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Morphometric Study Of The Pedicles Of Dried Adult Human Lumbar Vertebrae

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Abstract:

Background: Pedicles of the lumbar vertebrae are short and strong. In the lumbar region the pedicles play an important role in the transfer of weight from the neural arch to the anterior part of the vertebral column. Fractures of the lumbar pedicles are common in older age group due to osteoporosis and requires open surgical or percutaneous pedicle screw fixation to stabilize the vertebrae. Hence the morphometric knowledge of the lumbar pedicle is important.

Aims of study: The aim of our study is to determine the height and width of pedicles and inter-peduncle distance. To compare present study data with the previous one. To discuss the various applied aspects of the study.

Methodology: 115 dried adult human lumbar vertebrae (23 sets, 5 vertebrae in each set from same individual) were examined. Height and width of the right and left lumbar pedicles and interpeduncle distance was measured using sliding verniar caliper.

Results: Vertical height of the pedicle goes on increasing from L1 to L3 vertebrae and again reduces in L4 and L5, in L5 it is least. Width of the pedicle goes on increasing from L1 to L5 vertebrae; width is nearly similar in L2 and L3 vertebrae. Interpeduncle distance is less in L1 and almost similar in L2, L3, L4 and larger in L5 vertebrae. No statistically significant difference is seen in height and width of the pedicle on right and left side.

Conclusion: Morphometric knowledge of the pedicles is important for orthopedic surgeons and radiologist for proper selection of the pedicle screw and operative repair.

Keywords: interpeduncle, lumbar, pedicle, vertebrae

Introduction:

Lumbar vertebral pedicles are short, thick and flat to rounded dorsal projections from the superior part of the body at the junction of its lateral and dorsal surface. Pedicles form the concavity by the curved superior and inferior border. Superior border of pedicle is shallower than the inferior one. When vertebrae articulate by the intervertebral disc and facet joints, these adjacent vertebral notches contribute to an intervertebral foramen. A foramen contains a segmental mixed spinal nerve and its sheaths, two to four recurrent meningeal nerves, variable numbers of spinal arteries, and plexiform venous connections between the internal and external vertebral venous plexus. These structures, particularly the nerves, may be affected by trauma or other disorders affecting the adjacent tissue. The complete perimeter of an intervertebral foramen consists of the notches, the dorsolateral aspects of parts of adjacent vertebral bodies and the intervening disc, and the capsule of the synovial facet joints. The laminae are directly continuous with the pedicles. Bony defect in the vertebrae

commonly affect the laminae but much more rarely the pedicle.[1] In most burst fractures, the posterior column of the fractured vertebra body remains intact and provides additional points of fixation. Insertion of pedicle screws at the level of the fracture would result in a segmental construct and a protective effect on the fractured vertebra body by indirectly supporting the anterior column. The placement of pedicle screws at the level of the fracture can make the fixation more stable and therefore decrease the risk of reduction loss.[2] In the lumbar region, where the concavity is posterior, a part of the compressive force of the anterior column is transmitted to the posterior.[3] The pedicle screw fixation has been used as a universal spinal fusion surgery method for many spinal disorders. Standard open technique for pedicle screw fixation, however, has been associated with several disadvantages. During the open technique, extensive tissue dissection and longtime retraction are inevitable to expose entry points of screw and to provide orientation of lateral to medial for optimal screw trajectory. The excessive retraction of muscle can cause ischemic damage and permanent pathological changes of the muscle. Already, some authors reported that the degree of damage of muscles and back pain after surgery were proportionate to the size and time of retraction during surgery. In addition, extensive dissection of paraspinal muscle can cause excessive blood loss and necrosis of tissue, which can be said to increase the need for transfusion and the chance of postoperative infection. Such problems cause longer bed rest duration, lengthy hospital stay, and significant cost. Moreover, some authors have suggested that the open technique can cause adjacent segmental degeneration due to extensive dissection of paraspinal muscle or iatrogenic injury of facet joint. As these problems become important matter, recently, minimally invasive pedicle screw fixation was introduced and developed.[4] So the knowledge of the morphometric data of the pedicles is important since the fractures are more common in the lumbar region and pedicle fixation is most commonly used technique for surgical treatment of it.

Materials and method:

The present study is done on the 23sets of dry adult human lumbar vertebrae; each set was obtained from same individual from department of Anatomy, GMC, Miraj. In total 115 lumbar vertebrae were studied. The morphometrical data of the pedicle of human lumbar vertebrae was taken. All measurements were taken twice and the mean was calculated to reduce the observer's bias. Deformed and broken vertebrae were excluded from the study. Paired t-test was uses to find the statistical significance of the observations. The following measurements on both sides were recorded using a sliding vernier caliper.

a) Vertical height: 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.
b) Pedicle width: Measured at the points on the medial and lateral surfaces of each pedicle at right angle to the long axis of pedicle.
c) Interpedicular distance: This is the maximum distance between the medial surfaces of the right and left pedicles of the same vertebra. This was recorded as the transverse diameter of the vertebral canal.

Fig. Measurement of Height of pedicle

Fig. Measurement of Width of pedicle

Fig. Measurement of Interpeduncle distance

Results:

Following observations were made from the data collected and results were analyzed statistically.

Table 1. Vertical height of the pedicles

Lumbar vertebrae	Right (Mean ± SD) in cms	Left (Mean ± SD) in cms	t-value	Minimum		Maximum	
				Right	Left	Right	Left
L1	1.39±0.09	1.38±0.08	0.19	1.19	1.18	1.58	1.55
L2	1.40±0.12	1.38±0.09	0.27	1.2	1.23	1.65	1.56
L3	1.46±0.12	1.47±0.11	0.36	1.32	1.27	1.73	1.64
L4	1.41±0.18	1.41±0.18	0.92	1.14	1.17	1.85	1.84
L5	1.28±0.16	1.25±0.15	0.10	1.03	0.96	1.82	1.56

Table 2. Width of the pedicles

Lumbar vertebrae	Right (Mean± SD)in cms	Left (Mean± SD)in cms	t-value	Minimum		Maximum	
				Right	Left	Right	Left
L1	0.68±0.17	0.66±0.15	0.38	0.45	0.45	1.09	1.05
L2	0.86±0.31	0.84±0.30	0.20	0.53	0.52	1.79	1.72
L3	0.86±0.11	0.86±0.12	0.84	0.69	0.73	1.23	1.33
L4	1.05±0.24	1.05±0.27	0.88	0.71	0.71	1.79	1.89
L5	1.45±0.24	1.46±0.25	0.72	1.03	1.00	1.99	2.03

Table 3. Inter-peduncle distance

Lumbar vertebrae	Inter-peduncle distance (Mean±SD) in cms	Minimum	Maximum
L1	1.89±0.19	1.35	2.25
L2	2.04±0.18	1.79	2.50
L3	2.05±0.14	1.80	2.40
L4	2.05±0.22	1.51	2.45
L5	2.29±0.26	1.92	2.89

Discussion:

Different studies were done on the lumbar pedicle considering its importance in weight transmission and related trauma. Various cadaveric, radiographic and ostiological studies are done for getting the morphometerical data on the lumbar pedicles. In 1994, Amonoo-Kuofi[5] studied the horizontal and vertical diameters of the pedicles of the lumbar vertebrae from plain anteroposterior radiographs of the lumbar spines of male and female subjects aged from 10 to 65 years from Saudi Arabia. The results showed that there was a significant difference between the pedicle diameters of males and females. Horizontal diameters ranged from 7.4 to 13.6 mm in females and from 7.5 to 14.2 mm in males. Female vertical diameters ranged from 14.2 to 18.2 mm while male vertical diameters ranged from 14.8 to 20.7 mm. There was increase of horizontal and vertical diameters from L1 to L5 in both sexes.

In 2004, Singel, Patel and Gohil[6] studied 60 lumbar vertebrae, 45 males and 15 females from Jamnagar, West India. Their observation showed that there was always an increase in width of lumbar pedicles proceeding from L1 to L5 levels and the width being maximum at L5 level to enable in weight transmission. The observation also showed that the height of lumbar pedicles decreases from L3 to L5 levels i.e. at the lower lumbar levels to enable the transmission of weight through thoracolumbar region. This finding was different from Amonoo-Kuofi but nearly same as present study.

In 2006, Arora, Dada and Singh[7] studied dry lumbar vertebrae pedicle in 25 male and 30 female vertebrae from Gaziyabad, North India. Horizontal and vertical diameter of the pedicle showed an increase in measurement from L1 to L5 vertebrae. These findings differ from that of the present study regarding height of the pedicled but similar to findings of Amonoo-Kuofi.

In 2007, Defino and Vendrame[8] performed study on 10 lumbar spine fragments from adult cadavers. The pedicles were cross-sectioned on both sides at the level of their smallest diameter. The following parameters were bilaterally assessed: pedicle shape and diameter, cortical walls thickness, pedicle area, cortical bone area, spongy bone area, and percentage of spongy and cortical bone of the pedicle. The vertebral pedicle of the lumbar spine has an oval shape, its vertical diameter is larger than its horizontal diameter, the medial cortical bone wall is thicker, and the area of the pedicle increases from L1 to L5, and the cortical and spongy bone areas ratio is constant throughout the extension of the lumbar spine. In 2007, Prakash et al.[9] done anatomical study on bones and X-rays regarding

pedicles of lumbar vertebrae in two parts in Mangalore, South India. In the first part of the present work direct gross measurements of 3 different diameters (v, d, and 1) of both the pedicles of LI to L5 vertebrae (200 male and 200 female) were recorded through sliding vernier caliper. In the second part plain anteroposterior radiographs of the lumbar spine from 500 individuals (250 males and 250 females) were collected, and divided in 6 age groups and 2 different diameters (t and h) were recorded. The minimum horizontal diameter (d) of both the pedicles increased from LI to L5. Whereas, the vertical height (v) of both the pedicles increased from LI to L2, decreased from L2 to L3 and increased from L3 to L5. The anteroposterior length (l) increased bilaterally from LI to L2 and decreased from L2 to L5. All the aforementioned parameters were greater in male than corresponding vertebraof female. Same trends were confirmed by the radiological study.

In 2011, Aruna and Rajeshwari[10] studied pedicles in 44 dry adult lumbar vertebral sets from Bangalore, South India. The vertical and horizontal diameters of the pedicle were measured using vernier calipers. The product of the two was calculated to get the pedicle index, which represented the size and strength of the pedicle. The horizontal and vertical diameters of the lumbar pedicles ranged from 7.40 to 17.52 and 14.82 to 12.33 mm. the mean vertical diameter have gradually decreased from L1 to L5 and the mean horizontal diameter have increased from L1 to L5. And the pedicle index increased from L1 to L5. These findings again differ from present study and study conducted by Amonoo-Kuofi(1994), Arora(2006), Prakash(2007) regarding height of the pedicle.

In 2011, Chawla et al.[11] conducted study on 30 dry lumbar vertebrae and 10 adult male cadavers from Chandigarh, North-West India. In the dry bone specimens the mean height of the pedicle was 14.0 ± 1.1 mm on right side and on left side the mean was 14.1 ± 1.0 mm. The mean width of the pedicle was 8.7 ± 1.4 mm on right and on the left side the mean was 8.7 ± 1.7 mm. The mean interpedicular distance (GH) between the medial surface of the right and left pedicle of the same vertebrae was 20.5 ± 1.3 mm. The correlation coefficient between the height and width of the pedicle was 0.429, pointing to a positive correlation between the two. In cadaveric specimen, Interpedicular distance between adjacent lumbar vertebrae: This is the vertical diameter of the intervertebral foramina at its rim and was measured from the root of the transverse process of the vertebra above to the root of the transverse process of the vertebra below. An increase was seen in the interpedicular distance between adjacent lumbar vertebrae from the Ll-L2 to L2-L3 levels and thereafter a decrease from the L3-L4 to L4-L5 levels on the right side. On the left side, a similar trend was seen, except that L2-L3 and L3- L4 had similar means. The difference in the measurements between the right and left side was statistically insignificant except at L1-L2 level. Interpedicular distance between the medial surface of the right (G) and left (H) pedicle of the same vertebrae.

In 2012, Vinay and Vishal[12] conducted study on 150 plain antero-posterior radiographs of lumbar spine of 150 healthy subjects (88 males and 62 females) from Mangalore, South India between the age group of 20 to 50 years. The Transverse diameter of spinal canal (TDC) and Transverse diameter of vertebral body (TDB) were measured at levels L1 to L5 using CR-35X digitizer. The results showed that the mean TDC and TDB increased gradually from L1 to L5 being minimum at L1 and maximum at L5. The intersegment differences of TDC were calculated, which helps in detection of isolated segmental anomalies and helpful to identify stenosis or dilatation of the spinal canal.

Pedicle screw instrumentation was recently approved by the US Food and Drug Administration for use in degenerative spondylolisthesis, degenerative lumbar spinal stenosis, although surgical decompression is warranted in patients with unremitting or progressive symptoms and neurologic deficit. Spinal fusion may be necessary for operative success.[13]

There is a high prevalence of lumbosacral transitional vertebra (LSTV) a degenerative disease in the population. This pathology has been reported to be related with increased interpedicular distance. It is a probability that some cases with this pathology can require posterior spinal instrumentation.[14] The dorso-lumbar spine is the most frequent site for injuries, osteoporosis, and other degenerative disorders like lumbar spondilosis.[15]

Also when we compare present study with previous one, a regional variation was seen in the pedicle width which should be kept under consideration.

Conclusion:

Since the dorso-lumbar spine is the most frequent site for injuries, osteoporosis, and other degenerative disorders like lumbar spondilosis. Morphometric knowledge of the pedicles is important for orthopedic surgeons and radiologist for proper selection of the pedicle screw for operative repair of such disorders.

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