

Morphometric analysis of lumbar vertebrae using CT scans in Nepalese population

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ABSTRACT:

Introduction: Understanding anatomy of the lumbar vertebrae is necessary to achieve clinical success during surgery, for the development of the spinal implants and instruments and to understand changes in elderly and in male and female patients. **Methods:** A cross-sectional study was done in 50 patients in Nepal to study the lumbar morphometric analysis of the vertebral body, intervertebral disc and spinal canal. Patients who underwent CT IVU for nephrolithiasis at our center were included for analysis of the lumbar morphometry. All the traumatic cases and pathological lesions, such as infection, tumor were excluded from the study. Patients having low backache due to probable intervertebral disc pathology were also excluded from the study. Data analysis was done from Microsoft excel and the mean, standard deviation and range were calculated. **Results:** The anterior-posterior diameter of the vertebral body, varied from 25.97 mm at L1 to 29.39 mm at L5. The transverse diameter of the body ranged from 31.55 mm at L1 to 44.13mm at L5. There were changes in height of body. First from L1 - L3 there was increase in height and from L4-L5 there was decrease in height with least height at L5 (22.71mm). According to our study the L1 vertebra has narrowest transverse diameter of spinal canal(21.25mm) whereas L4 has narrowest antero-posterior diameter of spinal canal(12.37mm).

Conclusion: In the lumbar area, detailed anatomical knowledge is critical for performing a safe operation. These findings give guidance to the surgeons during various approach while performing operative procedure like pedicle screws, vertebral body screws, cages and laminar hooks.

Keywords: Lumbar Vertebra, Computed Tomography, Morphometry

Introduction:

Lumbar vertebra supports weight of the upper body thus significant loading stress to the vertebral bodies is caused by the load lifted and carried by the upper extremity. The intervertebral disc in between the vertebrae act as shock absorber and are made up of fibrous cartilage.¹ Variation in the dimension of spine, canal and disc occurs within different subgroups and lumbar vertebra. Lumbar vertebra is one of the most frequent site of implant

surgery.² In recent years, anterior lumbar body fusion in association of variety of methods is gaining popularity to stabilize both implants and motion sequence as anterior route provide direct access to most spine diseases and allows optimal neural decompression along with adequate realignment, strong reconstruction with rapid restoration of clinical pain and low surgical complication.³ Several spinal problems require internal fixation techniques and for internal fixation various

devices can be applied for spine immobilization with help of screw inserted through pedicle.¹

Understanding anatomy of the patient is thus necessary to achieve clinical success, to appreciate the patterns of lumbar vertebra anatomy during anterior approach, for the development of the spinal implants and instruments, to understand changes in elderly, to define the abnormality/disease state and thus to access the need for proper medical and surgical treatment.⁴⁻⁶

There are many studies in West and few recent studies in Asian population to determine the morphometry of lumbar spine.^{1,3,7,8} Most of the studies have been carried out in cadaver or dry vertebrae specimen.^{9,10} Computed tomographic or Magnetic Resonance Imaging (MRI) studies in morphometry has been introduced in morphometric analysis in recent years.^{11,12} There are very sparse series of lumbar morphometry from Nepal, that too using dry vertebral specimen, plain X-ray or MRI.¹³⁻¹⁵ The aim of this study is to present various anthropometric characteristics of lumbar vertebra, disc and canal from CT images of the lumbar spine in Nepalese population reported at a tertiary care hospital. The difference in dimensions obtained from the study among population of different race and sex is then compared.

Methods:

A cross-sectional study was done among the 50 patients in one of the tertiary center in Nepal over the period of one month. All cases included were Nepalese citizen of age between 20-80 years old, who underwent CT IVU for nephrolithiasis at our center. All the traumatic cases and pathological lesions, such as infection, tumor were excluded from the study. Patients having low backache due to probable intervertebral disc pathology were also excluded from the study.

The variables measured from the study were AP diameter, height and transverse diameter of L1-L5 vertebrae and Lumbar disc (L1-L5), and AP and transverse diameter of Lumbar spinal canal of people of various age, sex and ethnic group.

Data analysis was done from Microsoft excel. All the data were entered in excel and the mean, standard deviation and range were calculated.

Results:

There were 50 cases with 48% males and 52% females. Mean age of the sample was 39.34(Standard deviation 16.54) years. The mean, Standard deviation and range of various dimensions of Lumbar spine, Disc and Canal are tabulated in Table 1,2 and 3 respectively similarly its variance with gender and ethnicity in Table 4 and 5 respectively.

Table 1: Dimensions of Lumbar Vertebral Body

Dimensions	Mean(in mm)	SD
L1 AP	25.97	2.52
L2 AP	27.12	2.51
L3 AP	28.58	2.05
L4 AP	29.54	2.03
L5 AP	29.39	2.35
L1 H	23.04	2.29
L2 H	23.67	1.76
L3 H	23.80	1.76
L4 H	23.15	1.92
L5 H	22.71	2.34
L1 T	31.55	4.50
L2 T	34.49	4.62
L3 T	37.33	5.25
L4 T	39.56	5.79
L5 T	44.13	7.92

Discussion:

The study shows various morphometric characteristics of lumbar vertebra, disc and canal from CT images of the lumbar spine in Nepalese population. The anterior-posterior diameter of the vertebral body, when measured in the CT scan, varied from 25.97 mm at L1 to 29.39 mm

at L5. There was gradual increase in the AP diameter from L 1 to L5. The transverse diameter of the body in the specimen ranged from 31.55 mm at L 1 to 44.13mm at L5. There was a gradual increase in the transverse diameter from L1 to L5. There were changes in height of body. First from L1 - L3 there was increase in height and from L4-L5 there was decrease in height with least height at L5 (22.71mm). There was a gradual increase in antero-posterior, transverse diameter and height of lumbar disc from L1-L5 in Nepalese populations. A study conducted by Jitendra Gupta et al in 210 male and female cadaveric bone showed similar gradual increase in antero-posterior and transverse diameter of lumbar vertebra from L1 to L5.¹

Table 2: Dimensions of Lumbar Disc

Dimensions	Mean(mm)	SD
L1/L2 Disc AP	29.45	2.90
L2/L3 Disc AP	31.16	3.06
L3/L4 Disc AP	31.86	2.77
L4/L5 Disc AP	32.44	3.03
L1/L2 Disc H	6.96	1.44
L2/L3 Disc H	8.37	1.89
L3/L4 Disc H	9.42	1.62
L4/L5 Disc H	10.03	2.06
L1/L2 Disc T	40.86	4.02
L2/L3 Disc T	44.64	4.19
L3/L4 Disc T	46.18	4.66
L4/L5 Disc T	48.09	4.71

According to our study the L1 vertebra has narrowest transverse diameter of spinal canal(21.25mm) whereas L4 has narrowest antero-posterior diameter of spinal canal(12.37mm). A study conducted by Zhou SH et al also showed spinal canal of L4 vertebra is narrowest (23.6 ± 2.9 mm).²

The antero-posterior diameter of lumbar vertebrae in Nepalese males varied from 27.00mm at L1 to 30.22mm at L4 whereas it was 29.99mm at L5. The height of lumbar vertebral body varied from 23.95mm at L1 to 24.21mm at L3, there was gradual decrease in height from L4 to L5. The transverse diameter of lumbar

vertebra in Nepalese male ranged from 41.95mm at L1 to 46.27mm at L5. The antero-posterior diameter of lumbar vertebrae in Nepalese females varied from 25.02mm at L1 to 28.91mm at L4 whereas it was 29.99 mm at L5. The height of lumbar vertebral body varied from 22.19mm at L1 to 23.42mm at L3, there was gradual decrease in height from L4 to L5. The transverse diameter of lumbar vertebra in Nepalese female ranged from 30.90mm at L1 to 42.15mm at L5. It showed both male and female followed same pattern of changes in lumbar vertebra dimension and Nepalese female has smaller dimension of vertebra compared to male. A cross-sectional study conducted by Muhammad M Alam et al also showed female has a smaller dimensions of lumbar vertebra compared to male in all aspect.³

Table 3: Dimensions of Lumbar Canal

Dimensions	Mean(in mm)	SD
L1 Canal AP	14.05	2.26
L2 Canal AP	13.06	2.33
L3 Canal AP	12.53	1.96
L4 Canal AP	12.37	2.03
L5 Canal AP	13.13	3.14
L1 Canal T	21.25	1.82
L2 Canal T	21.58	1.82
L3 Canal T	21.91	1.84
L4 Canal T	22.67	2.23
L5 Canal T	25.34	3.49

The antero-posterior diameter of lumbar vertebrae in Aryans varied from 26.10mm at L1 to 29.68mm at L5, gradual increase from L1 to L5 whereas in Mongolians there was gradual increase from L1(25.78mm) to L5(29.49mm) but sudden decrease at L5(28.96mm). The height of lumbar vertebrae in Aryans increased from L1(23.16mm) to L3(23.96mm) then decreased from L4(23.38mm) to L5(22.87mm). Similar pattern of increase in height from L1-L3(22.86mm-23.57mm) followed by decrease in height from L4-L5 was seen in Mongolian. There was gradual increase in transverse diameter of lumbar vertebrae in Aryans varying from

30.61mm at L1 to 43.42mm at L5. The transverse diameter also increased from L1(32.96mm) to L5(45.19mm) in Mongolians but the diameter was found to be more at each vertebral in Mongolians compared to Aryans.

Table 4: Dimensions in Males and Females in mm

Dimensions	Male(mean)	Female(mean)
L1 AP(Ant-Post)	27.00	25.02
L1 Height(H)	23.95	22.19
L1 Transverse(T)	32.25	30.90
L2 AP	28.05	26.25
L2 H	24.06	23.32
L2 T	35.75	33.33
L3 AP	29.22	27.98
L3 H	24.21	23.42
L3 T	39.02	35.76
L4 AP	30.22	28.91
L4 H	23.55	22.77
L4 T	40.93	38.29
L5 AP	29.99	28.84
L5 H	23.39	22.09
L5 T	46.27	42.15

Conclusions:

In the lumbar area, detailed anatomical knowledge is critical for performing a safe operation. These findings give guidance to the surgeons during various approach while performing operative procedure like pedicle screws, vertebral body screws, cages and laminar hooks.

Table 05: Dimensions in Aryans and Mongolians

Dimensions	Aryans(mm)	Mongolian(mm)
L1 AP(Ant-Post)	26.10	25.78
L1 Height(H)	23.16	22.86
L1 Transverse(T)	30.61	32.96
L2 AP	27.02	27.26
L2 H	23.92	23.31
L2 T	34.27	34.83
L3 AP	28.56	28.60
L3 H	23.96	23.57
L3 T	36.99	37.83
L4 AP	29.57	29.49
L4 H	23.38	22.79
L4 T	39.15	40.18
L5 AP	29.68	28.96
L5 H	22.87	22.48
L5 T	43.42	45.19

References:

- Gupta J, Patil M, Chourishi A, Medical RDG. A Study of Metric Measurement of Lumbar Vertebrae in the Population of. *Int J Bioassays*. 2012;(1952):128-130. Available from: <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.924.5066&rep=rep1&type=pdf>.
- Zhou SH, McCarthy ID, McGregor AH, Coombs RRH, Hughes SPF. Geometrical dimensions, of the lumbar vertebrae - Analysis of data from digitized CT images. *Eur Spine J*. 2000;9(3):242-248. <https://doi.org/10.1007/s005860000140>
- Alam MM, Waqas M, Shallwani H, Javed G. Lumbar Morphometry: A Study of Lumbar Vertebrae from a Pakistani Population Using Computed Tomography Scans. *Asian Spine J*. 2014;8(4):421-6. <https://doi.org/10.4184/asj.2014.8.4.421>
- Olsewski JM, Simmons EH, Kallen FC, Mendel FC, Severin CM, Berens DL. Morphometry of the lumbar spine: anatomical perspectives related to transp-dicular fixation. *J Bone Joint Surg Am* 1990;72:541-9. <https://doi.org/10.2106/00004623-199072040-00011>
- Acharya S, Dorje T, Srivastava A. Lower dorsal and lumbar pedicle morphometry in Indian population: a study of four hundred fifty vertebrae. *Spine (Phila Pa 1976)* 2010;35:E378-84. <https://doi.org/10.1097/BRS.0b013e3181cb7f2b>
- Orha AT, Dalcik C, Ilbay K. Evaluation of anthropometric characteristics due to sex and age variables of lumbar vertebra and spinal canal. *Anthropologist*. 2016;24(2):617-622. <https://doi.org/10.1080/09720073.2016.11892056>
- Bernhardt M, Swartz DE, Clothiaux PL, Crowell RR, White AA 3rd. Posterolateral lumbar and lumbosa-cral fusion with and without pedicle screw internal fixation. *Clin Orthop Relat Res* 1992;(284):109-15. <https://doi.org/10.1097/00003086-199211000-00014>

8. Berry JL, Moran JM, Berg WS, Steffee AD. A morphometric study of human lumbar and selected thoracic vertebrae. *Spine (Phila Pa 1976)* 1987;12:362-7. <https://doi.org/10.1097/00007632-198705000-00010>
9. Misenhimer GR, Peek RD, Wiltse LL, Rothman SL, Widell EH Jr. Anatomic analysis of pedicle cortical and cancellous diameter as related to screw size. *Spine (Phila Pa 1976)* 1989;14:367-72. <https://doi.org/10.1097/00007632-198904000-00004>
10. Saillant G. Anatomical study of the vertebral pedicles. Surgical application. *Rev Chir Orthop Reparatrice Appar Mot* 1976;62:151-60.
11. Bernard TN Jr, Seibert CE. Pedicle diameter determined by computed tomography. Its relevance to pedicle screw fixation in the lumbar spine. *Spine (Phila Pa 1976)* 1992;17(6 Suppl):S160-3. <https://doi.org/10.1097/00007632-199206001-00017>
12. Zindrick MR, Wiltse LL, Doornik A, et al. Analysis of the morphometric characteristics of the thoracic and lumbar pedicles. *Spine (Phila Pa 1976)* 1987;12:160- 6. <https://doi.org/10.1097/00007632-198703000-00012>
13. Khatiwada S, Sudhin BN, Pandey N, Shrestha I, Dhungel D. Morphometric study of lumbar vertebral pedicles. *Journal of Chitwan Medical College*.2021;11(35):46-51. <https://doi.org/10.54530/jcmc.315>
14. Marasini RP, Gautam P, Sherchan B, et al. A morphometric study of lumbar spine pedicles in Nepalese population. *JCMS Nepal* 2014;10(4):12-7. <https://doi.org/10.3126/jcmsn.v10i4.12972>
15. Mansur DI, Shrestha P, Maskey S, Sharma K, Karki S, Kisiju T. Morphometric Study of Lumbar Intervertebral Spaces (discs) by Using MRI. *Journal of Lumbini Medical College*. 2020;8(1): 10-6. DOI: <https://doi.org/10.22502/jlmc.v8i1.320>