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Morphological Characteristics of Lumber Pedicle: A Study of Adult Nigerian Cadaver

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***Abstract*— Knowledge of pedicle morphometry is important in the surgeons' ability to successfully apply a surgical screw to the spine of patients who need instrumentation for various reasons. This is more so considering that a wrongly placed pedicle screw can produce complications worse than the actual injury itself. Often these may present as spinal cord or nerve root injuries, pedicle fractures, vascular injuries, leakage of cerebrospinal fluid among several others. A total of 185 adult lumber vertebrae, prepared through soil and water maceration were used in this study. There were 34 sets of males and three sets of females. Craniocaudal increase was noted in Pedicle length and thickness from L1 to L5 but this was not statistically significant. Pedicle width was observed to increase in a similar manner. Females had higher pedicle values than their male counterparts and the least was 8.25 mm. The study concludes that pedicle dimensions vary among population and between sex and recommend proper pre-operative evaluation and assessments prior to surgical instrumentation on the lumbar spine.**

***Index Terms*— Lumber, Pedicle screw, Spine, Morphometry.**

I. INTRODUCTION

Precise knowledge of the lumbar pedicles and their relations with neural structures has been proven to be of great importance for surgical interventions. This is true as most surgeons use anatomic landmarks, often in conjunction with fluoroscopy, to guide pedicle screw placement in the lumbar spine. Pedicle screw fixation is a method through whichvertebral reconstruction is achieved.In this method, a screw of appropriate diameter and length is carefully inserted through the pedicle for spine stabilization (Singel, Patel and Gohil, 2004; Tyagi, Chhabra and Narayan, 2017). In situations where the surgery is not properly executed vascular injuries, leakage of cerebrospinal fluid, pedicle fracture, thromboembolism and several other complications linked to surgeries are likely to be encountered (Amonoo-Kuofi, 1995; Vanichchorn et al., 1997; Lonstein et al., 1999).Despite modern techniques, the incidence of pedicle screw misplacement in the lumbar spine is relatively high in some centers although neuronavigation has been shown to improve accuracy of screw placement. However, this technology adds to the time spent under anaesthesia and resources needed for surgery (Maalya et al, 2010) and is currently not available in most developing countries around the world. Although segmental vertebrae morphometry for the thorax (Egwu et al., 2019) and the lumber pedicles (Abiodun et al., 2020) were reported in the

Nigerian population, it is important to evaluate and authenticate the existing information and present verifiable data for the characterization of each segment. Also, the dimensions of thoracic and lumbar pedicles were reported to vary with those obtained from other populations as do other anthropometric dimension, hence, the need for evaluating the existing range of dimensions of spinal pedicle screws according to local population (Badmus et al., 2020).

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II MATERIALS AND METHOD

A total of 185 macerated adult lumber vertebrae which consist of 34 sets of males and three sets of females, were used in this study. Cadavers for maceration were collected from the Department of Anatomy of the University of Port Harcourt and PAMO University of Medical Sciences, Port Harcourt.The vertebral columns were disarticulated and separated from the body thereafter, the bones were prepared by soil and water maceration. There was no use of chemicals, bleaching and polishing so as to avoid loss of collagen and other micro tissues from the end plates and discs and to preserve the chemical integrity of the bones.After thorough maceration, investigations were carried out with general observations for; normal lumbar vertebral formula; L1 - L5 and fusion abnormalities, added vertebrae, missing vertebrae and lumbarization. Bones with obvious pathological deformities were excluded.Measurements on the vertebrae were taken using a digital vernier caliper calibrated to 0.1 mm. All measurements were done with the vertebra placed in the supine position in the axial plane by one member of the research team and in accordance with standard protocols (Kado et al., 2006; White, Black and Folkens 2011; Bogduk 2012; Mavrych et al., 2014; Egwu et al., 2019). Measurements was done three times and the average score was used for the analysis. This was to avoid inter/intra-observer technical error of measurement. The parameters measured include:

i. The **pedicle width**(PDWD)– the transverse length measured from the lateral borders of the pedicle.
ii. The **pedicle height** (PDHT)- the maximum vertical measurement of the pedicle i.e., from the highest point of the superior surface of pedicle to the lowest point on the inferior surface.
iii. The **pedicle thickness** (PDTK)- the maximum measurable thickness of the pedicle.

A. Data Analysis

The mean, standard error of the mean, range and standard deviation were calculated. Unpaired T test was used to compare measured parameters between two variables. Pearman's correlation test was used to assess the relationship between the variables at $p<0.05$ level of significance. Analysis was done using SPSS statistical package.

B. *Ethical Clearance*

Permission to carry out the study was sought from the Department of Human Anatomy, Faculty of Basic Medical Sciences, University of Port Harcourt, Department of Anatomy, Faculty of Basic Medical Sciences, PAMO University of Medical Sciences, Port Harcourt where the study took place and approval was obtained from the College research ethics committee, College of Health Sciences, University of Port Harcourt. Compliance with institutional rules with respect to human experimental research and ethics was strictly adhered to.

III. RESULTS AND DISCUSSION

Pedicle length was found to show a gradual but significant decreased in mean length from L1 to L4. There was no significant change in the mean value between L4 and L5. Females were found to show higher mean values than their males counterpart. These values were higher on the right than the left in all parameters except for females L1 where the left mean values was higher than the right. This is in line with the report from Abiodun et al (2020). However, contrary to their findings, females showed higher pedicle mean values compared to males in the present study and the dimensions were higher on the right than the left from L2 to L5. The mean pedicle length was highest at L1 in males but at L2 in females and lowest at L5 in males but at L4 in females though the difference between L4 and L5 was less than 2mm (Table 1). The pedicle width was found to show gradual significant increase in the mean values from L1 to L5 in both males and females with the females showing higher mean values than their males counterparts and the left having higher mean values than the right in both sex. The highest mean pedicle width was noticed at L5 in both sex while the least mean pedicle width was noted at L1 in males and L2 in females though the difference was not statistically significant. This is in line with the report from Abiodun et al (2020).

Table 1: Descriptive statistics of the Males and Females Pedicle Dimensions (mm)

Vertebrae level	Parameter	N	Range	Minimum	Maximum	Mean ± Std. Deviation	Std. Error
L1 Males	PDHTL	34	8.41	10.80	19.21	17.10 ± 1.92	0.33
	PDHTR	34	8.69	11.00	19.69	17.07 ± 2.20	0.38
Females	PDHTL	3	1.07	18.43	19.50	18.86 ± 0.57	0.33
	PDHTR	3	.25	18.34	18.59	18.44 ± 0.13	0.08
Males	PDWDL	34	4.98	6.02	11.00	8.25 ± 1.17	0.20
	PDWDR	34	4.96	5.62	10.58	8.39 ± 1.30	0.23
Females	PDWDL	3	1.17	8.05	9.22	8.53 ± 0.61	0.36
	PDWDR	3	1.56	9.07	10.63	9.64 ± 0.86	0.50
Males	PDTKL	34	10.24	11.64	21.88	17.45 ± 2.49	0.43
	PDTKR	34	10.91	9.72	20.63	17.34 ± 2.71	0.47
Females	PDTKL	3	1.22	17.63	18.85	18.31 ± 0.62	0.36
	PDTKR	3	1.37	19.06	20.43	19.85 ± 0.71	0.41
L2 Males	PDHTL	34	7.01	12.26	19.27	16.47 ± 2.07	0.36
	PDHTR	34	8.66	11.50	20.16	16.67 ± 2.45	0.42
Females	PDHTL	3	1.00	18.71	19.71	19.05 ± 0.57	0.33
	PDHTR	3	.50	19.23	19.73	19.43 ± 0.27	0.15
Males	PDWDL	34	7.35	6.07	13.42	8.80 ± 1.45	0.25
	PDWDR	34	7.03	5.44	12.47	8.99 ± 1.71	0.30
Females	PDWDL	3	1.28	8.45	9.73	8.91 ± 0.71	0.41
	PDWDR	3	.05	8.45	8.50	8.47 ± 0.03	0.02
Males	PDTKL	34	10.41	9.59	20.00	16.69 ± 2.38	0.41
	PDTKR	34	10.28	10.68	20.96	17.19 ± 2.60	0.45

	Females	PDTKL	3	1.16	16.45	17.61	17.07 ± 0.58	0.34
		PDTKR	3	1.19	18.75	19.94	19.51 ± 0.66	0.38
L3	Males	PDHTL	34	9.58	9.80	19.38	15.11 ± 2.40	0.42
		PDHTR	34	11.92	8.65	20.57	15.38 ± 2.65	0.46
	Females	PDHTL	3	.90	16.62	17.52	16.94 ± 0.51	0.29
		PDHTR	3	1.03	16.90	17.93	17.46 ± 0.52	0.30
	Males	PDWDL	34	8.31	6.22	14.53	10.14 ± 2.18	0.38
		PDWDR	34	7.45	6.57	14.02	9.92 ± 1.86	0.32
	Females	PDWDL	3	1.45	10.20	11.65	10.74 ± 0.80	0.46
		PDWDR	3	.49	10.40	10.89	10.68 ± 0.25	0.15
	Males	PDTKL	34	10.65	9.69	20.34	16.19 ± 2.21	0.39
		PDTKR	34	12.30	9.02	21.32	16.70 ± 2.69	0.47
	Females	PDTKL	3	.65	16.60	17.25	16.91 ± 0.33	0.19
		PDTKR	3	1.48	17.34	18.82	18.19 ± 0.76	0.44
L4	Males	PDHTL	34	10.80	7.96	18.76	13.75 ± 2.06	0.36
		PDHTR	34	10.39	7.71	18.10	14.15 ± 2.48	0.43
	Females	PDHTL	3	1.41	13.44	14.85	14.10 ± 0.71	0.41
		PDHTR	3	1.17	14.17	15.34	14.92 ± 0.65	0.38
	Males	PDWDL	34	8.47	7.59	16.06	11.37 ± 2.40	0.42
		PDWDR	34	7.63	7.17	14.80	11.01 ± 2.42	0.42
	Females	PDWDL	3	1.05	12.60	13.65	13.05 ± 0.54	0.31
		PDWDR	3	.24	13.44	13.68	13.59 ± 0.13	0.08
	Males	PDTKL	34	10.17	11.21	21.38	16.06 ± 2.10	0.37
		PDTKR	34	11.26	12.10	23.36	16.69 ± 2.65	0.46
	Females	PDTKL	3	1.11	15.34	16.45	16.04 ± 0.61	0.35
		PDTKR	3	1.17	17.43	18.60	18.19 ± 0.66	0.38
L5	Males	PDHTL	34	10.02	9.13	19.15	13.48 ± 2.02	0.35
		PDHTR	34	11.21	9.49	20.70	14.41 ± 2.27	0.40
	Females	PDHTL	3	1.02	13.64	14.66	14.10 ± 0.52	0.30
		PDHTR	3	.84	14.93	15.77	15.23 ± 0.47	0.27
	Males	PDWDL	34	10.17	8.60	18.77	14.20 ± 2.99	0.52
		PDWDR	34	10.31	6.94	17.25	13.58 ± 2.62	0.46
	Females	PDWDL	3	1.12	14.33	15.45	14.93 ± 0.56	0.33
		PDWDR	3	.60	15.40	16.00	15.72 ± 0.30	0.18
	Males	PDTKL	34	11.88	12.04	23.92	16.19 ± 2.76	0.48
		PDTKR	34	12.38	10.55	22.93	16.26 ± 2.62	0.46
	Females	PDTKL	3	1.34	14.57	15.91	15.36 ± 0.70	0.41
		PDTKR	3	1.82	14.92	16.74	15.77 ± 0.92	0.53

The pedicle thickness was found to decrease gradually from L1 to L5 in both sex contrary to the findings by Abiodun et al., (2020) with females showing higher pedicle thickness than males. Pedicle thickness between right and left were significantly the same in males but females showed higher thickness values for the right than the left pedicles. Also contrary to our findings is the report by Maalya et al (2010) who reported that the lumbar pedicle gets slightly shorter and significantly thicker from L1 to L5. The lumber pedicles became significantly shorter but not thicker from L1 to L5 (Table 1).

These findings are in agreement with the report by Singel, Patel and Gohil (2004) who also recorded a decrease in vertical height in lumbar pedicles from L1 to L5 in an Indian population but contrary to those of Tan, Teo and Chua, (2004) and Karkhyle et al. (2015) of Chinese Singaporeans and Maharahtarian populations respectively. The difference noted may be due to racial variation.

It has been reported that lumbar pedicular screws are generally within the diameter range of 5.0 to 7.5 mm (Matuoka and Júnior, 2002). Since the findings of this study are higher than the reported screw sizes with the least size being 8.25 mm on the left side of L1, the screws can be considered to be safe for use in surgical procedures though caution should be applied as a misplaced screw can become very traumatic and therefore defeat the aim to which it was placed.

IV CONCLUSION

The dimensions of pedicle screws though much smaller than the least mean sizes of the pedicle from our findings does not confer the inappropriate use of pedicle screws without caution. The use of modern techniques is strongly advised in placing these screws in the course of surgical procedure so as to avoid the undesired result. This study also discovered variation in population specific findings suggesting there may be differences within population or between sex, therefore we recommend that before pedicles screws are used, there should be a proper pre-operative assessment by use of x-ray before surgery and careful evaluation during surgery to avoid post-operative trauma and challenges.

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