Radiological Evaluation of Horizontal and Vertical Diameters of the Pedicle of Lumbar Vertebrae in Adult Bangladeshi People of Different Body Weight

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Submission Date : 26 Oct 2024
Accepted Date : 27 Dec 2024
Published Date : 30 March 2025
DOI: https://doi.org/10.3329/jrpmc.v10i1.81516

Abstract:

Background:
Accurate knowledge of anatomy of spine with clear understanding of pedicle morphology and measurement of pedicle dimensions is crucial for treatment with pedicle screw instrumentation and that can minimize the risks of complications.

Objective:
The present study was carried out to find out the effect of different body weight on pedicle of lumbar vertebrae radiologically in both sexes of adult Bangladeshi people.

Methods:
This cross-sectional analytical study was conducted at the Department of Anatomy of Rangpur Medical College, Rangpur from a period of July 2018 to June 2019. One twenty-four (124) digital radiographs of both sex age ranging from 20 to 45 years. The vertical and horizontal diameters of the pedicles were measured in anteroposterior view of lumbar spine. Before taking radiograph, body mass index was calculated and subjects were grouped according to BMI into group A-normal weight, B-overweight, C-obese in both sexes. The data was analyzed and comparison between three groups A, B and C of both sexes was done.

Result:
The results showed that there were significant differences between pedicle diameters of males and females. Generally, there was a cephalocaudal increase pattern of horizontal diameters and decrease pattern of vertical diameters of both sex of different body weight. The evidence suggests that most of the pedicle's diameters were though higher in overweight and obese but did not vary significantly.

Conclusion:
This data can help the surgeons for performing safe transpedicular surgeries of different body weight people of Bangladesh.

Keywords: Bodyweight, Radiograph, Pedicle, Horizontal, Vertical

Citation: Afrin L, Chowdhury MS, Nawshin N. Radiological Evaluation of Horizontal and Vertical Diameters of the Pedicle of Lumbar Vertebrae in Adult Bangladeshi People of Different Body Weight.J Rang Med Col.2025 Mar;10(1):16-21. doi: https://doi.org/10.3329/jrpmc.v10i1.81516

Introduction:

Pedicles of lumbar vertebrae are thick projections arising from the upper part of the body at the junction of lateral and dorsal surface of the body.[1,2] Success Anterior access to the L1-L5 vertebrae and discs may be technically challenging and frequently requires a special approach by the neurosurgeon for adequate exposure of the operatory field.[3] The last decades have seen an increasing use of transpedicular screwing techniques as a mean of spinal fixation.[4] Transpedicular fixation is done in spinal fractures or degeneration of the spine and other conditions of spinal instability.[5] In transpedicular screw fixation depends on screw size, pedicle dimensions and the density of vertebra.[6] If there is disproportionate pedicle and the screw used either loosening of the screw occur or over penetration of the cortex or even the

fracture of the pedicle can occur. More serious outcomes as dural tears, CSF leak and nerve root injury with neurological deficits can occur.[7] A screw enables various devices (plates, rods or wires) to be applied to the spine for immobilization or fixation. The success of the technique depends upon the ability of the screw to obtain and maintain purchase within the vertebral body.[8] This is determined, among other factors, by the accurate choice of the screw, the size of the pedicle and the quality of the pedicle bone. The choice of the screw for the procedure is in turn determined by the minimum horizontal diameter of the pedicle.[9] Morphometric data on diameters of the pedicles are, therefore, useful in preoperative planning and in designing of pedicle screws. Pedicle screw systems provide significant and, in many cases, improved and previously unattainable spinal fixation. Preoperative determination of especially the horizontal diameter of the pedicles to be used for screw implantation from standardized Anteroposterior X-rays is the easiest way to avoid complication.[10] However, pedicle screw systems represent difficult surgical techniques involving several potential problems and complications. Only by detailed knowledge of the anatomy of the spine, with a clear understanding of the pedicle screw systems implementation, can the risks of complications be minimized.[11]

Methods:

This cross-sectional analytical study was conducted at the Department of Anatomy, Rangpur Medical College, Rangpur from a period of July 2018 to June 2019. The patient who came for another cause rather than musculoskeletal system was requested to do an X-ray of lumbar spine. 124 plain digital X-rays were collected from the Radiology Department of a well-known diagnostic center of Rangpur. For vertical and horizontal diameter of pedicle were taken from anteroposterior view of lumbar spine. Informed written consent was obtained from the subjects informing details of the purpose of the study. Subjects aged from 20 to 45 years were chosen by convenient sampling as per inclusion and exclusion criteria. Before taking radiograph body mass index (BMI) were calculated and subjects were grouped according to BMI into group A-normal weight, B-overweight, C-obese. Among them twenty-two, twenty and twenty subjects of both sexes were included in group A, B and C respectively. According to WHO (1995) normal weight is defined as BMI 20–24.9 kg/m^2. Overweight is defined as BMI 25–29.9 kg/m^2. Obesity is defined as BMI 30–39.9 kg/m^2.[12] The study was approved by the Ethical Review Committee of Rangpur Medical College, Rangpur. The measurements were taken by standardized plastic measuring scale and digital slide calipersdirectly on the X-ray films and recorded in millimeters.

Procedure of measurement of horizontal diameter of lumbar vertebral pedicle:

In AP radiographs pencil marks were placed on the limits (on the plain radiograph, the outline of the pedicle is somewhat oval) of the pedicle and diameters were measured in two perpendicular planes. The horizontal diameter was taken as a maximum diameter in a plane right angle to the vertical. The diameter of pedicles for each lumbar vertebra of both side on antero-posterior view recorded in millimeter by digital slide calipers[13] showed in Figure-(A).

Procedure of measurement of vertical diameter of lumbar vertebral pedicle:

In AP radiographs pencil marks were placed on the limits of the pedicle (on the plain radiograph, the outline of the pedicle is somewhat oval) and diameters were measured in two perpendicular planes. Vertical diameter was taken as a maximum diameter in the sagittal plane. The diameter of pedicles for each lumbar vertebra of both side on antero-posterior view recorded in millimeter by digital slide calipers[13] showed in Figure-1(B).

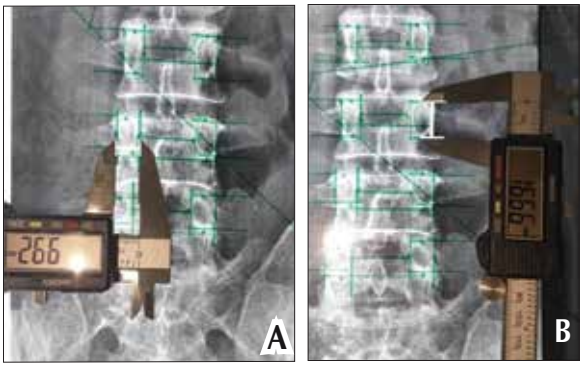

Figure-1(A&B): Photograph showing lumbar vertebral horizontal diameter of right pedicle of male in anterior posterior view

Figure 1(B) Photograph showing lumbar vertebral vertical diameter of left pedicle of male in anterior posterior view

Statistical processing of data:

The data collected were processed according to their distributions, central tendencies, and

dispersions. Then results were prepared in terms of ranges, frequency distributions, mean values, standard deviations (SD), percentage value etc. as applicable. Mathematical relationships for measurements of two groups were calculated by statistical analyses unpaired student's 't' test. The level of significance was set as $p<0.05$ at 95% confidence intervals. The Statistical analyses were done by using the SPSS software package for windows version 16.00.

Result:

Distribution of average horizontal diameter of lumbar vertebral pedicle (AvHDP) in both sexes:

The higher mean value of AvHDP, most of the lumbar disc (except L1 level, value of overweight was higher than obese) was found in obese subjects than normal weight and overweight but statistically, the difference did not reach in significant level in all subjects. In craniocaudal direction, the AvHDP of lumbar vertebra increase gradually in all group of both sexes except in female values of L2 level in normal weight was lower than L1 (Table-I).

When comparison was done between males and females of three weight groups, it was observed that significantly higher mean value was found in males at all levels than females (Table-II).

Table-I: Comparison of average horizontal diameter of lumbar vertebral pedicle in between normal weight (n=22), overweight (n=20) and obese (n=20) in both sexes

Average horizontal diameter of lumbar vertebral pedicle (mm)	Gender	Normal weight (A)	Overweight (B)	Obese (C)	p-valuefor significant difference between groups (p<0.05)
L1	Male	9.74±1.61 6.6-13	9.15±1.48 6-12	10.25±1.22 8-13.2	A vs B = NS A vs C = NS B vs C = NS
	Female	7.65±1.42 5.7-11.5	8.11±1.00 6-10	7.70±1.37 6-11	A vs B = NS A vs C = NS B vs C = NS
L2	Male	9.87±1.84 6.6-14.2	9.48±1.36 7-11.8	10.48±1.54 8-14.5	A vs B = NS A vs C = NS B vs C = NS
	Female	7.53±1.60 5.06-11.5	8.29±1.10 6-10	8.00±1.35 6-11	A vs B = NS A vs C = NS B vs C = NS
L3	Male	10.24±1.72 6.6-14.4	10.33±1.46 8-13.2	11.25±1.42 8.9-15.3	A vs B = NS A vs C = NS B vs C = NS
	Female	8.25±1.53 5.8-11.5	8.99±1.07 7-11	9.16±1.86 6.75-14.5	A vs B = NS A vs C = NS B vs C = NS
L4	Male	11.40±2.12 6.6-16.7	11.23±1.61 9.1-14.2	12.01±1.83 9.2-17.5	A vs B = NS A vs C = NS B vs C = NS
	Female	9.06±1.66 5.8-12	9.90±1.09 8.75-13	9.89±1.35 7.52-12	A vs B = NS A vs C = NS B vs C = NS
L5	Male	12.86±2.30 7.8-17.3	12.8±1.69 9.4-15.5	13.32±1.70 11-18	A vs B = NS A vs C = NS B vs C = NS
	Female	10.34±1.90 7.3-14	11.1±1.22 9.8-14	11.49±1.27 8.25-14	A vs B = NS A vs C = NS B vs C = NS

Results are shown as range and mean±SDs; S= Significant, NS= Non-significant

Table-II: Comparison between normal weight, overweight, obese subject regarding average horizontal diameter of lumbar vertebral pedicle in male and female

Average horizontal diameter of lumbar vertebral pedicle (mm)	Gender	Normal weight Mean±SD	p-value	Overweight Mean±SD	p-value	Obese Mean±SD	p-value
L1	Male	9.74±1.61	.000	9.15±1.48	.013	10.25±1.22	.000
	Female	7.65±1.42		8.11±1.00		7.70±1.37	
L2	Male	9.87±1.84	.000	9.48±1.36	.004	10.48±1.54	.000
	Female	7.53±1.60		8.29±1.10		8.00±1.35	
L3	Male	10.24±1.72	.000	10.33±1.46	.002	11.25±1.42	.000
	Female	8.25±1.53		8.99±1.07		9.16±1.86	
L4	Male	11.40±2.12	.000	11.23±1.61	.004	12.01±1.83	.000
	Female	9.06±1.66		9.90±1.09		9.89±1.35	
L5	Male	12.86±2.30	.000	12.83±1.69	.001	13.32±1.70	.000
	Female	10.34±1.90		11.11±1.22		11.49±1.27	

Results are shown as range and mean±SDs

Distribution of average vertical diameter of lumbar vertebral pedicle (AvVDP) in both sexes: Higher mean value of AvVDP of all lumbar disc was found in overweight subjects than normal weight at all level in both sexes. Values of obese were lower in male than overweight male but in female values were higher in obese than overweight at L1, L2 and L5 level. The difference was statistically nonsignificant in all level. In craniocaudal direction, the AvVDP of lumbar vertebra decrease gradually in all groups in both sexes (Table-III).

Table-III: Comparison of average vertical diameter of lumbar vertebral pedicle in between normal weight (n=22), overweight (n=20) and obese (n=20) in both sexes

Average vertical diameter of lumbar vertebral pedicle (mm)	Gender	Normal weight (A)	Overweight (B)	Obese (C)	P value for significant difference between groups (p≤0.05)
L1	Male	16.89±1.59 13.6-19.8	17.17±1.88 13-21.2	16.86±1.96 13.5-20.5	A vs B = NS A vs C = NS B vs C = NS
	Female	14.71±1.82 11.43-18.5	15.42±1.54 13-18.4	15.51±1.46 12-19	A vs B = NS A vs C = NS B vs C = NS
L2	Male	16.45±1.42 14.05-20	17.06±1.77 13-21	16.78±1.94 13.5-20	A vs B = NS A vs C = NS B vs C = NS
	Female	14.33±1.92 11.3-18.5	15.32±1.47 12-17.8	15.44±1.35 12-18	A vs B = NS A vs C = NS B vs C = NS
L3	Male	15.69±1.57 12.51-18.5	16.44±1.71 12.6-19.8	16.21±2.42 12.6-23	A vs B = NS A vs C = NS B vs C = NS
	Female	14.05±1.77 11.4-17.6	14.58±1.57 11-17	14.48±1.43 10.92-17	A vs B = NS A vs C = NS B vs C = NS
L4	Male	14.69±1.34 12-17.4	15.32±1.19 12.6-17.6	14.90±1.77 12-19	A vs B = NS A vs C = NS B vs C = NS
	Female	12.92±1.81 9.8-16.9	13.65±1.35 11-16	13.55±1.38 10.49-16.25	A vs B = NS A vs C = NS B vs C = NS
L5	Male	13.63±1.59 8.7-15.8	14.13±1.30 11.6-16.25	14.06±1.55 11.8-18	A vs B = NS A vs C = NS B vs C = NS
	Female	11.72±1.90 7.7-15	12.45±1.23 10-15	12.68±1.35 9.08-15.5	A vs B = NS A vs C = NS B vs C = NS

Results are shown as range and mean±SDs, S= Significant, NS= Non-significant

When comparison was done between males and females of three weight groups, it was observed that significantly higher mean value was found in males at all levels than females (Table-IV).

Table-IV: Comparison between normal weight, overweight, obese subject regarding average vertical diameter of lumbar vertebral pedicle in male and female

Average vertical diameter of lumbar vertebral pedicle (mm)	Gender	Normal weight Mean±SD	p-value	Overweight Mean±SD	p-value	Obese Mean±SD	p-value
L1	Male	16.87±1.59	.000	17.17±1.88	.003	16.86±1.96	.018
	Female	14.71±1.82		15.42±1.54		15.51±1.46	
L2	Male	16.45±1.42	.000	17.06±1.77	.002	16.78±1.94	.015
	Female	14.33±1.92		15.32±1.47		15.44±1.35	
L3	Male	15.69±1.57	.002	16.44±1.71	.001	16.21±2.42	.010
	Female	14.05±1.77		14.58±1.57		14.48±1.43	
L4	Male	14.69±1.34	.001	15.32±1.19	.000	14.90±1.77	.011
	Female	12.92±1.81		13.65±1.35		13.55±1.38	
L5	Male	13.63±1.59	.001	14.13±1.30	.000	14.06±1.55	.005
	Female	11.72±1.90		12.45±1.23		12.68±1.35	

Results are shown as range and mean±SDs

Discussions:

Accurate knowledge of pedicle morphology and measurement of pedicle dimensions is crucial for treatment with pedicle screw instrumentation.[14] Different researchers of other countries had the results of different variables of measurement of pedicles related with age and gender but there is no published work on effect of BMI on pedicles. Hence, a comparative discussion was done with effect of BMI on pedicles with that of measurement of pedicles related with age and gender of different authors and researchers of the other countries.

In present study horizontal and vertical diameter of pedicles where comparison was done between normal weight, over weight and obese group of male and female age ranging from 20 to 45 years. The horizontal diameter of pedicles (AvHDP), most of the higher mean value of lumbar disc was found in obese subjects than normal weight and overweight subjects. Statistically the difference did not reach in significant level in all subjects. In craniocaudal direction, the AvHDP of lumbar vertebra increase gradually in all group of both sexes except in female values of L2 level in normal weight was lower than L1 but L3, L4 and L5 gradually increase pattern persist. When comparison was done between male and females it was observed that male values were significantly higher than females at all levels in A, B and C groups.

The vertical diameter of pedicles (AvVDP), in male mean value was higher in B group than A group but value in C group was slightly lower than B but higher than A at lower three levels. In females value of B group was higher than A at all levels but value of C was either lower or higher than B in alternate manner. However, these differences were statistically not significant. When comparison was done between male and females it was observed that male values were significantly higher than females at all levels in A, B and C groups. Craniocaudally, there was a gradual decrease in AvVDP from L1 to L5 in all three groups of both sexes. The horizontal and vertical diameters of the pedicles of present study correlate well with figure published by Kadioglu et al[15] on Anatolian, Lien et al[16] on Taiwanese and Zindric et al[6] on Indians showed gradual cephalocaudal increase in horizontal diameter while vertical diameter showed a gradual decrease as we go down. On the other hand, the study conducted by Amonoo Kuofi[17] in Saudi Arabia, Olseki et al[18] on cadaveric Americans and Sugisaki et al[19] on American people reported gradual cephalocaudal (from L1 to L5) increase in horizontal diameter as well as vertical diameter. Thus, there is a general agreement regarding the cephalocaudal pattern of change of the horizontal diameter of the pedicle while diverging results (increase, decrease or constant) have been recorded regarding for the vertical diameters. Those variations are attributed to racial, ethnic or regional variation.

Conclusion:

Regarding pedicles of lumbar vertebrae, horizontal diameter and vertical diameter of pedicles were though higher in overweight and obese but did not vary significant. Horizontal diameter increases as

we go down from L1 to L5 in all groups except in female values of L2 level in normal weight was lower than L1 and vertical diameter decreases from L1 to L5 vertebra in all groups. The measurement obtained from this study form a base line for Bangladeshi adult people and may give guidance to clinicians for evaluation and treatment of spinal fixation.

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