

# **A Study of the Anthropometry of the Radiographic Lumbar Pedicles of Nigerians in Niger-Delta Region**

**A.I. UDOAKA, \*O.J. AKPORE**

Department of Anatomy, College of Health Sciences, University of Port Harcourt, Nigeria

\*Author for correspondence

## **ABSTRACT**

The Lumbar Pedicles play an important role in the transmission of weight in the Lumbar spine. They are useful in the study of the spine especially in the radiological diagnosis of a mass lesion of the spine and in the assessment of pedicle screw size and position. 500 normal anterior-posterior radiographs of adult Nigerians of the Niger Delta region were studied. The width and height of each pedicle were measured. The mean height was least at L<sub>1</sub> in the males and L<sub>4</sub> in the females and highest at L<sub>5</sub> in both genders. There was a progressive increase in width from L<sub>1</sub>, the least to L<sub>5</sub> the widest in both genders. The males in general tended to have larger pedicles than the females but the differences were not statistically significant ( $P>0.05$ ). The knowledge of these parameters is invaluable to the orthopedic surgeons and the radiologists.

**Key words:** Lumbar Pedicles, height, width, radiographs Niger Delta region.

The pedicle is the strongest part of the vertebral arch and acts as a strut to transmit forces between the body and the neural arch (Pal and Routal 1986, 1987). It is made entirely of cortical bone with a small core of cancellous bone (Roy-Camille et al 1986). On radiographs knowledge of the pedicle morphology is useful in the early radiological diagnosis of a mass lesion of the spine especially the intradural, extramedullary tumours which are associated with pedicle erosion. (Francel 1998).

The transpedicular screw implantation technique has gained popularity as a method of spinal fixation, the pedicles on radiographs have become useful in the study of the spine to determine the pedicle screw position (Sapkis et al 1999) and the screws size (Anastosis et al 2005). The transverse diameter of the pedicle (the pedicle width) determines the screw diameter while the vertical diameter (height) of the pedicle determines the screw path.

Complication of dural tears, leakage of cerebro-spinal fluid and injuries to nerve roots are associated with mismatched sizes, (Amonoo-Kuofi 1995). Studies on the pedicle morphology have been carried out by several workers including Roy-Camille (1984) Zindrich et al (1987) Berry et al (1987) Krag (1988). Recently Singel et al (2004), Anastosis et al (2005) and Arora et al (2006) have also studied the lumbar pedicles. Their findings have shown that the L<sub>5</sub> pedicle is the widest of all of them. Schneck (1989) indicated that the characteristic morphology and size of the lower

lumbar pedicles particularly L5 results from its role in preventing forward slide of L<sub>5</sub> on S<sub>1</sub>. Sexual dimorphism in pedicle morphology was noted by Scoles (1988), Olseuski (1990), Amonoo-Kuofi (1995), Anastosis et al (2005) and Prakash et al (2007). They reported statistically significant sex differences in pedicle morphology with males having larger pedicles than the females.

Racial variations which are well known in the skeleton, have also been reported in the morphology of the pedicle in difference populations, (Krogman (1978). Even within the same population variations were reported on pedicle shape, size and angulation. Weinstein et al (1992) Kin et al (1994) showed racial variations in pedicle size in Koreans. They noted significant differences from the Caucasian figures. Racial variations were also reported in the studies by Arora et al (2006) Northern Indians and Singh et al (2004) in Western Indians.

The aim of this study was to determine the pedicle width and height of the lumbar vertebrae in the Southern Nigerian population bearing in mind the racial, regional and gender differences, and the possibility of sexing the lumbar vertebrae using the pedicles.

## **MATERIALS AND METHOD**

The measurement of the lumbar pedicles was carried out using plain antero-posterior radiographs of the lumbar spine of 500 adult subjects (212 males and 288 females). The radiographs were collected randomly from the achieves of the Radiological



Departments of the University of Port Harcourt Teaching Hospital, Port Harcourt and the Braithwaite Memorial Specialist Hospital, Port Harcourt. Only those identified to be of Niger Delta region by their bio-data records were used for the study. All the radiographs were of normal findings and viewed with a viewbox, measurements taken with a measuring rule.

According to Prakash et al (2007), the maximum dimension of the pedicle in the vertical plane was recorded as the height and the maximum diameter in the horizontal plane at right angles to the vertical plane was recorded as the width. Measurements of the right and the left pedicles of all the lumbar vertebrae were recorded in millimeter (mm).

## RESULTS

Table 1 shows the means, standard deviation and range of height and width of the left and right pedicles of males. The height of the right pedicle increased from L<sub>1</sub> to L<sub>3</sub>, reduced at L<sub>4</sub> and then increased at L<sub>5</sub>. The left pedicle height decreased from L<sub>1</sub>, L<sub>2</sub>, increased at L<sub>3</sub>, decreased again at L<sub>4</sub> and then increased maximally at L<sub>5</sub>. The maximum mean height of the pedicle for males was 18.10mm for the right side and 18.56 for the left side. The minimum mean height was 17.28mm on the right and 17.00 on the left. The maximum mean width of pedicle for males was recorded at L<sub>1</sub> (13.74 for right and 23.76 for left side) while the minimum mean width of the pedicle for males was 9.55mm for right and 9.34mm for the left.

Table 2 shows that the height and width of lumbar pedicles in females were also maximal at L<sub>5</sub> level (18.31mm for right and 18.56mm for left). The minimum mean height was at L<sub>4</sub> level on the right (17.09mm) and at L<sub>1</sub> level on the left (17.12mm). The maximum mean width for females was also found at L<sub>5</sub> level for both right and left sides (13.68mm for right and 13.76mm for left). The minimum mean width was at L<sub>2</sub> level (9.21mm) on the right and L<sub>1</sub> (9.16mm) on the left.

As shown in Table3, the mean pedicle height of females was more than that of the males in most of the lumbar vertebrae, but the differences were not significant ( $P>0.05$ ) only the L<sub>3</sub> and L<sub>4</sub> pedicles of the males on the right were found to be larger and L<sub>4</sub> being significantly so ( $P<0.001$ ). The L<sub>4</sub> and L<sub>5</sub> pedicles on the left are equal in both makes

and females.

From Table 4, on the right side, the male mean pedicle width was greater than the females and significant in most of them ( $P<0.001$ ). The L<sub>5</sub> male pedicle was not significantly greater ( $P>0.05$ ). From the left side, the male pedicle width was significantly more in L<sub>1</sub> and L<sub>3</sub> ( $P<0.001$ ) while the female pedicle width was more only in L<sub>2</sub> ( $P<0.001$ )

**Table 1:** The right and left pedicle sizes of the lumbar vertebrae in male Nigerians

Males (n=212)					
Right			Left		
	Height (mm)	Width (mm)	Height (mm)	Width (mm)	
L <sub>1</sub> Mean	17.28	9.55	17.08	9.34	
SD	0.30	0.24	0.60	0.48	
Range	11-23	5-12	10-22	6-14	
L <sub>2</sub> Mean	17.30	9.88	17.00	9.63	
SD	0.45	0.24	0.82	0.41	
Range	11-22	7-13	12-22	7-13	
L <sub>3</sub> Mean	17.69	10.90	17.56	10.69	
SD	2.39	0.41	1.08	0.46	
Range	9-27	6-14	9-22	6-16	
L <sub>4</sub> Mean	17.60	12.29	17.22	11.13	
SD	1.90	0.87	1.36	0.60	
Range	14-27	8-19	10-22	6-20	
L <sub>5</sub> Mean	18.10	13.74	18.56	13.76	
SD	1.28	0.65	1.19	0.86	
Range	10-24	10-17	11-23	10-20	

**Table 2:** The right and left pedicle sizes of the lumbar vertebrae in females Nigerians.

Females (n = 288)					
Right				Left	
	Height (mm)	Width (mm)		Height (mm)	Width (mm)
L <sub>1</sub> Mean	17.37	9.35		17.12	9.16
SD	1.45	1.23		1.32	0.48
Range	9-25	6-15		11-26	6-14
L <sub>2</sub> Mean	17.40	9.21		17.27	9.74
SD	2.15	0.16		1.66	0.41
Range	11-28	7-15		11-27	7-14
L <sub>3</sub> Mean	17.62	10.75		17.72	10.69
SD	1.62	0.41		0.63	0.46
Range	7-22	6-14		11-22	6-16
L <sub>4</sub> Mean	17.09	11.96		17.22	10.69
SD	1.01	0.22		1.36	0.60
Range	10-22	8-20		10-22	6-20
L <sub>5</sub> Mean	18.31	13.68		18.56	13.76
SD	1.41	0.62		1.19	0.86
Range	10-23	10-20		11-23	10-20

**Table 3:** The mean height of the pedicles in Nigerian males and females with a test of significance.

		Male		Female		Male		Female	
		Right				Left			
		Height (mm)	Width (mm)			Height (mm)	Width (mm)		
L <sub>1</sub>	Mean	17.28	17.37			17.08	17.12		
	SD	0.30	1.45	P>0.05		0.60	1.32	P>0.05	
L <sub>2</sub>	Mean	17.30	17.40			17.00	17.27		
	SD	0.45	2.15	P>0.05		0.82	1.66	P>0.005	
L <sub>3</sub>	Mean	17.69	17.62			17.56	17.72		
	SD	2.39	1.62	P>0.05		1.08	0.63	P>0.01	
L <sub>4</sub>	Mean	17.60	17.09			17.22	17.22		
	SD	1.96	1.01	P<0.001		1.36	1.36	-	
L <sub>5</sub>	Mean	18.10	18.31			18.56	18.56		
	SD	1.28	1.41	P>0.05		1.19	1.19	-	

**Table 4:** The mean width of the pedicles in Nigerian males and females with test of significance

		Male		Female		Male		Female	
		Right				Left			
		Height (mm)	Width (mm)			Height (mm)	Width (mm)		
L <sub>1</sub>	Mean	9.55	9.35			9.34	9.16		
	SD	0.24	1.23	P>0.005		0.48	0.48	P>0.001	
L <sub>2</sub>	Mean	9.88	9.21			9.63	9.74		
	SD	0.24	0.16	P>0.001		0.41	0.14	P>0.001	
L <sub>3</sub>	Mean	10.90	10.75			10.69	10.69		
	SD	0.41	0.41	P>0.001		0.46	0.46	No difference	
L <sub>4</sub>	Mean	12.29	11.96			11.13	10.69		
	SD	0.87	0.22	P<0.001		0.6	0.6	P<0.001	
L <sub>5</sub>	Mean	13.74	13.68			13.76	13.76		
	SD	0.65	0.62	P>0.05		0.86	0.86	No difference	

**Table 5:** The mean dimensions of both right and left pedicle sizes in Saudi Arabian population (Amonoo-Kuofi) compared to the present study.

		Amonoo-Kuofi		Present study	
		Males	Females	Males	Female
L <sub>1</sub>	Height(mm)	19.40	16.30	17.18	17.24
	Width (mm)	10.30	8.70	9.44	9.25
L <sub>2</sub>	Height (mm)	18.90	15.30	17.15	17.33
	Width (mm)	10.70	9.00	9.75	9.47
L <sub>3</sub>	Height (mm)	19.30	15.90	17.62	17.67
	Width (mm)	12.10	10.50	10.79	10.72
L <sub>4</sub>	Height (mm)	19.90	16.10	17.411	7.15
	Width (mm)	13.00	11.10	11.711	1.54
L <sub>5</sub>	Height (mm)	20.70	17.50	18.33	18.4
	Width (mm)	14.20	12.50	13.75	13.72

## DISCUSSION

The pedicle is strong and has the ability to undergo regrowth and remodeling (Krenz and Troup 1973, Filder 1988, Postacchini and Cinotti 1992). This is more so because of its role in weight-bearing and to increasing levels of physical activity associated with individuals aged 18 years and above (Porter et al 1989). The pedicle being also subject to changing mechanical stresses shows appropriate



variation in strength (or diameters). This study showed the maximum width of the pedicle at L<sub>5</sub> in both sexes.

This study showed in average pedicle size for males was 17.41±1.15mm for the height and 10.74±0.52mm for the width that of the females was 17.46±1.38mm and 10.60±0.52mm for height and width respectively. The maximum width for males was 13.75mm while that of females was almost the same (13.72mm). This difference was not significant statistically ( $P>0.05$ ). The wider pedicle size in males was also reported by the study on the Saudi Arabian population by Amonoo-Kuofi et al (Table 5); however the difference in the values in their findings was as great as 1.7mm in contrast to our study that showed only a difference of 0.03mm. Our values are also higher than the people of Saudi Arabian and significantly so ( $P<0.05$ ). The width of the pedicles increased from L<sub>1</sub> to L<sub>5</sub> in our study which is also in keeping with that of Amonoo-Kuofi (1995). Their findings also showed a decrease from L<sub>1</sub> to L<sub>2</sub> in the height of the pedicle and then increase from L<sub>3</sub> to L<sub>5</sub> making L<sub>2</sub> the pedicle with the least height in both sexes. This is contrary to our study that showed a decrease from L<sub>3</sub> to L<sub>4</sub> making L<sub>4</sub> the pedicle with the minimum height. In both studies L<sub>5</sub> had the maximum height. Another study for comparison was the study by Singei et al (2004) who studied the Saurashtra region of India, though it was a study on the cadaveric specimen, the result showed similarities in the width of the pedicles with ours and Amonoo-Kuofi (1995). The differences noted in the various studies can be attributed to racial variations. Amonoo-Kuofi (1995) studied Saudi Arabians, Singei et al (2000) studied the Indian population while ours was on the Southern Nigerian population.

According to Pal and Routal (1987) at level L<sub>5</sub>, where transfer of weight from the anterior to the posterior column takes place, load through the pedicle has to pass in an antigravity direction thus the transfer of load from the body to the laminae in L<sub>5</sub> (and in some cases L<sub>4</sub>) will be upwards always against gravity through the strong pedicles, therefore considering these facts, the L<sub>5</sub> pedicle will always have maximum width.

In conclusion, this study which is in

agreement with earlier authors showed that there is always an increase in the width of the lumbar pedicles from L<sub>1</sub> to L<sub>5</sub>. The values for all the pedicle sizes in our population have been presented, the male values being bigger than of the females.

The height of the pedicles of the males though more than that of the females was not significant ( $P>0.05$ ) except for L<sub>4</sub> on the right side. The width also followed the same trend being wider in the males and significantly so in almost all the pedicles ( $P<0.05$ ) except L<sub>5</sub> on the right where the difference was not significant. These findings have shown sexual dimorphism in the width of the pedicles even in this present study.

## REFERENCES

- Amonoo-Kuofi HS (1995) Age related variations in the horizontal and vertical diameters of the pedicles of Lumbar Spine. *Journal of Anatomy* **186**, 321-328
- Anasotosios GC, Thomas A, Avram P, Ippokratis H, John P (2005) Pedicle dimensions of the thoracic and Lumbar Spine. *Journal of Anatomy* **18** (6) 404-405.
- Arora L, Dada R, Singh V (2006), Morphometric study of the lumbar pedicles in Delhi region of Northern India. *Indian Journal for Practicing Doctor* **3**(5) 11-12
- Berry JL, Moran JM, Berg WS, Steffee AD (1987). A Morphometric study of human lumbar and selected thoracic vertebrae Spine **12**, 362-367
- Fiddler MW (1988) remodeling of the spinal canal after burst fracture. A prospective study of two cases. *Journal of the bone and joint surgery* **70B**: 730-732.
- Francel PC (1998) Consultation with the specialist: Extrinsic spinal Cord mass lesions. *Pediatrics in review* **19**: 389-394
- Kim NH, Lee HM, Chung H, Kim HJ, Kim SJ (1994) Morphometric study of the pedicle of thoracic and Lumbar Vertebrae in Koreans. *Spine Journal* **19**(12) 1390-1394
- Krag MH, Beynon BD, Pope MH et al (1986) An internal fixation for posterior application to short segments of thoracic, lumbar and lumbo-sacral spine. *Clinical Orthopedics and related research* **203**: 75-98
- Krenz J, Troup JDG (1973). The structure of the pars interarticularis of the lower lumbar vertebrae and its relations to the aetiology of Spondylosis. With a report of a healing fracture in the neural arch of 4<sup>th</sup> lumbar vertebrae. *Journal of Bone and Joint Surgery*. **55b**: 735-741
- Krogman WM (1978) Race differences in human skeleton in forensic medicine 3<sup>rd</sup> edition. Charles C, Thomas publishers USA

- Olsewski JM, Simmon EH, Kallen FC, Mendel FC, Severin, CM, Berens DL (1990) Morphology of Lumbar Spine. Anatomical perspectives related to transpedicular screw fixation. *Journal of bone and joint surgery* **72A**: 541-549.
- Pal GP, Routal RV (1986) A study of weight transmission through cervical and upper thoracic region of vertebral column in man. *Journal of anatomy* **148**: 245-246
- Postacchini F, Ciriotti G (1992) Bone regrowth after surgical decomposition for Lumbar Spine stenosis. *Journal of Bone and joint surgery* **74B**: 862-869
- Porter RW, Adam MA, Hutton, WC (1989) Physical activity and strength of Lumbar Spine. *Spine* **14**: 210-203
- Prakash Latha VP, Reganigandha V, Mangala NP, Anu VR, Gajondra S (2007) Morphometry of vertebral pedicle, a comprehensive Anatomical study in the Lumbar region. *International Journal of Morphology* **25**(2) 393-406
- Roy-Camiller R, Salliant G, Mazel C (1986) Internal fixation of Lumbar Spine with pedicle screw planting. *Clinical orthopaedics and related research* **203**: 7-17
- Sapkas, G.S., Papadaki, S.A, Stathakopoulos, D.P, Papagelopoulos PJ, Badeskes AC, Kaiser JK (1999) Evaluation of pedicle screw position in Thoracic and Lumbar Spine fixation using plain Radiograph and computed tomography. A prospective study of 35 patients. *An International Journal for Study of Spine* **24**(18) 19-26
- Schneck CD (1989) The anatomy of Lumbar spondylosis. In *Lumbar interbody fusion* 17-33
- Scoles PV, Linton AE, Latmimer B, Levy ME, Digiovanni BF (1988) Vertebral body and posterior element morphology. The normal spine in middle life. *Spine* **13**, 1082-1086
- Singhi TC, Patel MM, Gohil DV (2004) A Study of width and height of Lumbar pedicles in Saurashtra region: *Journal of Anatomical Society of India* **53** (114)...
- Weinstein JN, Rydevik BL, Rauschnig W (1986) Anatomic and technical considerations of pedicle screw fixation. *Clinical Orthopaedics and related research* **248**: 34-46
- Sindrick MR, Wittse LL, Doornick A, Widell EH, Knight GW, Patwardham G, Thomas JC, Rohman SL, Fields BT (1987) Analysis of morphometric characteristics of the thoracic and Lumbar Pedicles. *Spine* **12**: 160-166