Journal of Research in Applied and Basic Medical Sciences 2021; 7(4): 195-199

Original Article

RABMS Journal of Research in Applied and Basic Medical Sciences

Morphometric analysis of dry human lumbar vertebrae

Prenika Shangloo[*1], Anjum Chowdhary[2], Nusrat Jabeen[3], Bonita Gupte[4]

[1] *Senior Resident, Department of Anatomy, Jammu University, GMC Jammu*

[2] *Resident, Department of Anatomy, Jammu University, Jammu*

[3] *Professor, Department of Anatomy, Jammu University, Jammu*

[4] *Senior Resident, Department of Anatomy, Jammu University, Jammu*

***Corresponding authors:** Dr. Prenika Shangloo, **Address**: *Department of Anatomy,* University of Jammu,
Email: prenika1982@gmail.com, **Tel**: +9419185787

Abstract

***Background & Aims*:** With change of posture from quadrupeds to bipeds, a shift of body weight from appendicular skeleton to the axial skeleton (spine) occurs. As a result, various changes in the spine took place and the human spine became more prone to diseases such as scoliosis, spondylolisthesis, osteoporosis of vertebrae and many more. Over the past decade, a number of corrective surgeries have been designed but trans-pedicular screw fixation in spondylosyndesis remains the gold standard for the correcting spinal deformities. Hence, the current study was designed to frame out the morphometric measurements of the pedicle of lumbar vertebrae so that guidelines can be delineated for the manufacturers of lumbar screw implants.

Materials and Methods: The present cross-sectional descriptive study was conducted on 100 lumbar vertebrae of unknown age and sex obtained from the Department of Anatomy Govt. Medical College (GMC) Jammu. All the measurements were taken twice on both right and left side with the help of sliding vernier calipers, averaged out and then tabulated in Microsoft Excel spreadsheet.

Results: The dimensions of the pedicle height of the lumbar vertebrae on the right side were recorded to be from 20.05 to 10.32mm with mean of 13.83±2.08mm. However, mean of the pedicle height on left side was 13.71± 2.09mm with the range of 20.01 to 10.22mm with statistically significant p- value of 0.025. Further, the range of pedicular width of lumbar vertebrae on the right side was 17.71 to 5.38mm with a mean of 10.8±2.73mm and on left side was from 17.69 to 5.37 mm with mean of 9.77±2.57 mm with statistically significant p value of 0.037. The mean inter-pedicular distance of lumbar vertebrae was 21.73±2.62mm with a range of 11-28mm.

Conclusions: The results of the present study concluded that mean pedicular width and mean pedicular height are more on right side and mean inter- pedicular distance was 21.73±2.62mm. Hence, it was concluded that measurements should be taken before designing the lumbar screws for North Indian population.

***Keywords*:** Lumbar vertebrae, Morphometry, Pedicle, Inter- pedicular distance

Received 17 January 2022; accepted for publication 14 March 2022

Introduction

Bipedalism and erect posture in human beings is associated with changes in spine curvatures and anatomy. The main flaw of the erect posture is associated with the compression of the vertebral column as a result of weight transmission from appendicular skeleton to the axial skeleton. The load in thoracic and lumbar regions is transmitted through two vertical running columns, the anterior among which is formed by vertebral bodies and intervertebral discs while the posterior column is formed by successive articulations of neural arch elements. In lumbar region where the curvature is posterior, a part of compressive force of the body (anterior column) is transmitted to the neural arch (posterior column) through the pedicles. This transfer of load between body and neural arch which is between anterior and posterior columns tends to approach the line of gravity (1).

These changes in the vertebral column are not constant instead they keep on remodeling throughout life, presumably in response to the changing needs of the body, and therefore, affecting the height of the intervertebral disc that intervenes between the adjacent vertebrae. The dimensions of the inter-vertebral foramina are influenced by dynamic and postural factors. For example, when a person rises from lying to standing, it results in axial load on inter-vertebral disc causing further bulging of the annulus, which in turn compromises the foramina (2). There can also be arthritis of the bony processes that make up the degenerated facet joint, which can compress the nerve in the intervertebral foramina (3).

The inter-vertebral foramen is described as the cross- road between peripheral nerves and movable skeletal support, transmitting nerves, blood vessels, and lymphatic vessels. Anatomical narrowing of the lumbar vertebral canal and inter-vertebral foramina have been reported as the cause of compression of the cauda equina and the emerging nerve roots which causes low backache radiating to legs, resulting in weakness and paresthesia along the distribution of the affected nerve roots (2). Various causes have been attributed to low backache, but spinal canal stenosis especially in cases where the cauda equina may be compressed within the lumbar spinal canal by constriction or narrowing of the bony ring of the canal, in contrast to impact by soft tissues, stands out to be the main cause of lower backache (4).

The pedicles of lumbar vertebrae are short, thick dorsal projections from superior part of body of lumbar vertebrae at the junction of its lateral and dorsal surfaces. All forces sustained by any of the posterior elements of lumbar vertebrae are ultimately transmitted to the pedicles, which then go to body of lumbar vertebrae. They transmit both gravitational loads and muscular movements (1).

During the last decade, there has been considerable development in the newer techniques of the surgical treatment of low back pain and to stabilize and correct the human spine. Many approaches have been proposed for patients' specific modeling of the spine to explore the method to correct the spinal deformities such as scoliosis. Multiple spinal instrumentation procedures are being developed (5). Trans-pedicular screw fixation of the spine has been developed as a very successful method, as it corrects various spinal problems such as fractures in the lumbar spine, resection of tumors in vertebral bodies, gross spondylolisthesis and lumbar instabilities. Moreover, as compared to thoracic and cervical ones, the strong pedicles of lumbar vertebrae make them ideal for screw fixation (6).

When size of the screw and pedicle is mismatched, the instrumentation may fail. This may result in cortex perforation of the pedicle or fracture of pedicle. The complications associated with oversized pedicle screw are dural tears, leakage of cerebrospinal fluid and injuries to nerve roots. Even within the same population, the anatomical variations have been reported on the pedicle shape, size, and angulations (1).

Different studies were done on the lumbar pedicle considering its importance in weight transmission and related trauma. Various cadaveric, radiographic, and osteological studies were done for the morphometrical data on the lumbar pedicle (7). Thus, understanding the morphometry of the pedicle and the anatomy of adjacent neural structures helps in decreasing the risk of

postoperative complications but however, the morphometrical data of the pedicular dimensions varies from region to region. Few studies are available in our subcontinent, morphometry of the lumbar spine and most of these studies are based on mid sagittal diameter, inter-pedicular distance, and are mainly CT based. However, normal values for dimensions in North- Indian population are lacking, promising us to know the morphometry of lumbar pedicles and instigating us to perform the current study.

Materials & Methods

The present study was conducted on 100 lumbar vertebrae of unknown age and sex, which was obtained from the Department of Anatomy, Govt. Medical College (GMC) Jammu. Thereafter, the morphometry of the lumbar vertebrae was studied in detail. The bones which were dry and complete in all respects and without any gross abnormality were included in the study, so that they could give the correct morphometrical measurements.

The pedicular height was measured at the points just opposite each other on the upper and lower margins of the pedicles in the vertical plane, on its lateral aspect whereas pedicular width was measured at the points, on the medial and lateral surfaces of each pedicle at right angle to the long axis of pedicle and the inter-pedicular distance were taken as the maximum distance between the medial surfaces of the right and left pedicles of the same vertebra. All the measurements were taken twice on both right and left side with the help of sliding vernier caliper, averaged out and then tabulated in Microsoft Excel spreadsheet.

Results

The observations of the current study can be concluded as follows:

Pedicular Height: The pedicle height of the lumbar vertebrae on right side ranged from 20.05 mm to 10.32 mm with mean 13.83 ± 2.08mm. However, mean of the pedicle height on left side was estimated to be 13.71± 2.09 mm with range falling between 20.01mm (maximum) - 10.22mm (minimum). The total average of pedicular height ranged from 20.03mm to 10.27mm with a mean of 13.77 ±2.08mm. These observations were statistically significant with p value of 0.025 **(**Table 1**).**

Table 1: Depicting statistical measurements of pedicular height of lumbar vertebrae on right side, left side and total average (in mm)

S.no	Parameters	Right	Left	Total Average	p-value
1	Maximum	20.05	20.01	20.03	0.025
2	Minimum	10.32	10.22	10.27	
3	Range	20.05-10.32	20.01-10.22	20.03-10.27	
4	Mean	13.83	13.71	13.77	
5	Standard deviation	2.08	2.09	2.08	

Pedicular Width: The observations summarized that pedicle width of lumbar vertebrae on right side ranged from 17.71 to 5.38mm with a mean of 10.8 ± 2.73mm. However, the pedicular width on left side ranged from 17.69 to 5.37 mm with mean of 9.77 and ± 2.57 mm with statistical significant p-value of 0.037. The total average width of pedicle ranged from 17.7 to 5.37 mm with mean of 10.32 ±2.65mm **(**Table 2**).**

Table 2: Depicting statistical measurements of pedicular width of lumbar vertebrae on the right side, left side and total average (in mm)

S.no	Parameters	Right	Left	Total Average	p-value
1	Maximum	17.71	17.69	17.7	0.037
2	Minimum	5.38	5.37	5.37	
3	Range	17.71-5.38	17.69- 5.37	17.7-5.37	
4	Mean	10.8	9.77	10.32	
5	Standard deviation	2.73	2.57	2.65	

Inter- pedicular Distance: The mean inter-pedicular distance of lumbar vertebrae was 21.73mm with a range of 11-28mm (minimum being 11mm and maximum being 28mm) and standard deviation of ± 2.62mm **(**Table 3**).**

Table 3: Depicting measurements of inter-pedicular distance in lumbar vertebrae (in mm)

S.no	Parameters	Measurements
1	Maximum	28
2	Minimum	11
3	Range	28-11
4	Mean	21.73
5	Standard Deviation	2.62

Discussion

A vast variety of citing literature is available that suggests that pedicle screw fixation is a safe and effective treatment for many spinal disorders. Hence, the current study was designed to evaluate the Morphometric measurements of the pedicle of lumbar vertebrae and the inter-pedicular distance so that it becomes easier for orthopedic surgeons and neurosurgeons to assess the right size of the screw to be implanted.

The observations of the current study inferred that the pedicle height on right and left side was not same with statistically significant p-value of 0.025. The observations of present study were in accordance with various studies of past (4, 7-11) who also concluded that mean height of the right pedicle is more than the mean height of the left pedicle. However, the measurements given in those articles resulted in either more or less sizes as compared to the results of current study. Furthermore, few studies concluded that the measurements of pedicular height of the lumbar vertebrae remain to be same on both sides (6) contrary to our data, *Chawla K et al.* (2011) concluded that the pedicular height was more on left side as compared to the right side (12).

Additionally, the results of the present study can be summed up as the mean pedicular width on right side to be more than mean pedicular width on left side with significant p-value of 0.037.These findings were in accordance with the results of various other studies (4, 7, 9, 11, 13). However, few authors who were in disagreement with the current results included *Chawla K et al.* (2011) who inferred that the mean pedicular width is equal on both sides (13) and *Patil DK and Bhuiyan PS* (2014) who concluded that mean pedicular width of lumbar vertebrae is more on left side as compared to the right side (8).

It was concluded from the inter-pedicular distance measurements that mean inter-pedicular distance was 21.73±2.62mm with a range of 11 to 28mm. These conclusions were positively supported by various studies whose measurements of mean inter-pedicular distance were more or less in comparitation with the results of current study (4, 7, 9, 12). However, the

measurements of mean inter-pedicular distance inferred by *Ablyazov O* (2012) were way far more than the results of the current study who reported the inter-pedicular distance in lumbar spine to be ranging from 24.79± 0.50mm to 30.84± 0.97mm (14).

The variation between the results of the current study and previous studies can be attributed to the ethnicity, inter-observer bias, type of measuring instrument used, type of study (dry bone study/ X-ray based study), sex and age.

Conclusion

Morphometric analysis of pedicles of the lumbar vertebrae is important in assessing the size of the screw being used for the management of various clinical conditions like fractures, spondylolisthesis, osteoporosis, spinal deformities, ankylosing spondilitis, injuries like inter-vertebral disc prolapsed, etc. The results of present study concluded that mean pedicular width and mean pedicular height is more on the right side and mean inter- pedicular distance stood to be same when compared with the populations of other parts of Indian sub-continent. Hence, it was concluded that measurements should be taken before designing the lumbar screws for North Indian population.

Conflict of interest

The authors have no conflict of interest in this study.

References

1. Singel TC, Patel MM and Gohil DV. A study of width and height of lumbar pedicles in Saurashtra region. J Anat. Soc India 2004; 53(1):4-9.
2. Devi R and Rajagopalan N. Morphometry of lumbar intervertebral foramen. Indian J Orthop 2005;39(3):145-7.
3. Whitten R, Orlando M. 1. Facet Joint Syndrome [Internet]. 2019 [cited 2022 Mar 16]. Available from: https://www.spineuniverse.com/conditions/spinal-disorders/facet-joint-syndrome
4. Choubisa L and Babel H. Morphometric study of pedicles of dried adult human lumbar vertebrae in Udaipur. Int J Anat Res 2018; 6(3.3):5660-66.
5. Choubey AK, Sahni H, Bhatia M and Sahu S. MR Morphometry of lumbar spine. Int j anat radiol surg 2018, 7(2):14-9.
6. Tiwari A, Pandey S and Naik DC. Morphometric study of atypical lumbar vertebrae and its physiological correlation. Int J Med Sci Public Health 2015; 4(2): 262-5.
7. Wankhede HA, Shailandra S, Anupama KS and Narsingh GH. Morphometric study of the pedicles of dried adult human lumbar vertebrae. International Journal of Anatomy Physiology and Biochemistry 2014; 1(1):1-5.
8. Patil DK and Bhuiyan PS. A morphometric study of the pedicles of dry human typical lumbar vertebrae. Indian Journal of Basic and Applied Medical Research 2014; 3(3): 428-33.
9. Philipose S, Kuriakose S, Viveka S and Kariappa M. Morphometric study of pedicles of lumbar vertebrae in southern India. J. evid. Based med. healthc 2015; 2(39): 6182-91.
10. Sreevidya J, Dharani V, Savithri K and Sudha S. Study of lumbar vertebrae with respect to the dimensions of the pedicle in south Indian population. Indian Journal of Basic and Applied Medical Research 2017; 6(2):523-30.
11. Abbas J, Peled N, Hershkantz I and Hamoud K. Pedicle morphometry variations in individuals with degenerative lumbar spinal stenosis. Biomed Reseach International 2020. https://doi.org/10.1155/2020/7125914.
12. Chawla K, Sharma M, Abhaya A and Kochhar S. Morphometry of the lumbar pedicle in North West India. Eur J Anat 2011; 15(3):155-61.
13. Lien SB, Lien SB, Liou NH and Wu SS. Analysis of Anatomic morphometry of the pedicles and safe zone for through pedicle procedures in the thoracic and lumbar spine. Eur Spine J 2007; 16: 1215-22.
14. Ablyazov O. X-ray parameters of lumbar spine. Medical and Health Science Journal 2012; 10: 37-40.