Journal of the Anatomical Society of India 65 (2016) 33–37

Contents lists available at ScienceDirect

Journal of the Anatomical Society of India

journal homepage: www.elsevier.com/locate/jasi

Original Article

Lumbar spinal stenosis and morphometry of lumbar vertebral canal

V. Singh [a], R. Sethi [a,*], B.K.S. Chauhan [b], B.B. Thukral [c]

[a] Department of Anatomy, Santosh Medical College, Santosh University, Ghaziabad, NCR Delhi, India
[b] Department of Radiology, Santosh Medical College, Santosh University, Ghaziabad, NCR Delhi, India
[c] Department of Radiodiagnosis & Imaging, Safdarjung Hospital & VMMC, New Delhi, India

ARTICLE INFO

Article history:
Received 25 July 2016
Accepted 29 July 2016
Available online 10 August 2016

Keywords:
Morphometry
Lumbar canal
Lumbar steonsis
Low back pain
Prevalence

ABSTRACT

Introduction: Lumbar spinal stenosis (LSS) is a progressive degenerative process manifesting as low back pain. Though the causes for pain in lower lumbar region are multi-factorial, narrowing of vertebral canal has been documented to play a pivotal role. Hence, the objective of present study was to define the morphometry of lumbar canal by measuring the antero-posterior (AP) and transverse (TD) diameters and assess the prevalence of LSS in Indian population.
Materials and methods: An assessment by CT scan was done on 100 subjects within age range of 20–70 years after grouping them into healthy and symptomatic subjects based on a pre-defined questionnaire. The diameters were defined and compared amongst healthy and symptomatic subjects. The data was used to define prevalence of LSS in the population of Delhi-NCR.
Results: The antero-posterior diameter was smaller in females as compared to males while transverse diameter was smaller in males as compared to females. In both the study groups, the diameters were comparable and statistically significant. The prevalence of LSS was maximum in middle age group individuals with L5 vertebral level showing highest frequency of a narrow canal. LSS was seen in higher frequency in females than males.
Discussion: An early diagnosis and proper treatment of LSS may prevent intractable pain with its inherent neurogenic sequelae. All pain-physicians, neurologists, and neurosurgeons should be aware of antero-posterior and transverse diameters of canal for better prognosis.

1. Introduction

Lumbar spinal stenosis (LSS) is defined as anatomical narrowing of lumbar vertebral canal. There occurs compression of cauda equina and emerging nerve roots, manifesting as low back pain (LBP).[1–3] Stenosis of lumbar canal is a potentially disabling cause of lower back pain. Though treatable this condition is often a major cause of inactivity, loss of productivity and potential loss of independence of individual, especially older age groups. There occurs focal, segmental or diffuse narrowing of the central canal or the root canals by bony and/or soft tissue encroachments on the neural components eliciting as Central or Lateral stenosis, respectively.[4]

Central stenosis is the most common form of LSS which occurs at the disc level when the central spinal canal is narrowed secondarily to osseous and/or ligamentous thickening following degenerative changes.[5,6] Various earlier morphometric studies have demonstrated that this abnormality may involve the transverse, sagittal, or both the diameters of the canal.[7–9] Central spinal stenosis commonly affects middle and elderly age groups and has been shown to be the most common indicator for spinal surgery, especially in individuals over 65 years of age. Epidemiological data suggest an incidence of 5 cases per 100,000 for lumbar spine stenosis with an ever-increasing prevalence.[10] It has been predicted that over 64 million adults will be affected by this disabling condition over the next decade.[11–13]

The diagnosis of LSS depends largely on clinical history, physical examination supplemented by various imaging modalities. The lower lumbar levels are the most commonly involved segments and use of modern neuroimaging techniques have facilitated the diagnosis in recent years. Computed tomography (CT) scans provide excellent visualization of bony vertebral canal (Fig. 1) and hence, measurements of canal diameters can be made with improved accuracy and resolution compared to other imaging techniques.[14,15] The vertebral canal diameters are assumed to play a significant role with regard to development of symptoms of LBP.

* Corresponding author.
E-mail address: ruchirasethi@gmail.com (R. Sethi).

http://dx.doi.org/10.1016/j.jasi.2016.07.008
0003-2778/

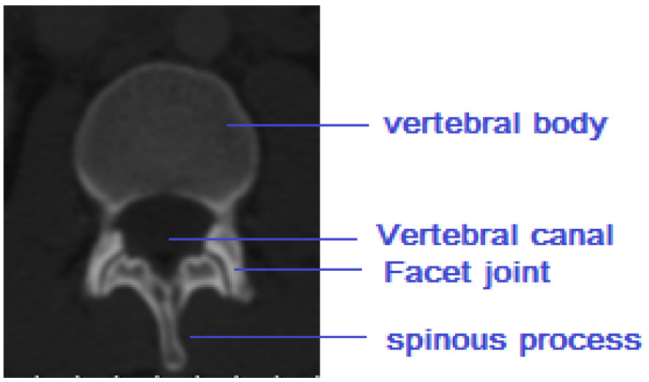

Fig. 1. Vertebral canal in CT reconstruction.

The aim of the present study thus is to test the hypothesis that decrease in vertebral canal diameters are significant risk factor for producing LBP, by comparing the diameters in symptomatic and asymptomatic individuals. The data was further utilized to assess the prevalence of LSS in individuals of Delhi NCR region and evaluate its distribution with respect to age and sex of an individual.

2. Materials and method

The present study was conducted in the department of Radiology of Santosh Medical College, Ghaziabad in collaboration with Safdarjung Hospital, New Delhi. The subjects were selected by structured performa for epidemiological details and further a pre-defined questionnaire was given to categorize into asymptomatic and symptomatic groups.[16,17] The subjects were explained the investigations involved and a written informed consent was taken. The complete project was approved by the Ethical Committee of the Institute.

Study groups: a total of two study groups with age ranging from 20 years to 70 years (mean age 43.88 ± 14.071) were formed as per the result of the questionnaire. The symptomatic groups consisted of 50 individuals of either sex (male = 23 and female = 27). The asymptomatic group included 50 individuals with 26 males and 24 females.

Exclusion criteria: (1) lumbar vertebrae fracture, (2) gross vertebral anomalies, (3) spinal tumors, (4) history of previous spinal surgery, (5) gross spinal pathology, and (6) contraindication for CT scanning.

Methodology: all subjects underwent CT scan of the lumbar spine with Philips Brilliance 40 CT scanner (MAS/MA-250/337, KV 120) with 2.5 mm image slice. Dimensions of lumbar canal at all vertebral levels from L1 to L5 of all 100 subjects were measured. Bone window with multi-planar reconstruction was used to obtain images in both axial and sagittal planes and these images were utilized to assess the diameters. The images were read on Philips dicom viewer and antero-posterior (AP) and transverse (TD) diameters for both the groups were measured. The AP diameter (sagittal diameter) was measured at the mid sagittal level as the distance between posterior border of the vertebra and the lamina posteriorly in the midline.[17] The transverse or inter-pedicular distance was measured at the mid pedicular level as the distance between inner borders of both the pedicles of vertebral body[18–20] (Fig. 2).

Statistical analysis: it was performed using SPSS version 19 and mean, standard deviation (SD), and standard error of mean (SEM) were computed for both the diameters. Student *t*-test was performed to find the statistical difference between two groups. A p value < 0.05 is considered to be significant. The prevalence of symptomatic LSS was assessed at 95% confidence interval and distribution with respect to age and gender was computed.

3. Results

The demographic profile of the two study groups is shown in Table 1.

3.1. Antero-posterior diameter

The result of antero-posterior diameter at all vertebral level in both normal and symptomatic groups is shown in Table 2.

In normal group, the mean of mid sagittal diameter showed a sharp decrease from fifth lumbar vertebrae to first lumbar vertebrae. In male subjects, there occurred a sharp decrease in diameter from L5 towards L3 vertebral level followed by gradual fall till first lumbar vertebrae. While in females the mean diametric values show an irregular pattern with lowest diameter being at L3 vertebral level (Fig. 3). The AP diameter at all vertebral levels was smaller in females than males.

On the other hand, in symptomatic group there was a decrease in diameter from first towards fifth lumbar vertebrae. On measuring the diameters separately for both the genders, there occurred a spike of increased diameter from the proximal to third vertebral level. The caudal end of the vertebral canal (L4 and L5) showed the narrowest diameters. There was a statistically significant difference in AP diameter at all except first lumbar vertebrae in both normal and symptomatic groups.

3.2. Transverse diameter

The result of transverse diameter in both normal and symptomatic group is shown in Table 3.

In normal group the mean diameter increased gradually from first to fifth lumbar vertebrae. Males followed the pattern as of the whole group while in females the greatest diameter was seen at L4

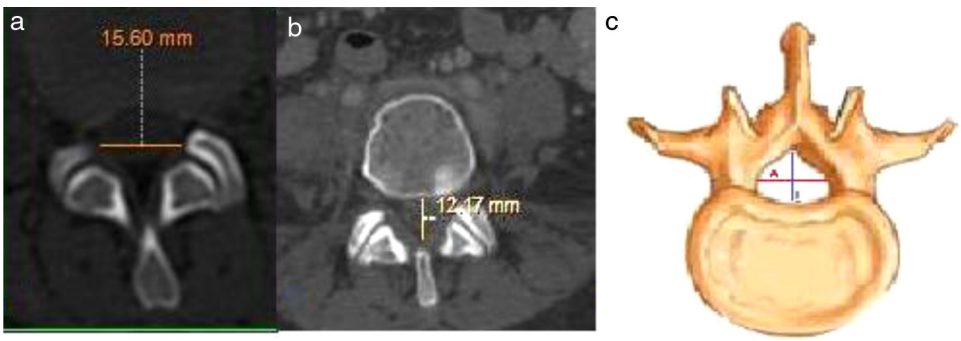

Fig. 2. Methods to measure transverse (A) and antero-posterior, (B) diameter in CT images and bone image, (C) defining both the diameters.

Table 1
Demographic profile of study groups.

Group	Gender	Number	Mean age (in yrs)	SD	Min (in yrs)	Max (in yrs)
Normal	Male	26	45.00	15.08	22	70
	Female	24	44.21	13.93	25	69
Symptomatic	Male	23	41.92	13.21	22	68
	Female	27	44.19	14.45	20	70

SD, standard deviation.

Table 2
AP diameter in study groups.

Vertebral level	Normal group			Symptomatic group			*P*-value
	Mean	SD	SEM	Mean	SD	SEM	
L5	14.86	3.59	0.51	8.99	2.81	0.39	0.00001* S
L4	14.54	2.79	0.39	9.65	2.66	0.38	0.00001* S
L3	14.08	2.34	0.33	10.09	2.44	0.34	0.00001* S
L2	14.11	2.05	0.29	11.3	2.61	0.37	0.00001* S
L1	14	2.02	0.28	14.25	16.2	2.29	0.915 NS

SD, standard deviation; SEM, standard error of mean; *S, significant; NS, non significant.

Table 3
Transverse diameter in study groups.

Vertebral level	Normal group			Symptomatic group			*P*-value
	Mean	SD	SEM	Mean	SD	SEM	
L5	29.25	5.04	0.71	18.79	7.99	1.13	0.00001* S
L4	29.21	5.72	0.81	19.96	16.24	2.29	0.00025* S
L3	28.09	5.58	0.79	17.92	6.39	0.9	0.00001* S
L2	27.57	27.57	0.78	18.42	5.71	0.81	0.00001* S
L1	27.25	27.25	0.81	18.77	5.07	0.72	0.00001* S

SD, standard deviation; SEM, standard error of mean; *S, significant.

vertebral level, with smallest diameter at L5 vertebral level. The diameters were smaller in males than in females. On the other hand, in symptomatic group the smallest diameter was seen at third vertebral level in the whole group but when mean diameter was seen for each gender, though the smallest diameter was seen at L3 vertebral level, there occurred a spike at L4 vertebral level in males. The values were almost coinciding at third vertebral level for both the genders (Fig. 4). The results were statistically significant at all vertebral levels between normal and symptomatic groups.

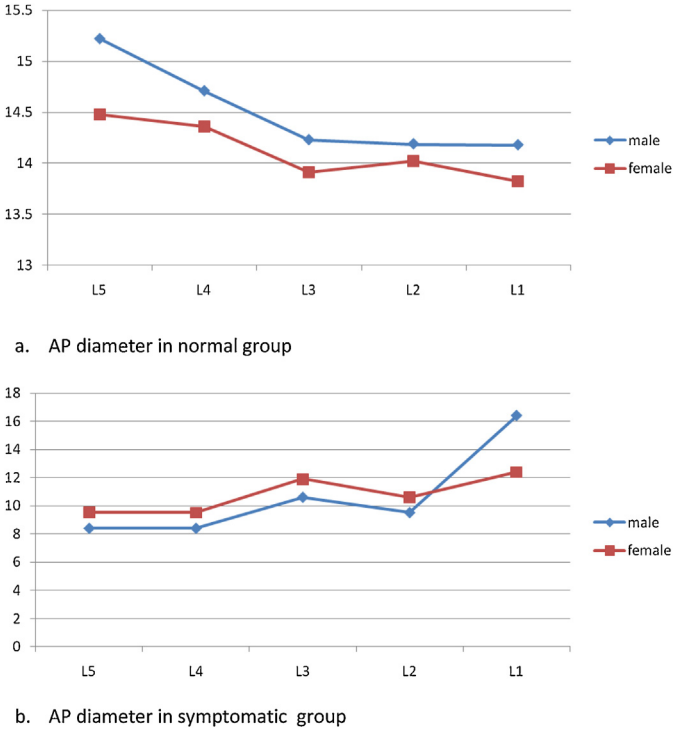

Fig. 3. AP diameter in normal (a) and symptomatic (b) groups for males and females.

3.3. Prevalence of LSS

Out of both AP and TD diameter, AP diameter being the smaller diameter is considered as more diagnostic for LSS. The vertebral column with two or more than two vertebral levels with AP diameter less than 10 mm were categorized as stenotic spines and out of total 50 symptomatic individuals 42 vertebral columns were stenosed. The prevalence of stenosis at different vertebral level in both the genders is shown in Fig. 5. Stenosis was more prevalent in females than males. Fifth lumbar level depicts the highest prevalence of stenosis followed by L4 and L3 vertebral level consequently.

The stenotic spines were distributed as per the age groups and stenosis was maximum within 30–49 years age group (Table 4).

4. Discussion

An early and proper treatment of LSS may prevent intractable pain with its inherent neurogenic sequelae. The non-invasive imaging modalities play a key role in defining and determining LSS. In the present study CT scan images were read for morphometric parameters of osseous lumbar vertebral canal.

4.1. Canal diameters

Eisenstein in his study on CT scans of lumbar spine has observed that normal canal diameter is always more than 12 mm and a diameter less than 10 mm suggests absolute stenosis.[9] The results

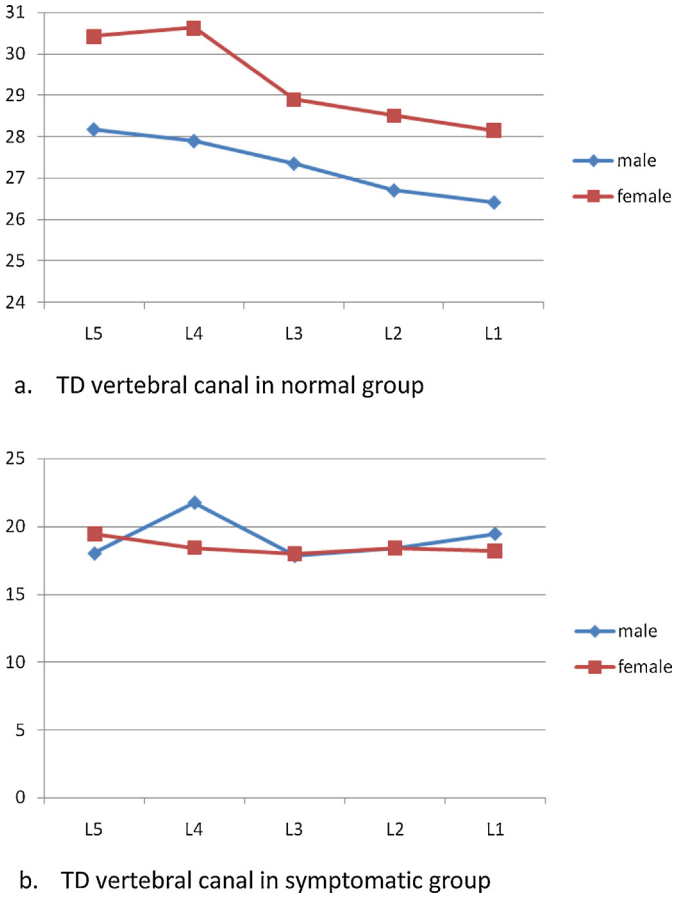

Fig. 4. Transverse diameter in normal (a) and symptomatic (b) group for males and females.

of present study are consistent with Eisenstein as lumbar vertebral canal with diameter more than 12 mm were asymptomatic and only those cases where diameter was less than 10 mm presented with symptoms of LBP, a manifestation of LSS.

In healthy individuals, the AP and transverse diameters were greatest caudally. The larger size of the canal at this level ensures protection of the contents during complex movements at this transitional region of mobile lumbar and immobile sacrum apart from accommodating the sacral nerve roots.[21] The AP diameter was smaller in females as compared to males, a result consistent with that of study of Alam et al. on Pakistani population.[22] The increase in transverse diameter caudally may occur due to increase load bearing by lower vertebrae.

In symptomatic subjects there occurred decrease in diameter caudally. The results of the present study can successfully be

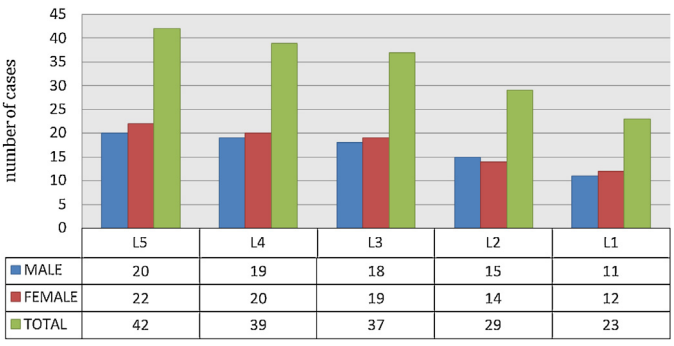

Fig. 5. Prevalence of LSS at different vertebral levels.

Table 4
Prevalence of LSS as per age groups.

Age groups	Frequency	Prev %
20–29	8	19.1
30–39	12	28.5
40–49	9	21.4
50–59	6	14.3
60–70	7	16.7

compared with the results of myelographic measurements of lumbar spinal canal by Robertson et al., in which a constant narrowing of the lumbar spinal canal from above downwards was observed.[23] Moreover, computerized tomographic study by Postacchini et al. also indicated a gradual narrowing of the lumbar spinal canal from L1 to L5.[24]

4.2. LSS prevalence

Out of 50 symptomatic cases 42 (84%) were found to have narrowed vertebral canal where as 8 cases were having normal vertebral diameters at four or more than four vertebral levels. The result of highest prevalence of stenosis at L5 vertebral level is similar to MRI study on Indian population of Ahmad et al.[25] The stenosis was more prevalent in females at all vertebral levels suggesting effect of estrogen hormone on degeneration process of the spine. Also the values of AP diameter are already less as compared to males thus even a small change in diameter will produce clinically obvious symptoms. In various earlier studies it has been observed that mid sagittal diameters are smaller in females as compared to males predicting higher incidence of stenosis, a result consistent with that of present study.[18–21]

5. Conclusion

In the present study, it is found that both antero-posterior and transverse diameters of the spinal canal are larger in asymptomatic subjects than in patients presenting with LBP. This suggests that the narrowing of spinal canal makes an individual susceptible to cord compression and further development of neurogenic signs and symptoms. The prevalence of stenosis was more in caudal region and in females. Therefore, it is deduced that weight bearing and hormonal factors play a key role in developing spinal canal stenosis. Thus, early diagnosis and precautions can alleviate sufferings of the patients.

Conflicts of interest

The authors have none to declare.

Acknowledgement

This is a part of Ph.D thesis work of R Sethi under the guidance of Dr V.Singh, Dr BKS Chauhan and Dr BB Thukral.

References

1. Singh K, Samartiz D, Vaccaro AR, et al. Congenital lumbar spinal stenosis: a prospective, control matched, cohort radiographic analysis. *Spine J.* 2005;5(6):615–622.
2. Venner RM, Crock HV. Clinical studies of isolated disc resorption in the lumbar spine. *J Bone Jt Surg Br.* 1988;63B:491–494.
3. Verbiest H. A radicular syndrome from developmental narrowing of the lumbar vertebral canal. *J Bone Jt Surg.* 1954;36:230–237.
4. Fortin JD, Wheeler MT. Imaging in lumbar spinal stenosis. *Pain Physician.* 2004;7:133–139.

5. Botwin KP, Gruber RD. Lumbar spinal stenosis: anatomy and pathogenesis. *Phys Med Rehabil Clin N Am.* 2003;14:1–15.
6. Jarvik JG, Hollingworth W, Heagerty PJ, et al. Three year incidence of low back pain in an initially asymptomatic cohort: clinical and imaging risk factors. *Spine.* 2005;30:1541–1548.
7. Epstien NE, Maldonado VC, Cusick JF. Symptomatic lumbar spinal stenosis. *Surg Neurol.* 1998;50(July (1)):3–10.
8. Hinck VC, Clark WM, Hopkins CE. Normal interpeiculate distances (minimum and maximum) in children and adults. *Am J Roentgenol.* 1966;97:141–153.
9. Eisenstien S. The trefoil configuration of the lumbar vertebral canal: a study of South African skeletal material. *J Bone Jt Surg Br.* 1980;62-B(February (1)): 73–77.
10. Melancia JL, Fernandes A, Antunes JL. Handbook of clinical neurology. *Spinal Stenosis Neurological Aspects of Symptomatic Disease Part I.* vol. 119. Elsevier; 2014: 541–549(chapter 35).
11. Bae HW, Rajaee SS, Kanin LE. Nationwide trends in surgical management of lumbar spinal stenosis. *Spine.* 2013;38:916–926.
12. Deyo RA. Treatment of lumbar spinal stenosis: a balancing act. *Spine J.* 2010; 10:625–627.
13. Katz JN, Harris MB. Clinical practice Lumbar spinal stenosis. *N Engl J Med.* 2008; 358:818–825.
14. Alvarez JA, Hardy RH. Lumbar spine stenosis: a common cause of back and leg pain. *Am Fam Physician.* 1998;57(8):1825–1834.
15. Singh V, Sethi R. Lumbago and associated morbid anatomy of lumbar spinal canal and facet joints. *J Anat Soc India.* 2014;63:77–84.
16. Davidson M, Keating J. A comparison of five low back pain disability questionnaires: reliability and responsiveness. *Phys Ther.* 2002;82:8–24.
17. Fritz JM, Irrgang JJ. A comparison of a modified Oswestry low back pain disability questionnaire and the Quebec back pain disability scale. *Phys Ther.* 2001;81:776–788.
18. Schonstrom NS, Bolender NF, Spengler DM. The pathomorphology of spinal stenosis as seen on CT scans of the lumbar spine. *Spine (Phila Pa 1976).* 1985;10(November (9)):806–811.
19. Hamanishi C, Matukara N, Fujita M, et al. Cross sectional area of the stenotic lumbar dural tube measured from transverse views of MRI. *J Spinal Discord.* 1994;7:388–393.
20. El-Rakhawy M, El Shahat R, Labib I, et al. Lumbar vertebral canal stenosis: concept of morphometric and radiometric study of the human lumbar vertebral canal. *Int J Exp Clin Anat.* 2010;4:51–62.
21. Amonoo-Kuofi HS. Maximum and minimum lumbar interpedicular distances in adult Nigerians. *J Anat.* 1982;135:225–233.
22. Alam MM, Waqas M, Shallwani H, Javed G. Lumbar morphometry: a study of lumbar vertebra from a Pakistani population using CT scans. *Asian Spine J.* 2014;8(August (4)):421–426.
23. Roberson GH, Liewellyin HJ, Taveras JM. The narrow lumbar spinal canal syndrome. *Radiology.* 1973;107(1):89–97.
24. Postacdiini F, Pezzeri G, Montanaro A, Natali CI. Computerised tomography in lumbar stenosis. *J Bone Jt Surg.* 1980. 62Bf78.
25. Ahmad T, Goel P, Ramesh Babu CS. A study of lumbar canal by M.R.I. in clinically symptomatic and asymptomatic subjects. *J Anat Soc India.* 2011;60(2):184–187.