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Research Article

MRI Study of Midsagittal Diameter of Lumbar Canal in North Indian Population and Its Correlation with Gender

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ABSTRACT

Background: Low backache and nerve root compression are the commonest cause of occupational and domestic disability in industrialized societies. It is a common cause of morbidity, disability and loss of productivity in elderly population as well as in young due to the changes in lifestyle. The knowledge of anatomical variations in lumbar spine might help in understanding the etiology as well as pathology of low back pain It is well established that the morphometric data varies within different sex, race and regions. The clinical significance of these variations and differences in morphometric assessment of lumbar spine has been reported in the past from several countries.

Aim: To study the normal midsagittal diameter of lumbar canal by magnetic resonance imaging in North Indian population and its correlation with gender.

Materials & methods: Study was carried out in the Department of Anatomy in collaboration with Department of Radio diagnosis Era's Lucknow Medical College & Hospital, Lucknow. 130 Subjects in the age group of 20-70 yrs who underwent MRI of lumbar spine.

Results: MRI lumbar spine revealed the antero-posterior/midsagittal diameter of canal was comparatively smaller in the North Indian population. The canal was narrowest at L4-L5 (0.95cm) and widest at L1-L2 (2.19cm). In both males and females, the antero-posterior diameter of canal was widest at L1-L2 level 2.19cm and 2.01 cm respectively. The anteroposterior diameter of the spinal canal showed a gradual decrease from L1 to L5, with males consistently showing larger diameters than females.

Conclusion: The knowledge of anatomical variations in lumbar spine might help in understanding the etiology as well as pathology of low back pain. The dimensions of the lumbar canal that were collected could be used as a baseline point for evaluation of patients presenting with low back pain and potential spinal canal stenosis. Also, the findings from the study could be used in the evaluation of patients with spinal stenosis. Therefore, it is necessary to continue research in the context of the clinical applicability of the described parameters in the process of evaluation and eventual prediction of the operative outcome.

Keywords: *Lumbar spine, Magnetic resonance imaging, Midsagittal diameter*

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INTRODUCTION

The advent of modern era of medicine has blessed the humans with an increase in life expectancy and healthy life style. Backache is an extremely common human phenomenon; a price mankind had to pay for the upright posture. Back pain is one of the leading causes of disability in the world. Between the period from 1990-2017 life with disability (YLDs) increased from 42.5 to 64.9 million, respectively (1,2). The highest prevalence of this entity was noted in the low-income and middle- income countries (2). Back pain has become a growing burden for healthcare system, and it is one of the main reasons for absence from work population (2,3). It is a common medical condition, frequently occurring with non-specific signs and symptoms (4,5) The knowledge of anatomical variations in lumbar spine might help in understanding the etiology as well as pathology of low back pain. It is well established that the morphometric data varies within different sex, race and regions. The clinical significance of these variations and differences in morphometric assessment of lumbar spine has been reported in the past from several countries. Pathological changes can occur in the diameters of lumbar spinal canal. Therefore assessing the canal size is an important diagnostic procedure. In clinical situations, variations in lumbar spine anatomy are helpful in understanding the pathologies leading to one of most common clinical situations associated with lumbar spine, i.e. low back pain. The patterns of behavior of the normal back and the nature of events and incidents which lead to derangement have intrigued the practitioner since primitive times. Vertebral canal is roughly triangular in shape. It is narrowest in anteroposterior (AP) diameter in axial plane. It is bounded anteriorly by posterior edge of vertebral bodies and posterior longitudinal ligament, laterally

by pedicles and postero-laterally by facet joints and articular capsules. Average AP diameter of lumbar canal in adults as determined by Anatomic and radiographic studies ranges between 15-23mm (Weinstein PR, 1993) 3. Vertebral canal stenosis is an important structural change with significant radiological and clinical implications and has attracted the attention of anatomists and clinicians. Many cases of spinal canal stenosis are related to the anatomical variants with varying degrees of reduction of spinal canal

diameters. (Eisenstein, 1977) 4 . From a radiological perspective emphasizing the underlying structural anomaly, stenosis of spinal canal with or without clinical manifestations is a more appropriate definition for spinal canal stenosis (Herkowitz et al.,2011) 5

Aim & objectives

The study was carried out with an aim to study the normal midsagittal diameter of lumbar spine by magnetic resonance imaging in North Indian population.

Materials & methods

Study was carried out in Department of Anatomy in collaboration with Department of Radio diagnosis Era's Lucknow Medical College & Hospital, Lucknow. 130 Subjects in the age group of 20-70 yrs who underwent MRI of lumbar spine were included.

Inclusion Criteria-

All subjects referred to Department of Radio diagnosis for MRI scan of dorsal and lumbo-sacral spine or MRI for Abdomino-pelvic pathology not affecting the anatomy of the region of study.

Exclusion Criteria-

Subjects less than 20 yrs age, Subjects having history of spine surgery, with pacemaker and cochlear implant,Trauma, Cyst or Neoplasm affecting the lumbosacral spine,Subjects with deformity and/or degenerative spinal disease of vertebral column and Disc replacement

Methodology

MRI was done using Hitachi Aperto 0.4 Tesla Magnetic resonance Imaging Machine.

Subjects were prepared and MRI was carried out in supine position, verbal commands were given through a speaker as and when necessary during scanning. Anatomic thin slices of T1 weighted (Axial, Sagittal), T2 weighted (Axial, Sagittal) sequences were taken. Imaging protocol included sagittal T1 weighted spin echo sequences with repetition time (TR) 530 m/secs and echo time (TE) 14m/secs were used. T2 weighted fast spin echo sequences with TR 3000m/secs and TE 120m/secs in sagittal and TR 3000m/secs and TE 90m/secs in axial view was used. Images were taken using 4.5 mm slice thickness with 5mm interval and 350 cm field of view (FOV) in sagittal and 220 cm in axial view. The data obtained from MR images were stored in a computerized system that allowed enhancement, magnification, and rotation and had a measuring tool. Antero-posterior diameter of lumbar canal of 130 subjects were measured.

Measurement of Vertebral canal-

Midsagittal diameter (MSD)/ Anteroposterior diameter (APD) of canal was measured as the Anteroposterior length of spinal canal in cm from posterior edge of intervertebral disc space to most posterior point of bony canal in the axial plane (Manisch N *et al.* 2012).

Figure 1: MRI image of antero-posterior diameter of canal

Results

Dimensions of vertebral canal

Various axial and sagittal MRI slices were selected for the morphometric parameters of lumbar vertebrae and lumbar vertebral canal. The measurement parameters of the vertebrae and canal were studied across different age groups in both male and female subjects, and the findings were accordingly tabulated.

Results

In the present study an attempt has been made to determine the diameters of lumbar canal in North Indian population. For this purpose a total of 130 subjects were enrolled for the study. Table 1 shows the age wise distribution of subjects:

Table 1: Demographic profile of subjects

SN	Variable	Statistic
1.	21-40 Yrs	66 (50.8%)
2.	41-60 Yrs	45 (34.6%)
3.	>60 Yrs	19 (14.6%
Mean Age ±SD (Range) in years		42.22±13.26 (21-76)

Table 2: Gender profile of subjects enrolled in the study:

SN	Variable	Statistic
1.	Male	79 (60.8%)
2.	Female	51 (39.2%)

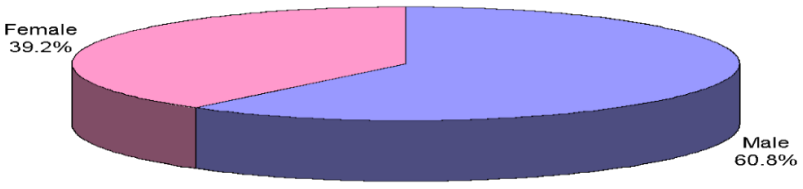

Figure 2: Gender wise distribution of Subjects.

Anteroposterior Diameter (APD) / Midsagittal Diameter (MSD) of Vertebral canal

Table 3: APD/MSD of Canal (in all subjects)

SN	Variable	Range cm		Central Tendency cm		Normative Range (95%CI) cm	
		Min	Max	Mean	SD	Lower	Upper
1.	L1-L2	1.03	2.19	1.37	0.23	1.33	1.41
2.	L2-L3	1.06	1.98	1.36	0.18	1.33	1.39
3.	L3-L4	1.03	1.94	1.37	0.19	1.33	1.40
4.	L4-L5	0.95	1. 97	1.36	0.20	1.33	1.40

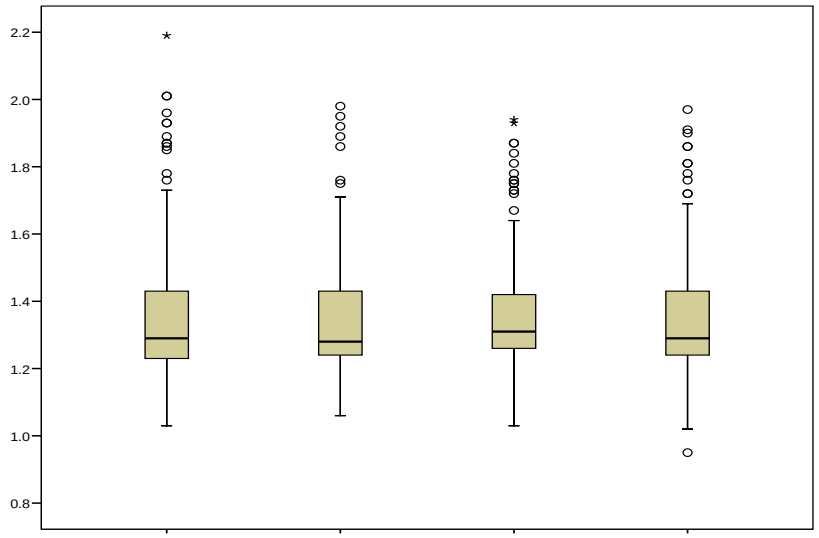

Fig3: **Box plot showing distribution of AP Diameter of Canal.**

Table 4: APD/MSD of Canal (Males) (n=71)

SN	Variable	Range cm		Central Tendency cm		Normative Range (95% CI) cm	
		Min	Max	Mean	SD	Lower	Upper
1.	L1-L2	1.03	2.19	1.38	0.24	1.33	1.43
2.	L2-L3	1.06	1.98	1.37	0.18	1.32	1.41
3.	L3-L4	1.10	1.94	1.37	0.18	1.33	1.41
4.	L4-L5	1.09	1.90	1.36	0.17	1.33	1.40

Fig4: Box plot showing distribution of AP Diameter of Canal in Males.

The APD/MSD of canal in males was found to be ranging from 1.03cm to 2.19 cm. Mean diameters of canal L1-L2, L2-L3, L3-L4 and L4-L5 were 1.38cm ±0.24cm, 1.37cm ±0.18cm, 1.37cm ±0.18cm and 1.36cm ±0.17 cm respectively. There was slight progressive reduction in diameters from L1-L2 to L4-L5. Overlapping trend of the canal was observed and it ranged from 1.32cm to 1.43 cm. The canal was narrowest at L4-L5 (1.36cm)

Table 5: APD/MSD of Canal (Females) (n=59)

SN	Variable	Range cm		Central Tendency cm		Normative Range (95% CI) cm	
		Min	Max	Mean	SD	Lower	Upper
1.	L1-L2	1.04	2.01	1.37	0.23	1.30	1.43
2.	L2-L3	1.09	1.92	1.35	0.17	1.30	1.39
3.	L3-L4	1.03	1.93	1.36	0.20	1.30	1.42
4.	L4-L5	0.95	1.97	1.37	0.24	1.30	1.43

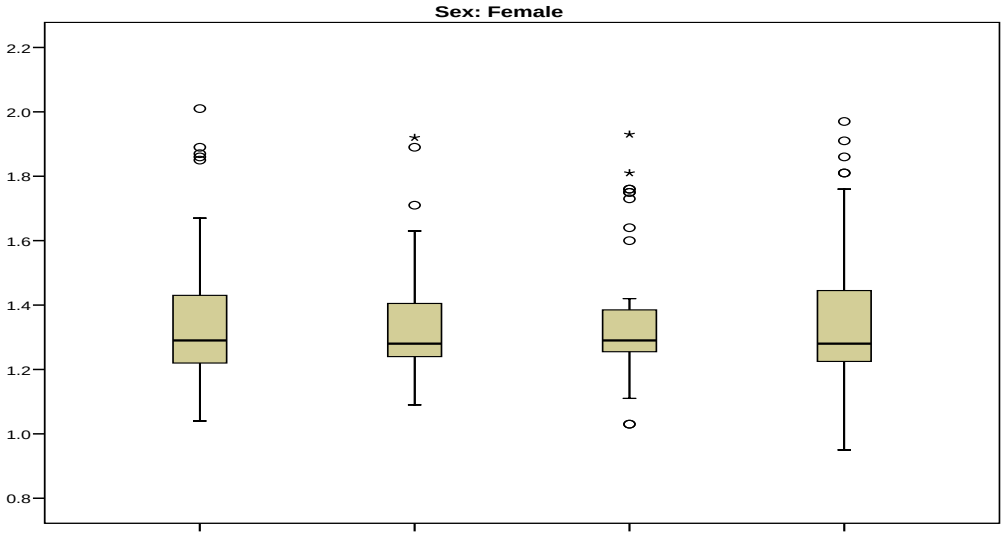

Figure 5: Box plot showing distribution of AP Diameter of Canal in Females.

The minimum and maximum dimension of canal in females from L1-L2 to L4-L5 ranged from 0.95 to 2.01 cm. Mean diameters of canal L1-L2, L2-L3, L3-L4 and L4-L5 were 1.37±0.23, 1.35±0.17, 1.36±0.20 and 1.37±0.24 cm respectively. Overlapping trend was observed in females and normative range of canal ranged from 1.30cm to 1.43 cm. The mean diameters reduced slightly from L1-L2 to L2-L3 and than showed a slight progressive increase. Minimum narrowest dimension was L4-L5 level (0.95cm).

Discussion

Low back pain is neither a disease nor a diagnostic entity. It has a lifetime prevalence from 54% to 80%, an annual prevalence of 15% to 45%, and a point prevalence of 30%. It is the second most common reason for disability among adults in the United States with approximately 150 million work days lost per year (Herkowitz *et al.* 2011). MRI is often used to diagnose the cause of low back pain.Narrowing of bony ring of the canal may lead to compression of the nerve roots causing low back pain (Verbiest, 1954; Sarpeyener,1945;Verbeist,1977). The exact reason why some individuals with this condition have debilitating symptoms while others have no symptoms is not well understood. These differences in presentation may be related to the different abilities of individuals to compensate for the anatomic changes that have occurred (Herkowitz *et al.* 2011).

In different studies performed in several countries, the maximum and minimum ranges of spinal canal diameters have been found different for each population. The persons with lower diameters of spinal canal are predisposed to spinal canal stenosis, which is the major cause of spinal radiculopathies. Determining the normal range of spinal canal diameters can help us in making an initial diagnosis and select predisposed individuals.

Antero-posterior diameter of canal

The midsagittal diameter/anteroposterior diameter of the lumbar spinal canal is the dimension in which the capacity of canal is deficient (Verbeist, 1954, Dommisse, 1975). Less data is available using MRI to quantitate developmental stenosis (Singh *et al.* 2005).

In the present study APD/MSD of vertebral canal was measured at the level of intervertebral disc. The minimum AP diameter of canal was found at L4/L5 (0.95) cm. The largest dimension in the present study was L1/L2 (2.01cm). The mean anteroposterior diameter of canal from L1-L2 to L4-L5 showed values ranging from 1.36cm to 1.37cms. Mean diameters of canals L1-L2, L2-L3, L3-L4 and L4-L5 were 1.37±0.23, 1.36±0.18 and 1.37±0.19 and 1.36±0.20 cm respectively.

Overlapping trend in the normative range of canal was observed and it ranged from 1.33cm to 1.41cms. Akl and Zidan, (1983) did morphologic study of the lumbar spinal canal on postmortal lumbar vertebrae of Egyptians by plain radiograph. In their study the largest midsagittal diameter was L1 and then reduction occurred from L1 to L3 and increased again until L5. The mean diameter in their study ranged from 14.7mm to 16.5mm. Rama Devi and N Rajagopalan, (2003) in their cadaveric study by X ray measured the APD and transverse diameter of canal in 25 cadavers in South Indian community. They reported a gradual decrease in dimension from L1to L5 (L1mean 13.25mm, L5 11.56mm). On comparing their data with the current study the anteroposterior canal dimension is higher. This could due to the difference in the method of study (MRI verses plain radiographs). The difference is also attributed because the current measurements were performed on living humans using MRI whereas they measured the lumbar vertebrae which had undergone postmortal changes. Abbas *et al*. (2010) measured the antero-posterior diameter of canal from L3 to S1 by CT in Israel population. The subjects included in their study were 100 asymptomatic as a control group and 67 subjects who had degenerative lumbar spinal stenosis (DLSS). The mean mid-sagittal diameter recorded in DLSS group was 15.3mm at L3, 15.2mm at L4, 15.2mm at L5, whereas in control group it was 16.1mm at L3, 16.mm at L4, and 17mm at the level of L5. They concluded that in control group AP diameter increased from L3 to L5 whereas in DLSS it remained similar at all levels. This is in contrast with the present study as it showed similar trend at all levels in asymptomatic subjects. The dimensions found in the present study are also narrower than the study done by Abbas *et al.* This difference could be attributed to difference in population.

Tarek Aly *et al*. (2013) measured the midsagittal diameter of canal in 300 subjects by computed tomography in Egyptian population. They reported that the range of midsagittal diameter in their study was 11.07mm to 26.07mm at all levels. The shortest midsagittal diameter in their study was 11.01mm whereas, according to Gilad, (1985) the lower limit of normal is 12mm in contrast to both the abovementioned studies the shortest diameter in our study was 0.95cm which was much lower as compared to previous reported studies.

Deep S Chatha and M.E.Schweitzer, (2011) measured the mid-sagittal diameter of vertebral canal by MRI. They measured the MSD from L1-L2 to L5-S1at intervertebral disc level and from L1 to L5 at the vertebral level. In their study they found that canal at intervertebral disc space was narrowest at L5-S1 (mean 1.16cm) and widest at L1-L2 (1.56cm). This is in agreement with the present study. When the results of our study were compared against the result presented by Deep and coworkers the mean anteroposterior diameter of this study was significantly lower at each spinal level. This could be due to difference in population. As the Deep and Mark study was done in Canadian population.

In the present study the AP diameter of spinal canal was found to be constant from the upper to lower level (L1-L2 to L4-L5), which is in agreement with data of Hinck, and coworkers (1965) who did radiographic study in children and adults. Several researchers have suggested that normal AP diameter of bony canal increases as we descend from L3 to L5 (Larsen JL, 1980; Karantanas *et al.,* 1988; Rauschning W *et al.,* 1983). Uttam Yadav et al did an observational study was on the basis of a review of thin-cut (3 mm) computed tomographic images of lumbar vertebrae. A total of 302 patients were studied, and various dimensions were analyzed. The vertebral and bony spinal canal dimensions were found to be greater in male patients. Comparison of populations revealed statistically significant differences in the spinal canal between an Indian population and others. This is not in agreement with the present study as no significant difference was found in the present study. Khalid et al in their study of 279 patients, 137 (49%) were male and 142 (51%) were female. Different measurements were taken from the CT scan of axial cuts of the lower lumbar canal (L3, L4, and L5). The pattern of segmental variation of the lower lumbar vertebral canal was found to be like other populations. In contrast, the mean lower lumbar vertebral canal diameters were characteristically different from the other population: There were significant differences in the dimensions of the lumbar spine canal between female and male patients.This is inconsistent with the present study as no statistically significant diffence was not found in male and females. Badaam et al measured the anteroposterior diameter of the lumbar vertebral canal by MRI in cases and control. They found the midsagittal diameter was lower in the back ache cases

Belma jackanjac et al did a retrospective study and measured the anteroposterior diameter of the spinal canal. In their study they found it was larger in male than female which does not support the present study.

Conclusion

The antero-posterior/midsagittal diameter of canal was comparitively smaller in the North Indian population. Amongst the 130 subjects studied the canal was narrowest at L4-L5 (0.95cm) and widest at L1-L2 (2.19cm). In both males and females the antero-posterior diameter of canal was widest at L1-L2 level 2.19cm and 2.01 cm respectively. The anteroposterior diameter of the spinal canal showed a gradual decrease from L1 to L5, with males consistently showing larger diameters than females. This comprehensive analysis of lumbar spine morphometry provides valuable data into normal variations and its clinical implications. Sexual dimorphism underscores the importance of gender-specific reference values in clinical practice, contributing to the existing knowledge of lumbar spine anatomy

References

Abbas J, Hamoud K, May H, et al. Degenerative lumbar spinal stenosis and lumbar spine configuration. Eur Spine J. 2010; 19:1865–1873.

Akl M, Zidan A. Morphometry of the lumbar spine and lumbosacral region in Egyptians. Egypt Orthop J. 1983; 18:34-43.

and lumbar vertebrae in normal adults. Br J Radiol.1985;58(695):1031-1034.

Badaam A, Sukre S B, Hashmi S, et al. (December 31, 2023) The MRI of Lumbar Vertebral Canal in Low Back Pain: A Cross-Sectional Study. Cureus 15(12): e51407. DOI 10.7759/cureus.5140

Belma Jaganjac1,2, Amina Džidić-Krivić3,4, Hakija Bečulić5,6, Armin Šljivo7, Emir Begagić8, Adis Šiši. Magnetic resonance morphometry of the lumbar spinal canal in Zenica -

Doboj Canton in Bosnia and Herzegovina.Medicinski Glasnik July2023;20(2):263-268 DOI:10.17392/1575-23

Chaathe DS, Schweitzer ME. MRI criteria of developmental lumbar spinal stenosis revisited. Bull NYU Hosp Jt Dis 2011; 69: 303-7.

Devi R, Rajagopalan N. Dimensions of the lumbar vertebral canal.Indian J Orthop.2003;37:13.

Dommisse GF. Morphological aspects of the lumbar spine and lumbosacral region. Orthopaedics clinics of North America 1975; 6:163)-175.

Eisentein S. The morphometry and pathological anatomy of lumbar spine in South African, Negroes and Caucasoids with specific reference to spinal stenosis. J Bone Surg. 1977; B (2): 173-177. 5) Herkowitz HN, Garfin SR, Eismont FJ, Bell GR. Balderston RA.Rothman-Simeone The Spine, 6th ed., Elsevier, 2011:246 &1064.

Gilad I, Nissan M. Sagittal radiographic measurements of the cervical

Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, Hoy D, Karppinen J, Pran-sky G, Sieper J, Smeets RJ, Underwood M. Lancet Low Back Pain Series Working Group. What low back pain is and why we need to pay attention. Lan-cet 2018; 391:2356-67.

Karantanas A H , Zibis A H, Papaliagia M, Georgiou E, Rousogiannis S. Dimensions of lumbar spinal canal: Variations and correlation with somatotropic parameters using C T. Eur Radiol. 1998; 8:1581-5.

Khalid Alghamdi , Ibrahim omar. Morphometry of the lower lumbar spinal canal among a sample of the Saudi population: Are we at risk? Journal of Musculoskeletal Surgery and Research April 2023 7:1-7

Larsen JL, Smith D. Vertebral body size in lumbar spinal stenosis. Acta Radiolog.1980; 21:785-788.

Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J.Radiologic criteria for diagnosis of spinal stenosis: results of a Delphi survey. Radiology2012;264(1)174-179

Peabody T, Das JM. Anatomy, Back, Vertebral Ca-nal. StarPearls. https://www.ncbi.nlm.nih.gov/bo-oks/NBK55787/#_NBK557587_(25Fe-bruary 2023)

Rauschning W, Bergstrom k, Pech P. Correlative craniospinal anatomy studies by computed tomography and cryomicrotomy. J Comput AssistTomogr. 1983;7: 9–13.

Sarpyener M.A. Congenital stricture of the spinal canal. Journal of Boneand Joint Surjery 1945; 27: 70-79

Tarek A, Osama A. Geometrical Dimensions & morphological study of the lumbar spinal canal in the normal Egyptian population. J of orthopedics 2013; 36(2): 229-234.

Uttam yadav,Vivek singh, Nishant bhargawa, Arun kumar srivastava. CT Morphometry—Study of Indian Population. Int J Spine Surg. 2020 Apr; 14(2): 175–181.

Verbeist H. Results of surgical treatment of idiopathic developmental stenosis of the lumbar vertebral canal. A review of 27 years experience.J Bone Joint surg. 1977; 59B: 181-188.

Verblest, H. A radicular syndrome from developmental narrowing of the lumbar vertebral canal. J Bone and Joint Surg. 1954;36B: 230-237.

Weinstein PR. In: Hardy RW Jr, ed. Lumbar disc disease. 2d ed. New York: Raven, 1993; Anatomy of the lumbar spine : 5–13.

Wu A, March L, Zheng X, Huang J, Wang X, Zhao J, Blyth FM, Smith E, Buchbinder R, Hoy D. Global low back pain prevalence and years lived with disa-bility from 1990 to 2017: estimates from the Glo-bal Burden of Disease Study 2017. Ann Transl Med 2020; 8:299.