ORIGINAL ARTICLE

Radiograph-based Morphometric Classification of Lumbar Spinal Canal

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Abstract

Lumbar canal volume is measured by the pedicle length and interpedicular distance on plain radiographs of the lumbar spine. Since the L4 level of the lumbar spine is the central level of the lumbar canal. This level is the most commonly affected level of the lumbar spine in various pathologies like a prolapsed intervertebral disk (PIVD), lumbar canal stenosis, including discogenic or degenerative spinal disorders. During our observations, we found various patterns of lumbar spine morphology based on pedicle length and interpedicular distance of the L4 vertebra on anteroposterior and lateral lumbar spine radiographs. This new approach to divide the lumbar spine morphology into these classes will help us in predicting the susceptibility of an individual to various types of LBP and neurological complications. This will also help the operating surgeon in planning the various surgical interventions for various lumbar pathologies based on the morphology of the lumbar spine.

Keywords: Lumbar spinal canal, Morphology, Radiographic.

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Introduction

Since the gross morphology of the spine varies in different individuals, the human spine undergoes a lot of changes from birth to old age.[1] Normal spine has various curves like lordosis in the cervical and lumbar spine and kyphosis in the dorsal spine.[2] Spine is constituted by a series of vertebras stacked on one another with intervertebral disks in between the vertebras. These vertebras are held in place by various ligaments, both anteriorly and posteriorly. Spinal flexibility gives humans fine and gross movements at various junctions.[3] In addition to providing the erect posture to human beings, it envelopes as well as protects an essential and vital part of central nervous system, the spinal cord. So far, researchers have focused more on biomechanical characteristics of the lower lumbar spine, while gross vertebral morphology is too essential to understand the etiology of different lumbar spine pathologies and to devise their various treatment modalities. The gross morphology of the lumbar spine is essential to understand the biomechanics of the spine and, their inter-relationship is key to understanding the pathogenesis of the lumbar spine.[4,5]

Lumbar canal measurements in the lumbar vertebrae are essential to understanding the pathogenesis of lumbar spinal pathologies and various lumbar surgical interventions, such as lumbar pedicle screw fixation. In order to measure the lumbar spinal canal, previous studies depended on direct measurements from plain radio- graphs[6-8] or computed tomography (CT) scans.[9]

Low back pain (LBP) is the commonest chief complaint with which patients present to orthopedic and neurosurgery clinics. Lower back pain may be further divided into mechanical LBP, instability LBP, discogenic pain, infective LBP, inflammatory LBP, or pain due to degenerative spine. The type of pain and susceptibility of an individual to suffer from LBP and neurological complications are usually determined by various factors like canal width, pedicle length, interpedicular distance, the curvature of spine and status of intervertebral disk height and disk prolapse. Individuals with a wide spinal canal are less likely to suffer from neurological complications as enough space is available to accommodate the thecal sac, traversing, and exiting nerves. While as an individual with narrow spinal canal are more easily susceptible to suffer from neurological complications like radicular pain and neurological deficits.

Lumbar canal volume is measured by the pedicle length and interpedicular distance on plain radiographs of the lumbar spine. Since the L4 level of lumber spine is the central level of the lumbar canal. This level is the most commonly affected level of the lumbar spine in various pathologies like a prolapsed intervertebral disk (PIVD), lumbar canal stenosis, including discogenic or degenerative spinal disorders. During our observations, we found various patterns of lumbar spine morphology based on pedicle length and interpedicular distance of the L4 vertebra on anteroposterior and lateral lumbar spine radiographs. This new approach to divide the lumbar spine morphology into these classes will help us in predicting the susceptibility of an individual to various types of LBP and neurological complications. Since the pedicle is the junction between the posterior elements and the anterior body of the vertebra, it has become the key element for surgical management of lumbar spinal disorders after the introduction of the pedicle screw for spinal fusion surgeries. Morphological studies using direct,[10-14] radiological[15-21] or both[22] have been conducted to

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establish a reference for the screw insertion. This will also help the operating surgeon in planning the various surgical interventions for various lumbar pathologies based on the morphology of the lumbar spine.

Aims and Objectives

The aim of this study is to classify the lumbar spine into various morphological types based on pedicle length and interpedicular distance of L4 vertebra measured on anteroposterior and lateral radiographs of thelumbar spine.

Materials and Methods

This study was conducted in the department of orthopedics and spine surgery, Government Medical College, Anantnag. The study was conducted on 400 serial standard anteroposterior and lateral lumbar spine digital radiographs taken on day to day basis in orthopedic clinics. The X-rays taken in patients suffering from infections, trauma, tumors, spondylolisthesis, or severely deformed and degenerative spine were excluded from the study. The X-rays taken in individuals with age between 20 and 60 years were included in the study. The X-rays were taken by standard 300 ma (GE) X-ray equipment in a lying down position alternately on anteroposterior and lateral positions. The pedicle length and interpedicular distance on the radiographs were measured using the latest version of the PACS system. The pedicle length and interpedicular distance of the L4 vertebra of 400 serial lumbar spine x rays were measured and recorded in an excel sheet of Microsoft Office.

Statistical Methods

Statistical analysis was performed using the mean, SD, standard error, and Student's *t*-test. A p value <0.05 was considered statistically significant.

Measurement Methods

Pedicle length, on a true lateral lumbar radiograph, was measured from the posterior cortex of the superior articular surface up to the junction of pedicle and body (Fig. 1)

Interpedicular distance, on a true anteroposterior lumbar radiograph, was measured at L4 pedicular level as the distance between the inner borders of both pedicles of the L4 vertebra (Fig. 2).

Results

To our observation of 400 serial lumbar spines AP and lateral radiographs, the pedicle length of the L4 vertebra ranges from 6–18 mm and, interpedicular distance ranges from 24–36 mm.

New Classification

Based on these observations, we found four patterns of lumbar vertebral canal. The lumbar canal having long pedicles and wide interpedicular distance are considered as wide canal (Fig. 2) due to large volume of the lumbar canal to accommodate the neural structures. Lumber spine with long pedicles and short interpedicular distances have increased anteroposterior distance but short coronal diameter. This type of lumbar canal pattern we considered as deep canals (Fig. 3). While as lumbar canal patterns having short pedicle length and long enough interpedicular distance have a shallow pattern of the lumbar canal. Their anteroposterior diameter is less but adequate coronal diameter, this type of morphology we named the shallow canal (Fig. 4). The fourth pattern of the lumbar canal is having both short pedicles and short interpedicular distance. These canal patterns we have considered as narrow canals (Fig. 5), as these types of lumbar canals have very small volumes for important neural structures and are more prone to neurological complications. The various patterns of the lumbar canal has been shown in Table 1.

Discussion

Plain or digital radiograph of the lumbar spine is the first and commonest investigation done in the evaluation of lower back pain.[6-8] Standard true anteroposterior and lateral radiographs of the lumbar spine give treating doctors enormous information while evaluating the various etiologies of LBP.[7,8] It also gives the treating physician or surgeon the idea about the gross morphology of the lumbar spine of that patient.[7] The various structures visualized on lateral lumbar radiograph include disk space, vertebral body, pedicles, superior and inferior facet joints, pars interarticularis, and spinous process. While as on an anteroposterior radiograph, we see an axial view of pedicles, facet joints, laminae, and transverse processes. It also helps us in understanding the curvature of the spine, both in coronal and sagittal planes. The anteroposterior and lateral radiograph of the lumbar spine also gives us an idea about the gross morphology of the lumbar canal. The anterior wall of the canal consists of the alternating posterior aspect of vertebral bodies

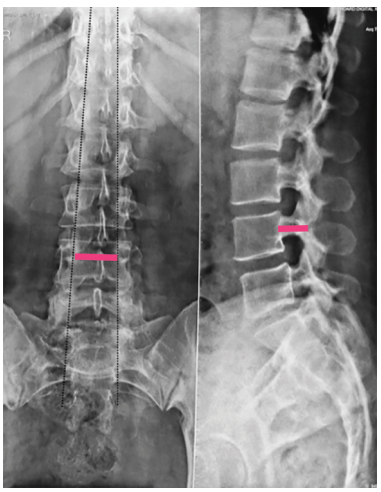

Fig. 1: Pedicle length on a true lateral lumbar radiograph

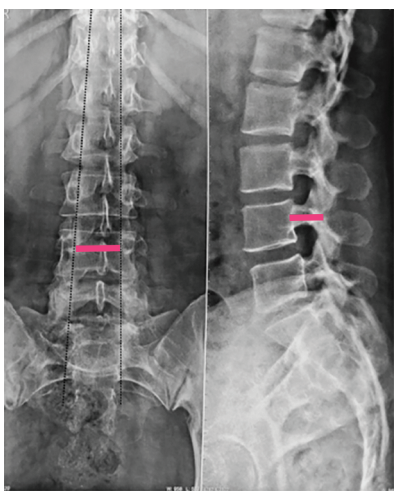

Fig. 2: Wide canal

and annulus intervertebral disks, which are covered by a posterior longitudinal ligament. The posterior wall of the lumbar canal is formed by vertebral laminae and ligamentum flavum. On the side, the canal is bound by two pedicles except at the intervertebral foramina where the nerve root is exiting. The spinal canal contains the dural tube, the spinal nerves, and the epidural tissue. On plain anteroposterior and lateral radiographs of the lumbar spine, the lumbar canal volume is determined by the length of the pedicles and the distance between the innermost cortices of the two pedicles lying on sides.

The standardized method for precise spinal canal measurement is CT. It is used to measure the anteroposterior diameter and interpedicular distance of the lumbar spinal canal. It is a very useful diagnostic tool to determine spinal canal dimensions with accuracy.[1] Due to high radiation exposure and high cost to the patient, a CT scan is not a routine to evaluate the spinal canal morphology. In addition, this advanced diagnostic facility is not widely available particularly in developing nations. But the length of pedicles and interpedicular distance on standard computerized or plain anteroposterior and lateral radiographs give enough virtual morphology of the lumbar spinal canal.

Classification of lumbar spinal canal morphology based on pedicle length and interpedicular distance of the L4 lumbar vertebra is a simple, straightforward way of knowing the lumbar canal morphology without additional cost or harmful radiation to the patient.

Our classification of lumbar canal morphology is easy to measure and readily reproducible method. This is an objective method to determine the lumbar canal morphology without significant intraobsever or interobserver variability.

Our new classification system is a prognostic classification system of lumbar spine pathologies. A wide lumbar canal morphology is less likely to develop an early neurological complications in any space-occupying lesion of the lumbar canal-like prolapse intervertebral disk, purulent material, granulation tissue or tumor while narrow canal patients are more prone to develop early neurological deficit in space-occupying lesion of the lumbar canal.

Since the pedicle screw is widely used to stabilize the spine, pedicle penetration, neurological irritation and cerebrospinal fluid leakage associated with pedicle screw misplacement are very common. Our morphometric classification of the lumbar spine will give the operating surgeon a fair idea of the orientation of pedicles before surgery. A wide lumbar canal morphology has more medial pedicle screw angulation than a narrow lumbar canal with short pedicles. A deep lumbar canal will have a longer pedicle screw length compared to shallow lumbar canal morphology.

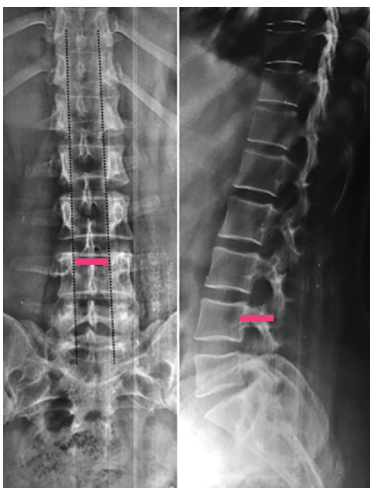

Fig. 3: Deep canal

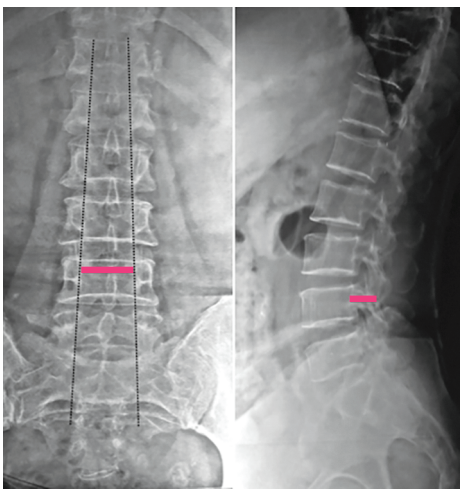

Fig. 4: Shallow canal

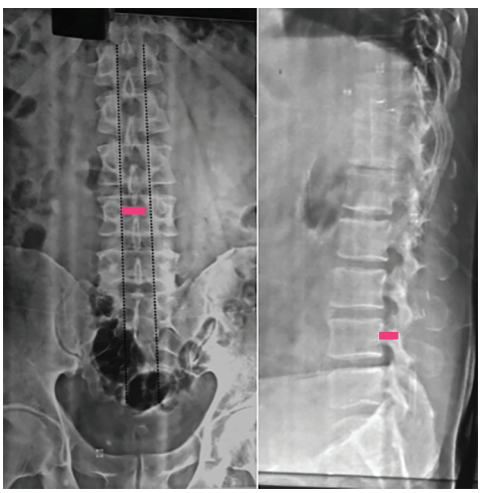

Fig. 5: Narrow canal

Table 1: Various patterns of lumbar canal

Type	*Morphology*	*Pedicle length (range in mm)*	*Interpedicular distance (range in cm)*
Type I	Wide canal	Pedicle length >14 mm	Interpedicular distance >32 mm
Type II	Deep canal	Pedal length >14 mm	Interpedicular distance 28–32 mm
Type III	Shallow canal	Pedicle length 8–14 mm	Interpedicular distance >32 mm
Type IV	Narrow canal	Pedicle length <8 mm	Interpedicular distance <28 mm

This classification system will also help in decision-making while dealing with various morphologies of the lumbar canal. The individuals with a wide lumbar canal often need simple midline decompression with facet joint sparing to achieve adequate decompression in order to treat acquired spinal stenosis. While as individuals with narrow canals often need to facet joint sacrifice to achieve wide decompression and often need a simultaneous fusion of the spine to avoid iatrogenic instability of the lumbar spine.

Our new classification system can help in determining the prognosis of disease while treating lumbar canal pathologies. Usually, wide lumbar canal morphology patients have good results on conservative treatment, a very good postsurgical neuro-recovery, and less chances of recurrent stenosis. While as narrow canal morphology is less likely to recover with conservative approach, more prone to the early neurological deficit, less chances of postoperative neuro-recovery, and has more chances of recurrent lumbar canal stenosis.

Conclusion

Even though CT is an accurate method of determining the lumbar canal morphology, but our radiograph-based virtual morphological pattern of lumbar canal morphology is easy, simple, and reproducible. The new classification may help treating physicians or operating surgeons in decision making, determining the prognosis, and planning the surgical procedures for various lumbar spine pathologies.

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