Study of Lumber Herniated Disc in Bihari Scenario

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ABSTRACT

Introduction: Lumbar vertebrae pedicles are short and strong as well. The pedicles play a vital role, in lumber area, in transferring weight from neural arch to the vertebral columns' anterior part. Because of osteoporosis in older age group lumber pedicle fracture are common and needs open surgical intervention or sometimes percutaneous pedicle screw fixation may be done to stabilize the vertebrae. And for this the morphometric knowledge of the lumbar pedicle becomes not only important but vital also. Aims: The aim of our study is to determine the height and width of pedicles and inter-pedicle distance and to compare present study data with the previous one and to discuss the various applied aspects of the study among the orthopaedic surgeons of Bihar (India).

Material and Methods: This anatomical study was conducted on 25 dry L3 lumbar vertebrae and 10 adult male cadavers obtained from Department of Anatomy, Nalanda Medical College and Hospital, Patna comprehensively. The specimens belonged to mostly population of Bihar (India).

Results: The pedicle vertical height increases from L1 to L3 vertebrae and then reduces in L4 to L5 with its least. In the same way the pedicle width increases from L1 to L5 vertebrae; width is approx same in L2 and L3 vertebrae. On the other hand Inter-pedicle distance is at lowering side in L1 and approx same in L2, L3, L4 and larger in L5 vertebrae. No significant difference is seen in height and width statistically of the pedicle on right and left side.

Conclusion: Morphometric knowledge of pedicles is vital and important for an orthopaedic surgeons as well as radiologist for accurate selection of the pedicle screw and operative repair, especially in Bihar (India)

Keywords: Pedicle, Vertebra, Lumbar Spine, Morphometry.

INTRODUCTION

Any alteration of structural configuration of the pedicle may cause hindrance of the weight bearing mechanism and compression of neural elements. This anatomical study was conducted on 25 dry L3 lumbar vertebrae and 10 adult male cadavers obtained from Department of Anatomy, Nalanda Medical College and Hospital, Patna comprehensively. The specimens belonged to mostly population of Bihar (India). In this study following parameter were taken using slide calliper: Pedicle vertical height (h) and width (w) in dry third lumber vertebrae (L3); interpedicular distance (GH) and cadaveric specimens of all lumbar vertebras along with interpedicular distance between adjacent lumbar vertebrae.

In the dry bone Lumber 3 (L3) Vertebrae the mean height of the pedicle was 13.9 ± 1.0 mm on the right side whereas on the left it was 14.0 ± 1.0 mm. The pedicle mean width was 8.7 ± 1.4 mm on right side and 8.7 ± 1.7 mm on left. The mean interpedicular distance was 20.5 ± 1.3 mm, where in cadaveric lumber 3 vertebrae mean value was 22.7 ± 1.73mm. These distances increased L1 to L5 as 21.6±1.69mm to 25.4±3.19mm. However, an increase was observed between adjacent lumbar vertebrae in the interpedicular distance from the L1-L2 to L2-L3 levels, at the same time a decrease from the L3-L4 to L4-L5 levels on the right side also observed, and similar trend was observed on the left side excluding that L2-L3 and L3-L4 had similar means. This study provides data from Bihari (India) population for orthopaedic procedures.

(Inceoglu et al.)[1] reported that since it is the mobile part of the vertebral column the lumbar region is subject to instability following trauma, in particular that related to RTA, the use of heavy machineries, and adventurous sports, apart from surgical laminectomies, deteriorative conditions, inherited defects, and metastasizing malignant tumours of prostate along with other pelvic organs.

Several devices such as rods, plates or wires can be fixed to the spinal column by screws for immobilization. The factors involved in establishing stability using implants include accurate screw fixation and good bone quality for proper screw path (Zindrick et al.,).[2] Transpedicular screw fixation techniques have gained more popularity than the anterior instrumentation and hook-rod devices as the means of spinal fixation in recent past (Zindrick et al.,).[3] The unique anatomy of pedicles provides an excellent implantation site for screw fixation in reconstructive spinal surgeries with a view to maintaining and restoring stability in such patients (Roy-Camiller et al.,).[4]

The reduced transverse interpedicular distance of the vertebra has been reported by (Clinotti et al.)[5] as one of the major causes of the narrowing of the vertebral canal in the cervical and lumbar regions and also the narrowing of the intervertebral foramen transmitting spinal nerves, which is limited above and below by the pedicles of the adjacent vertebrae, resulting in neural compression.

(King D)[6] was the first to attempt screw emplacement parallel to the inferior border of the lamina and across the facet joints for internal fixation of the lumbosacral region, whereas (Boucher)[7] passing long screws through the lamina and pedicle into the vertebral body was successfully initiated for spinal fusion by screw fixation with internal splinting.

According to (King D screws inserted into the pedicle for the reduction and stabilization of spondylolisthesis have afforded good results.

(Magerel)[8] developed adjustable external spinal skeletal fixation for stabilizing the lower thoracic and lumbar spine in patients with acute spinal trauma, in which screws were firmly anchored through the pedicle into the vertebral bodies, although

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the foundation for pedicle screws and posterior plates was established earlier by (Roy-Camiller et al.,).[4] Those authors designed and used posterior plates with screws driven parallel to the sagittal plane into the pedicles and articular processes to counter the complications of pedicle screw plate stabilization, including lumbar fractures and mal-unions.

By King D developed a new segmental instrumentation of pedicle screw fixation with spinal plates contoured for anatomic positioning to enhance graft consolidation and fusion for disorders of the thoracolumbar spine in 1948.

(Luque)[9] introduced another method of interpedicular segmental fixation using pedicle screws wired to Luque rods. Further enhancements of pedicle screw fixation techniques were associated with considerations of the anatomical contours, mobility, complications such as screw loosening, screw migration, screw breaking, nerve root impingement, and deep wound infection.

The aim of our study is to determine the height and width of pedicles and inter-pedicle distance and to compare present study data with the previous one and to discuss the various applied aspects of the study among the orthopaedic surgeons of Bihar (India)

MATERIAL AND METHODS

This anatomical study was conducted on 25 dry L3 lumbar vertebrae and 10 adult male cadavers obtained from Department of Anatomy, Nalanda Medical College and Hospital, Patna comprehensively. The specimens belonged to mostly population of Bihar (India). The study addresses the morphometry of the pedicle of human lumbar vertebrae in the following different materials. All measurements were done at three different sittings, and the mean of the values corrected to the nearest millimetre was recorded.

A: Morphometry of dry bone

Direct gross morphometry of the pedicles of randomly selected 25 fully ossified human lumbar vertebrae was carried out.

Both sides measurements were recorded using a sliding vernier caliper.

Vertical height (h): 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.

Pedicle width (w): Measured at the points on the medial and lateral surfaces of each pedicle at right angle to the long axis of pedicle.

Interpedicular distance (GH): This is the maximum distance between the medial surfaces of the same vertebras' right and left pedicles and got recorded as the vertebral canals' transverse diameter.

B: Morphometry of cadaveric specimens

This part of the study was performed on ten normal adult male cadavers. Cadavers with any gross anomalies, a history of any intervertebral disc collapse, and osteophytes were excluded from the study. The shape of the vertebral canal and intervertebral foramina was noted and the following parameters were recorded using a sliding vernier caliper:

Interpedicular distance between adjacent lumbar vertebrae: The vertical diameter of the intervertebral foramina at its rim which was measured from root of crosswise process of vertebra above to root of crosswise process of the vertebra.

It was recorded on both sides, i.e. right and left separately.

After that, the each segments' intervertebral disc of the lumbar part of the vertebral column was cut transversely using a hand saw, and the following parameters were measured in each vertebra. Interpedicular distance between medial surface of the right (G) and left (H) pedicles of the same vertebra was noted as the vertebral canals' crosswise diameter.

STATISTICAL ANALYSIS

A Quantitative parameters' descriptive statistics was performed considering calculating average, standard deviations, standard errors of the mean, upper and lower value and number of cases as the sample. A distribution frequency and proportion for qualitative parameters description was performed. In comparison between the levels, it was used a variance analysis for parametric samples.

RESULTS

Gross observations of the L3 Vertebra

The pedicles of lumbar vertebrae were present between the lamina and the vertebral body. They were thicker near the ends and in the middle these were narrower by encircling pressure. The pedicles upper and lower surfaces were curved inward.

A: In Dry Bone: Following measurements of pedicles of 25 completely calcified human lumbar vertebrae were recorded on both sides during observing the gross morphometry:

Vertical height (h): The pedicles' mean height was 13.9.0 ± 1.01 mm on the right side, with minimum value of 11.0 mm and a maximum of 15.6 mm. On the left side, the mean height was 14.0 ± 1.0 mm, with a minimum value of 11.7 mm and a maximum value of 16.0 mm. The difference in the measurements between the right and left side was statistically insignificant.

Pedicle width (w): The mean width of the pedicle was 8.7 ± 1.4 mm on the right side with a minimum value of 5.5 mm and a maximum of 10.8 mm, whereas on the left it was 8.7 ± 1.7 mm with a lower value of 5.4 mm and a upper of 12.5 mm. The difference in measurements between the right and left side was statistically insignificant.

Interpedicular distance (GH): The mean interpedicular distance between the medial surface of the right and left pedicle

		Right	Left	P-Value
	Mean	**16.7 mm**	**15.0 mm**	
L1L2	S.D.	1.56	2.24	0.041*
	Range	15.0-20.4 mm	9.4-17.5 mm	
	Mean	17.1 mm	17.2 mm	
L1-L2	S.D.	1.9	2.45	0.079
	Range	14.9-20.3 mm	13.2-20.6 mm	
	Mean	16.9 mm	17.2 mm	
L1-L2	S.D.	2.02	2.23	0.45
	Range	13.9-20.0 mm	13.6-20.7 mm	
	Mean	16.6 mm	16.6 mm	
L1-L2	S.D.	2.57	2.37	0.97
	Range	12.7-20.7 mm	12.8-19.5 mm	

Table-1: Interpedicular distance between adjacent lumbar vertebrae.

of the same vertebra was 20.5 ± 1.3 mm, with a minimum value of 18.0 mm and a maximum of 24.9 mm.
The pedicle, correlation coefficient between the height and width was 0.429, indicating a positive correlation between both.

B: In Cadaveric Specimen: The intervertebral foramen shape in the upper levels was oval, in middle levels observed gradually narrowing and in lower part of the intervertebral foramen, providing it an inverted 'tear drop' or keyhole shape appearance. It was observed that in the different specimens the inter-vertebral foramina were having different shapes, like round, oval, auricular or tear-drop.
The under mentioned parameters were measured on intact lumbar vertebral specimen from 10 adult male corpses:
Between adjacent lumbar vertebrae, inter-pedicular distance:
In Right side it was found to be on upper level between L2 and L3, i.e. 18.0 mm, while on lower level between L4 and L5, i.e. 16.6 mm. On the Left side it was on upper level between L2 and L3, L3 and L4, i.e. 17.2 mm and on lower level between L1 and L2, i.e. 15.1 mm.
An increase was observed in interpedicular distance from L1-L2 to L2-L3 levels where a decrease observed from L3-L4 to L4-L5 levels on right side. A similar pattern was seen on the left side but no change was felt from the L2-L3 to L3-L4 levels. The difference between the right and left side was statistically insignificant except at the L1- L2 level.
The Interpedicular distance between the medial surface of the right (G) and left (H) pedicle of the same vertebra was at maximum level of L5, i.e. 25.4 mm and at minimum level at L1, i.e. 21.6 mm.
A gradual increase from L1 to L5 was observed in interpedicular distance.

L1 Vertebrae	Mean	21.6 mm
	S.D.	1.69
	Range	19.3-24.1 mm
L2 Vertebrae	Mean	22.0 mm
	S.D.	1.46
	Range	19.5-24.3 mm
L3 Vertebrae	Mean	22.7 mm
	S.D.	1.73
	Range	19.8-25.3 mm
L4 Vertebrae	Mean	23.1 mm
	S.D.	2.25
	Range	20.2-26.6 mm
L5 Vertebrae	Mean	25.4 mm
	S.D.	3.19
	Range	20.4-30.0 mm

Table-2: Interpedicular distance between medial surface of right and left pedicle of the same vertebrae.

DISCUSSION

Since lumber vertebrae is a mobile part, so it is frequently involved and affected in RTA, Tumour, congenital defects, degenerative conditions and neoplastic metastases and hence it may need instrumentation for its stability functional outcome to be restored.
A thorough and depth anatomical knowledge in detail is required to identify the exact place for instrumentation pointed to spinal fixation while going for surgical intervention. Pedicular fixation of lumber vertebrae is done for unstable fracture to be safe and demanding. It has advantage over anterior instrumentation and hook-rod devices, as reported by (Matsuzaki et al.).[10] Several devices such as rods, plates or wires can be applied with the help of screws to the spine for immobilization or fixation (Amonoo Kuofi,).[11]
Injuries to the pedicle cortex, nerve root, facet joint and vital adjacent structures may be caused due to a misdirected or misplaced pedicle screw, (Misenhimer et al.; Weinstein et al.,).[12,13] Thus, for safer pedicle screw placement it is important to understand pedicle dimensions and angulations for the development of techniques and devices for spinal instrumentation.
In the process of pedicle screw insertion, the screw is inserted and passed into the body of the vertebra anteriorly through the posterior aspect of the pedicle. The selection of the screw to be used is determined by the minimum diameter of the pedicle because the success of this procedure depends upon the ability of the screw to obtain strength within the vertebral body. So, in preoperative planning and designing pedicle screws along with other implants, morphometric data concerning pedicles is very helpful.
In the present study L3 was selected in dry bone specimens for morphometric analysis just because a typical lumbar vertebra, which was located in the middle of lumbar vertebral column.
While studying the lumbar vertebra (L3), the pedicle mean vertical height was 13.9 ± 1.0mm on the right side with a lower value of 11.0 mm, on the other hand on left side, it was 14.0 ± 1.0 mm, with a lower value of 11.7 mm, while the pedicle mean width was 8.7 ± 1.4 mm on the right side with a lower value of 5.5 mm and on the left side the mean width was 8.7 ± 1.7 mm, with a lower value of 5.4 mm. Many other authors have also reported similar findings (Misenhimer et al.; Berry et al.; Hou et al.; Scoles et al.; Wolf et al.)[12,14-17] with minimum differences. Higher values for vertical height were reported by (Arora et al.)[18] (16.42 mm in males and 15.6 mm in females) and (Singel et al.)[19] (10.4mm in males while in females 10.6mm).
In our study the vertical height was more than the width at almost all levels and minimum diameter of the pedicle is the screw diameter deciding factor, so it has of little significance.
It has been observed that almost all studies have reported that the ertical height and width lumber pedicle mean values were higher in males with respect to females, which may be explained as the more upper body weight of males (Steffee et al.,).[20] While (Singel et al.)[19] reported that the vertical height and width of the pedicle were more in females than in males, no doubt the difference was little.
The findings of our study are quite similar to a report by (Lien et al.)[21] stating that the values for the left and right pedicles of the lumbar vertebrae were almost the same.
Conclusively it can be said that the vertical height of the pedicle is mostly more than its width and the vertebrae vertical height and width are directly proportional to each other and these both values have a lowest sexual variation.
On the right side the mean vertical height was 14.1 mm and on left side it was 14.1 mm, while on the right side the pedicle mean width was 8.8 mm and on the left side it was 8.8 mm. A marginal difference found between the current study findings and (Lien et al.)[21] study.

The lateral walls of the vertebral canal constituted with transverse interpedicular distance (GH) between the medial surfaces of the pedicles of the same vertebra. The antero-posterior shortening of the pedicle and the reduction in transverse interpedicular distance is one of the commonest causes of stenosis of the vertebral canal. In the present study, the interpedicular distance was observed in the L3 vertebra only, while it was observed at each vertebral level of the cadaveric lumbar spine.

Since there are no studies available addressing cadaveric specimens, the mean interpedicular distance in the cadaveric specimen of present study was compared with dry bone study as well as with radiological studies.

It was observed in studied 25 dry bones (L3) that the maximum transverse interpedicular distance was 25.1 mm and the minimum it was 18 mm and the mean value was 20.5 ± 1.3 mm. A gradual increase was also observed from L1 to L5 in cadaveric specimens. The mean values of interpedicular distances of our study are comparatively lower at all lumbar levels than in the other studies. It is also evident from the fact that in the Bihari population the mean interpedicular distance is more in Bihari as compared to North Indians states. The dry bone recordings value difference and the cadaveric specimens might be caused due to the presence of soft tissue around the specimens, while the magnification factor and the observer bias cannot be ruled out in recording from the plain radiographs in some studies.

(Postacchini et al.)[22] studied Indian as well as Italian skeletons in Rome and observed slightly lower readings in the Indian population, while the interpedicular distances in Italian skeleton were quite similar to those observed in the present study.

The interpedicular distance between adjacent lumbar vertebrae is the vertical height of the intervertebral foramen. The shape of intervertebral foramina at upper levels was oval, while there was a gradual narrowing of the lower part of the intervertebral foramina in L3 and below, giving it an inverted 'tear drop' or keyhole appearance.

In most studies, including this one, the maximum dimensions were recorded between L2-L3, while the dimensions of L2-L3 and L3-L4 were fairly similar. Generally, the dimensions were lowest in L1-L2 followed by L4-L5. The vertical diameter displayed an increase from the L1-L2 to the L2-L3 levels and thereafter a statistically non-significant decrease from L3-L4 to L4-L5. The antero-posterior diameter decreased from L1-L3 and thereafter a significant bilateral increase at L4-L5 was seen. This was also reported by (Devi R and Rajagopalan).[23]

The majority of foramina are oval in outline when the associated intervertebral disc is normal, but in the case of abnormal disc, the auricular shape prevails and the ratio of oval to auricular foramina is reversed. Since the intervertebral disc is a vital constituent in the middle of the anterior wall of the intervertebral foramen, its integrity has bearing on the vertical diameter of the intervertebral foramina (Cinotti et al.,).[5] But for giving an accurate interpretation consideration of the other components will also be needed.

In the study by (Roy Camiller et al.)[4] the plates which were used for spine fixation had holes at every 1.3 cm and they fixed the screws at every alternate hole. The average distance between two pedicles was 2.6cm between the entry points of two consecutive pedicles. On the other hand in the study of (Steffee et al.)[20] the plates had a distance of 2.6 cm between the centres of two slots to accommodate the specially designed Steffee pedicular screw. These implants suits the interpedicular distance for the Bihari (India) population well but sometimes it may need some modification because the distance between the centres of two contiguous pedicles was around 29 mm (range 29 mm to 32 mm).

CONCLUSION

To conclude, for the Bihari population in lumbar vertebrae Steffee pedicle screws of 5.5mm diameter may be used safely because the diameter of the pedicular screw is monitored by the minimum diameter of the pedicle. In this study the diameter of screw across the width was 8.7 mm.

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