse diameter of vertebral foramen (YZ)
13	Pedicle width of thoracic vertebrae (A1B1)
14	Pedicle thickness of thoracic vertebrae (C1D1)
15	Pedicle length of thoracic vertebrae (E1F1)
16	Chord length of thoracic vertebrae (G1H1)
17	Length of transverse process (I1J1)
18	Width of transverse process (K1L1)
19	Thickness of transverse process (M1N1)

Results

The anatomical dimensions of the different parts of thoracic vertebrae, which are measured in this study are represented in tables 2 and 3. The vertebral body anteroposterior dimension was more at its inferior border than at the superior ($p < 0.001$). The right lamina was longer than the left sided lamina ($p < 0.001$). The inferior articular facet width was greater on the right side than the left ($p < 0.01$) and its height was greater for the left side than the right side ($p < 0.01$). The pedicle length was observed to be more on the left side than the right side ($p < 0.001$). The chord length also followed the same morphology with a 'p' value <0.05.

Table 2. Unpaired dimensions of the thoracic vertebrae (n=100)

parameter measured	mean ± SD	
vertebral body height	18.15 ± 2.43	
vertebral body AP length at superior border	21.77 ± 4.08	p < 0.001*
vertebral body AP length at inferior border	22.61 ± 3.85	
vertebral body transverse length	28.32 ± 3.91	
distance between lateral walls of pedicle	28.09 ± 4.53	
mid sagittal diameter of vertebral foramen	13.79 ± 1.25	
transverse diameter of vertebral foramen	16.28 ± 2.26	
measurements are in mm; paired 't' test; statistical significance* p<0.001		

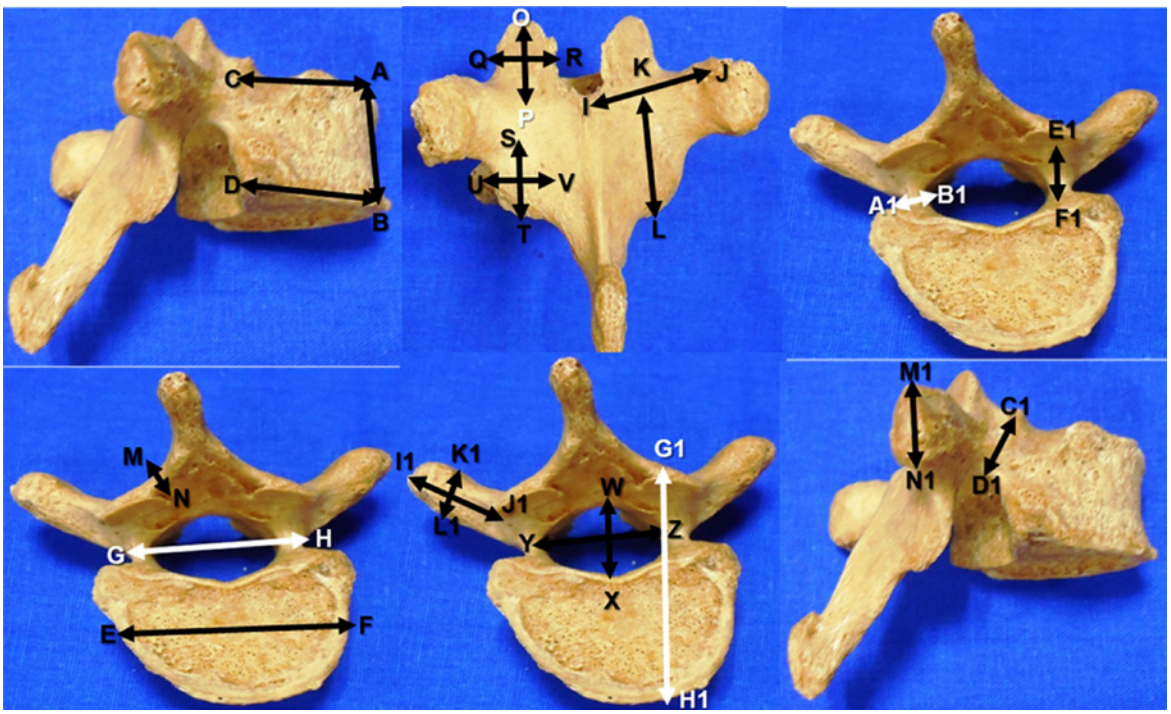

Figure 1. Demonstration of the dimensions measured in the thoracic vertebrae in this study

Table 3. Paired dimensions of the thoracic vertebrae (n=100).

Measurement	On right side	On left side	'p' value
Length of lamina	10.95±1.87	10.56±1.63	< 0.001*
Height of lamina	19.60±3.85	19.60±3.67	0.997
Lamina thickness	5.94±1.01	6.03±0.96	0.111
Height of superior articular facet	9.86±1.71	9.68±1.40	0.093
Width of superior articular facet	9.5±1.66	9.53±1.75	0.73
Width of inferior articular facet	9.63±1.48	9.41±1.40	< 0.01*
Height of inferior articular facet	9.51±1.42	9.83±1.61	< 0.01*
Pedicle length	9.49±1.48	10.39±1.74	<0.001*
Pedicle width	11.80±2.22	11.79±2.30	0.907
Pedicle thickness	6.22±4.06	5.85±1.90	0.15
Chord length	32.35±4.91	32.74±5.42	<0.05*
Length of transverse process	16.11±3.39	16.06±3.34	0.71
Width of transverse process	10.57±1.43	10.76±1.51	<0.001*
Thickness of transverse process	8.69±1.61	8.43±1.41	<0.001*

measurements are in mm; paired 't' test; statistical significance* p<0.05-significant; p<0.01-moderately significant; p<0.001-highly significant

The width of transverse process was more for the left side ($p < 0.001$) and thickness was greater for the right side ($p < 0.001$). The remaining parameters, which were compared on the right and left sides did not show the statistical significance ($p > 0.05$).

Discussion

The spinal column surgery is performed in the malignancies, traumatic injuries, prolapsed intervertebral disc and pathological conditions like scoliosis. It is reported that this is among the hardest surgeries to perform and it is prone for the postoperative complications[7]. The thoracic vertebrae of the spinal column have very narrow vertebral foramen. Along with narrow pedicles, this poses a greater challenge to the surgeons during spinal screw fixation surgeries. Although thoracic vertebral injury requires a greater force, because of its attachment to the rib cage and directions of facet joint, but whenever it happens, it is mostly associated with the neurovascular injuries[8] and hence it becomes vital to stabilize the vertebral column. The trans-pedicular screw fixation is a widely used method nowadays to achieve instrumentation and stabilization of vertebrae in conditions like scoliosis, injuries due to trauma, collapse of vertebrae due to infectious reasons[5]. However, considering the fact that the morphometry of vertebral pedicles is different in different populations[9-11] and because of its close proximity to the spinal cord and the aorta, it becomes essential for the surgeons to have an in-depth knowledge about the vertebrae especially the pedicles of the target population.

Krag *et al.*[12] performed the morphometry of the vertebrae in cadavers, both manually and radiologically. Misenheimer *et al.*[13] measured the pedicle diameter in the thoracic vertebrae of the cadavers by using the coronal and axial computed tomogram images. The present study provided further insight and details regarding the morphometry of dorsal vertebrae with a special focus on vertebral foramen and pedicle of thoracic vertebrae. This will help to understand more about the vertebral canal stenosis in our sample population and will also help the surgeons in understanding the selection of right size pedicle screws in relation to thoracic vertebrae. Characterizing the morphology of the spine among populations would allow personalizing the conditions under which each individual should be exposed, for example, at work, or also to determine a possible risk factor that explains the presence of a clinical picture in case of an injury at the spine level, thus modifying the decision making in the clinical approach. The data are not only useful in the field of neurosurgery, but are also extrapolated to specialties such as neurology and orthopedics, for the management of neurological and musculoskeletal disorders, which are a frequent cause of outpatient and emergency room visits.

The dimensions of the cervical spine were already determined in our collections, few years ago.[14] This present study was the continuation of this and determined the parameters in the dorsal vertebrae. These can be considered as the reference data for

our study population. The limitations of the present study include the age, gender based segregation and numbering of the vertebrae, which are not performed in this study. This was just a cross sectional study and the vertebrae of the same individual could not be determined as these are random collections. More studies with larger cohort and validated methods of accurate geometric measurements will be helpful in studying this complex anatomy.

Conclusion

The anatomical dimensions of the several parts of the thoracic spine will help the operating neurosurgeons and spine surgeons during the surgeries like laminectomy and decompression. They are also essential in planning the accurate sizes of the plates and screws in the internal fixation. The implants have to be manufactured based on the anatomical dimensions of the thoracic spine of that particular sample population.

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