Journal of Surgical Radiology
https://journalsurgrad.com/
ISSN Print 2156-213X| ISSN Online: 2156-4566 Volume: 03 Issue: 01 Open Access

Research Article

Morphometric assessment of adult human lumbar vertebrae

Dr. Mohammed Muzammil Ahmed
Associate Professor Department of Anatomy Shadan Institute of Medical Sciences Teaching Hospital & Research Centre

*Corresponding Author
Dr. Mohammed Muzammil Ahmed

Article History
Received: 05.01.2024
Revised: 15.01.2024
Accepted: 06.02.2024
Published: 24.02.2024

Citations:
Mohammed Muzammil Ahmed. Morphometric assessment of adult human lumbar vertebrae. *J Surg Radiol*, *03*(01);2024; 5-8.

Abstract: Background The vertebrae undergo continuous remodeling throughout life, primarily in response to the changing needs of the body. 1 Evolution of human erect posture and bipedal gait coupled with lifestyle changes is often reflected as stress on the vertebral column. 2 The lumbar region of vertebral column being the most common site of expression of this stress in the form of low backache. 2 The five lumbar vertebrae are distinguished by their large size, wider body in transverse plane, strong and short paired pedicles, shallow superior vertebral notches, spinal canal etc. The dimensions of these vertebral segments provide key relevance in clinical diagnosis of lower backache as well as other pathological lumbar diseases Lumbar morphometry is intended at its stabilization and correction of deformities. 3 Accurate anatomical description of the shape and orientation of lumbar vertebrae are necessary for the development and use of implantable devices and spinal instrumentation in spinal disorders including fractures. 4 It is also imperative to assess the differences in morphometry of vertebrae Material And Method The anteroposterior body diameter (APD) was measured as the anteroposterior distance of each vertebral body, while the interpedicular distance (IPD) was measured as the minimal distance between the medial surfaces of the pedicles on either side. The midsagittal diameter (MSD) was measured as the maximum anteroposterior distance of the spinal canal of each vertebra while the pedicle length (PL) were measured starting from the origin of the pedicle from the body to the superior articular facet on either sideusing the average. Results The vertebral body anteroposterior dimension was more at its lower border than at the upper ($p<0.01$). The length of lamina was higher over the right side ($p < 0.001$). The height of lamina, width of inferior articular facet, diameter of lateral recess and thickness of pars inter-articularis were greater for the left side ($p<0.01$). The remaining parameters, which were compared on the right and left sides did not reveal the difference with respect to the statistical significance ($p>0.05$). Conclusion This anatomical study offered several dimensions of lumbar vertebrae, which are essential in the surgical practice. The implants at the lumbar vertebrae need to be manufactured based on the anatomical dimensions of that particular sample population.

Keywords: Lumbar Vertebrae; Pars Interarticularis; Skeletal Fixation.

INTRODUCTION

The vertebrae undergo continuous remodeling throughout life, primarily in response to the changing needs of the body. 1 Evolution of human erect posture and bipedal gait coupled with lifestyle changes is often reflected as stress on the vertebral column. 2 The lumbar region of vertebral column being the most common site of expression of this stress in the form of low backache. 2 The five lumbar vertebrae are distinguished by their large size, wider body in transverse plane, strong and short paired pedicles, shallow superior vertebral notches, spinal canal etc. The dimensions of these vertebral segments provide key relevance in clinical diagnosis of lower backache as well as other pathological lumbar diseases Lumbar morphometry is intended at its stabilization and correction of deformities. 3 Accurate anatomical description of the shape and orientation of lumbar vertebrae are necessary for the development and use of implantable devices and spinal instrumentation in spinal disorders including fractures. 4 It is also imperative to assess the differences in morphometry of vertebrae in men and women and to understand changes among them, as incorrect placement of instruments and devices may have serious complications. 4 The research noted that vertebral bodies and intervertebral disc sustain all the vertebral compression force, the magnitude of which increases from the axis vertebra to the lumbo-sacral joint. 5 Thus each vertebra bears the weight of all the part of the body above it and since the lower ones have to bear much more weight than the upper ones, the former are much larger. Several studies have been carried out to analyze morphometry of posterior element of lumbar vertebra. 4,6 However, the morphometric data on vertebral body is relatively scarce. The present study, the objective was intended to formulate morphometric database of lumbar vertebral bodies.

METHODOLOGY & MATERIALS

Sample collection. The specimens represent the lumbar vertebrae of individuals who died during the apartheid era between the years 1908-1970 (over six decades). The study included collections archived of 107 individuals (103 males and 67 females) aged between 21 and 80 years. The total lumbar vertebrae measured was 298 with the following lumbar segments; L1=46, L2=82, L3=92, L4=53, L5=25 (representing first to fifth lumbar vertebrae respectively. We excluded any vertebrae with obvious anatomical distortions emanation from obvious damage or pathology which would impair our assessments. Specimen measurement. All lumbar specimens (L1 to L5) were measured in millimeters (mm) using digital caliper and were carried out in a

supine placement of the vertebra in the axial plane by three different members of the team (to minimize inter-individual errors of reporting). The anteroposterior body diameter (APD) was measured as the anteroposterior distance of each vertebral body, while the interpedicular distance (IPD) was measured as the minimal distance between the medial surfaces of the pedicles on either side. The midsagittal diameter (MSD) was measured as the maximum anteroposterior distance of the spinal canal of each vertebra while the pedicle length (PL) were measured starting from the origin of the pedicle from the body to the superior articular facet on either side using the average. Ratio of midsagittal diameter to antero-posterior body diameter (MSD/APD) was calculated by dividing MSD by the APD s represent the lumbar vertebrae of individuals who died during the apartheid era between the years 1908-1970 (over six decades). The study included collections archived of 107 individuals (103 males and 67 females) aged between 21 and 80 years. The total lumbar vertebrae measured was 298 with the following lumbar segments; L1=46, L2=82, L3=92, L4=53, L5=25 (representing first to fifth lumbar vertebrae respectively. We excluded any vertebrae with obvious anatomical distortions emanation from obvious damage or pathology which would impair our assessments. Ethical approval. Ethical approval was obtained from the UKZN Biomedical Research Ethics Committee (BREC) (Ethics number: BCA356/14). Specimen measurement. All lumbar specimens (L1 to L5) were measured in millimeters (mm) using digital caliper and were carried out in a supine placement of the vertebra in the axial plane by three different members of the team (to minimize inter individual errors of reporting). The anteroposterior body diameter (APD) was measured as the anteroposterior distance of each vertebral body, while the interpedicular distance (IPD) was measured as the minimal distance between the medial surfaces of the pedicles on either side. The midsagittal diameter (MSD) was measured as the maximum anteroposterior distance of the spinal canal of each vertebra while the pedicle length (PL) were measured starting from the origin of the pedicle from the body to the superior articular facet on either side using the average. Ratio of midsagittal diameter to antero-posterior body diameter (MSD/APD) was calculated by dividing MSD by the APD (Fig. 1). Statistical analysis. Data were analyzed for descriptive statistics and represented as mean + standard deviation using GraphPad Prism 5 (Version 5.03, GraphPad Software, USA). Student's t-test was used to analyze for differences between gender while Pearson's correlation was used to check for association between age of subjects and the parameters recorded. Statistical significance was considered at $P<0.05$.

RESULT

The anatomical data obtained in this study are given in Tables 2 and 3. The vertebral body anteroposterior dimension was more at its lower border than at the upper ($p< 0.001$). The height of lamina, width of inferior articular facet, diameter of lateral recess and thickness of pars inter-articularis were greater for the left side (p0.05).

Table 2. Unpaired measurements of the lumbar vertebrae (n=210)

Parameter measured	mean SD	
vertebral body height	25.6 1.9	
vertebral body AP length at superior border	32.1 3.4	p<0.01*
vertebral body AP length at inferior border	31.6 3	
vertebral body transverse length	45 5.2	
distance between lateral walls of pedicle	43.1 8.8	
mid sagittal AP diameter of vertebral foramen	14.2 1.9	
transverse diameter of vertebral foramen	21.6 2.5	

Table 3. Paired dimensions of the lumbar vertebrae (n=210) (n=210, statistical analysis - paired 't' test).

Measurement	On right side	On left side	'p' value
Length of lamina	11.7 2.1	11.3 2.1	p<0.001
Height of lamina	21.8 3.7	21.4 3.8	p<0.001
Thickness of lamina	6.4 1.1	6.4 1.2	p>0.05
Height of superior articular facet	12.6 2.3	12.7 2.3	p>0.05
Width of superior articular facet	11.9 1.9	12.7 1.9	p>0.05
Width of inferior articular facet	11.3 1.9	11.4 1.8	p<0.05
Height of inferior articular facet	13.5 1.9	14.6 2.2	p>0.05
Diameter of lateral recess	7.4 1.6	7.5 1.6	p<0.01
Height of pars inter-articularis	42.9 3.9	41.7 3.8	p>0.06
Width of pars inter-articularis	13.5 2.2	13.3 3	p>0.05
Thickness of pars inter-articularis	8 1.1	8.51.3	p<0.001

DISCUSSION

If the significant part of vertebral body is involved in a disease, there will be neurological deficits and instability of the back. Internal fixation of vertebral column is the best management available for the traumatic spine injury, lumbar canal stenosis, spondylolisthesis and malignant tumors. The internal fixation offers better stabilization and decreases the duration of the morbidity. The spinal surgery is also performed in prolapsed intervertebral disc and conditions like scoliosis. It was reported that, this is among the hardest surgeries to perform as it is prone for the postoperative complications. Krag et al. performed the morphometry of the vertebrae in cadavers, both manually and radiologically. Characterizing the morphology of the spine among populations, would allow personalizing the conditions under which each individual should be exposed. The morphometric data of the vertebrae are not only useful in the field of neurosurgery, but are also essential to the specialties like neurology and orthopedics. Dimensions of the cervical and thoracic spine were already determined in our collections, few years ago. 6This present study was the continuation of this and here we determined the parameters in the lumbar vertebrae. The morphometrical data of various parts of lumbar vertebrae, procured from this study can be considered as the reference data for our study population. There are not many studies being performed about the morphometry of pars inter-articularis. It offers structural support to the vertebral column and considered as the main support. Pars inter-articularis is a dense cortical bone and is exposed in the posterior approaches. There are morphometrical studies, which are performed by using the radiological methods like utilizing the radiographs and computed tomogram scans. The vertebral column robusticity increased significantly over the time affecting the dimensions of the vertebral body as well. 8 According to Kapoor et al., the inter-pedicular distance was 18.5 mm at the first lumbar vertebra, 21.5 mm at the lower lumbar vertebrae. Aly and Amin 10 reported that the interpedicular 8.51.3 pSince it was just a cross sectional anatomical investigation from the dried vertebrae, the specimens from the same cadaver 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. However, this study offers data about the pars interarticularis of the lumbar vertebrae, which are scarcely reported in the scientific literature. This makes this study interesting as this is novel in the anatomical literature and different from the previous publications.

CONCLUSION

We report the measurements of parts of the vertebrae of the lumbar region in sample Indian population. It is believed that, these data 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 depending on the anatomical dimensions of that particular sample population.

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