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Morphometric Evaluation of the Thoracic Vertebral Pedicle: A Cadaveric Study.

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ABSTRACT

The present study was conducted to provide base line data of the thoracic pedicle using macerated vertebrae bones. One hundred and eighty thoracic vertebrae were studied by direct measurements for linear dimensions of the Mid-Pedicle Width, Pedicle Length, and Pedicle Height in 15 human cadavers using a digital Vernier calliper with accuracy of 0.05mm. SPPSS ANOVA and Turkey Post Hoc multiple comparison tests were used to determine the significance of observed difference between the measured vertebrae dimensions, while Pearson's correlation analysis was used to determine the strength of the relationship. The significance level was set at 95%. Respectively, the highest and lowest mean values; for pedicle length (PL) was found at T12 (17.61±2.4mm) and T3 (14.59±2.09mm) respectively, at T12 (17.34±1.59mm) and T1 (9.78±0.99mm) respectively for pedicle height (PH); and at T12 (T12=11.26±2.78mm) and T4 (5.84±1.17mm) respectively for the mid-pedicle width (MPW). T1 and T12 vertebrae were observed to be significantly different from other vertebrae ($P<0.05$). Of the predictor variables evaluated for estimating pedicle dimensions, MPW had no significant correlation with PL ($r=0.134$; $R2=0.02$, $P=0.07$), MPW was averagely (+) correlated with PL ($r=0.58$; $R2=0.34$, $P<0.01$), while a week (+) correlation between the PL and PH was recorded ($r=0.261$; $R2=0.07$, $P<0.01$). The changes in measurement across the vertebrae can be explained on the basis of segmental musculoskeletal anatomy and biomechanical stress acting on different regions of the spine. Considering the mid-thoracic region, currently available screws used across the world for the thoracic region of adult spine may not be suitable for majority of the Nigerian population. Results of this study will play a key role in the design of other instruments; it will also assist in understanding spine pathologies; and in the management of spinal disorders in this part of the world.

Keywords: Cadavers, Dimensions, Morphometry, Spine, Thoracic pedicles.

INTRODUCTION

In Nigeria, considerable progress has been made in surgical interventions involving the spine, but anthropometric data on the spine morphometry of Nigerian population is scarce. Design of anatomical plates, screws and rods and right implant selection require country specific data to successfully correct deformities, achieve biomechanical stability and prevent multiple repeat surgeries. Thoracic screw fixation is the treatment of choice for many thoracic spine derangement, as it offers some advantages over other modalities.[1] The thoracic region is usually subdivided as upper (T1-T4), middle (T5-T8), and lower (T9-T12) thoracic areas.[2,3]

Detailed understanding of the dimensional anatomy of the bony components which make up the functional spinal units is however fundamental for the bioengineers as well as the spine surgeons and physical therapists concerned with surgical interventions of the spine.[,4,5,6] Various modalities of treatment have evolved over centuries in the treatment of spinal column injury.[7] Spine instrumentation are procedures carried out, with the use of medico-mechanical devices to correct spinal injuries involved with the vertebral column. However, complications may arise without proper understanding of the anthropometric relationships of the vertebrae.

Apart from the surgical implication of the pedicles which have been extensively researched, only a few studies have investigated and reported the anatomical relationship between the pedicles; [5,6,8,9] investigated the linear and angular morphometric measurements of cadaveric thoracic spine by direct anthropometric measurements. Computerised tomographic (CT) study of the spine pedicles has also been extensively investigated;[10,11,12,13,14,15] with ethnic difference documented.[16,17]

However this study is aimed to at providing base line morphometric data on selected dimensions of the thoracic pedicle and their anthropometric relationships.

METHODS

Fifteen (15) sets of intact human vertebrae consisting of 180 thoracic vertebrae (all males) were obtained from the Department of Human Anatomy, University of Port Harcourt in Rivers States, and Niger Delta University, Bayelsa State, both in Southern Nigeria. The sample studied were within the age range of 25-70 years. Muscles and tendons were neatly removed from the surface of the bones by maceration, cleaning, bleaching, polishing and assembly using standard protocols.

Each cadaver was placed in the prone position and the thoracic vertebrae were obtained after removal of all soft tissue. Each vertebra from T1 to T12 was separated individually. Cadavers with gross deformities such as scoliosis or kyphosis were excluded.

All measurements were done directly. The dry vertebra measurements were performed using Vernier callipers with a resolution of 0.01 mm. Each parameter was measured thrice and their averages were calculated and recorded as actual dimension.

The following parameters were measured in the thoracic vertebrae:

Figure 1.1 Mid-pedicle width (MPW): The outer cortical transverse distance of the mid pedicle.

Figure1.2 Pedicle height (PH): The superior inferior outer cortical width of the pedicle measured at two sites namely mid pedicle (MPH) and at root of the pedicle (RPH) (junction of pedicle with the vertebral body).

Figure 1.3 Pedicle length (PL): Distance from the posterior cortex of pedicle to the junction of pedicle with vertebral body in line with the axis of pedicle.

Statistical Analysis

The Data obtained from the measurements were analysed using statistical package for social sciences (SPSS) version 20 and the following analytical methods were employed. Use of central tendency and deviations to describe the basic features of the data in this study. The data from this analysis was represented in mean (⊠) ± standard deviation (S.D) and standard error (S.E). ANOVA and Turkey Post Hoc multiple comparison test was used in assessing the differences in the measured dimensions of the thoracic vertebrae (T1-T12). Pearson's correlation was used to determine the relationship between a dependent variable and one or more independent variables. A model of the relationship is hypothesized, and estimates of the parameter values are used to develop an estimated regression equation. The confidence level was set at 95%; hence, *P* values ⩽0.05 was considered to be statistically significant.

RESULTS

The Mean ± Standard deviation, and Standard error and Range of the pedicle morphometry and statistical data and analysis of 15 spines consisting of 180 thoracic vertebrae. The descriptive characteristics are as shown in Tables 1 to 3, Figure 2, and the segmental mean and percentage contribution to the thoracic vertebrae is represented in Table 4. Analysis of variance (ANOVA) in Table 5 and Post Hoc multiple comparison is represented in Table 6 while Pearson's correlation is represented in Table 7 with the scatter plot in Figure 3A-C. The mean value ± S.D for the observed dimensions of the vertebrae pedicle was observed as follows:

The total mean pedicle length was 15.80±2.20mm with T1=14.90±1.98, T2=14.87±2.32mm, T3=14.59±2.09mm, T4=15.57±2.00mm, T5=16.22±1.13mm, T6=15.18±2.22mm, T7=14.96±2.49mm, T8=17.01±2.40mm, T9=16.57±1.98mm, T10=15.59±2.01mm, T11=16.48±1.92mm, and T12=17.61±2.4mm [Table 1]. The maximum length being at T12 and minimum length being at T3. Significant mean difference (MD) with a mean error (M.E.D) of difference of ±0.75mm was observed between T1 vs T12 (MD=-2.72), T2 vs T12 (MD=-2.74), T3 vs T12 (MD=-3.65) and T7 vs T12 (MD=-2.65). The observed differences were significantly different at $P \leq 0.05$ [Table 5 & 6].

The total mean pedicle height was 12.78±2.33mm with T1=9.78±0.99mm, T2=11.07±1.13mm, T3=11.80±1.13mm, T4 =11.78±0.54mm, T5=11.85±0.75mm, T6=11.91±0.57mm, T7=11.78±0.76mm, T8=12.31±0.81mm, T9=12.99±1.02mm, T10=14.76±1.42mm, T11=16.00±1.52mm, and T12=17.34±1.59mm. The maximum pedicle height being at T12 and minimum height being at T1 [Table 2]. Significant mean difference (MD) with a mean error (M.E.D) of difference of ±0.39mm was observed between T1 vs T2 (MD=-1.29), T1 vs T3 (MD=-2.01) T1 vs T4 (MD=-1.99) T1 vs T5 (MD=-2.06), T1 vs T6 (MD=-2.12) T1 vs T7 (MD=-2.00), T1 vs T8 (MD=-2.53), T1 vs T9 (MD=-3.21), T1 vs T10 (MD=-4.98), T1 vs T11 (MD=-6.21), T1 vs T12 (MD=-7.56); T2 vs T9 (MD=-1.92), T2 vs T10 (MD=-3.69) T2 vs T11 (MD=-4.93), T2 vs T12 (MD=-6.27); T3 vs T10 (MD=-2.96), T3 vs T11 (MD=-4.20), T3 vs T12 (MD=-5.54); T4 vs T10 (MD=-2.99), T4 vs T11 (MD=-4.22), T4 vs T12 (MD=-5.57); T5 vs T10 (MD=-2.92), T5 vs T11 (MD=-4.15), T5 vs T12 (MD=-5.50); T6 vs T10 (MD=-2.85), T6 vs T11 (MD=-4.09), T6 vs T12 (MD=-5.43); T7 vs T10 (MD=-2.98), T7 vs T11 (MD=-4.21), T7 vs T12 (MD=-5.56); T8 vs T10 (MD=-2.98), T8 vs T11 (MD=-3.69), T8 vs T12 (MD=-5.03); T9 vs T10 (MD=-1.77), T9 vs T11 (MD=-3.01), T9 vs T12 (MD=-3.45); T10 vs T11 (MD=-1.23), T10 vs T12 (MD=-2.58); T11 vs T12 (MD=-1.34). The observed differences were significantly different at $P \leq 0.05$ [Table 5 & 6].

The total mean mid-pedicle width was 7.58±2.31mm with T1=8.22±1.33mm, T2=7.43±1.28 mm, T3=6.35±1.24 mm, T4=5.84±1.17mm, T5=6.22±2.14mm, T6=5.85±1.23mm, T7=6.45±1.33 mm, T8=7.14±1.92 mm, T9=7.69±1.96 mm, T10=8.54±1.52mm, T11=10.00±1.54mm, and T12=11.26±2.78 mm [Table 3]. The maximum Mid-pedicle width was at T12 and minimum width being at T4. Significant mean difference (MD) with a mean error (M.E.D) of difference of ±0.62mm was observed between T1 vs T4 (MD=2.39), T1 vs T6 (MD=2.37), T1 vs T12 (MD=-3.04), T2 vs T11 (MD=-2.57), T2 vs T12 (MD=-3.83); T3 vs T10 (MD=-2.20), T3 vs T11 (MD=-3.65), T3 vs T12 (MD=-5.00); T4 vs T10 (MD=-2.71), T4 vs T11 (MD=-4.16), T4 vs T12 (MD=-5.42); T5 vs T10 (MD=-2.32), T5 vs T11 (MD=-3.78), T5 vs T12 (MD=-5.04); T6 vs T10 (MD=-2.69), T6 vs T11 (MD=-4.15), T6 vs T12 (MD=-5.41); T7 vs T10 (MD=-2.10), T7 vs T11 (MD=-3.55), T7 vs T12 (MD=-4.12); T8 vs T11 (MD=-2.86), T8 vs T12 (MD=-4.12); T9 vs T11 (MD=-2.31), T9 vs T12 (MD=-3.57); T10 vs T12 (MD=-2.72). The observed differences were significantly different at $P \leq 0.05$ [Table 5 & 6].

The upper division of thoracic spine had a mean PL value of 14.98mm which contributed to 31.6% of the total mean PL, the middle division was 15.84mm (33.4%) while the lower division was 16.56mm (35.0%). The upper division of thoracic spine had a mean PH value of 11.11mm (29.0%) while the middle division was 11.96mm (31.2%) and the lower division was 15.27mm (39.8%). The mean MPW of the upper division was 6.97mm (30.6%) and the middle and lower divisions were 6.41mm (28.2%) and 9.37mm (41.2%) respectively [Table 4]. Of the predictor variables evaluated for estimating pedicle dimensions, MPW had no significant correlation with PL (r=0.134; R2=0.02, P=0.07), MPW was averagely (+) correlated with PL (r=0.58; R2=0.34, P<0.01), while a week (+) correlation between the PL and PH was recorded (r=0.261; R2=0.07, P<0.01). The regression equation for estimating statistically significant parameters was; PH=8.3376+0.5861 (MPW) in mm and PH=8.4134+0.2765 (PL) in mm

Table 1: Pedicle length (PL)

Vertebrae level	Pedicle Length (in mm)		RANGE (Min-Max) in mm
	MEAN±S.D	S.E.M	
T1	14.90±1.98	0.511	11.86 - 17.86
T2	14.87±2.32	0.599	8.66 - 17.73
T3	14.59±2.09	0.539	11.07 - 18.55
T4	15.57±2.00	0.310	12.78 - 17.61
T5	16.22±1.13	0.293	14.27 - 17.82
T6	15.18±2.22	0.574	11.37 - 18.73
T7	14.96±2.49	0.643	8.91 - 18.55
T8	17.01±2.40	0.621	11.16 - 20.42
T9	16.57±1.98	0.510	11.80 - 19.42
T10	15.59±2.01	0.518	13.06 - 19.58
T11	16.48±1.92	0.495	12.57 - 19.83
T12	17.61±2.40	0.620	13.73 - 22.11
Total	**15.80±2.20**	**0.164**	**8.66 - 22.11**

Thoracic pedicles were longer in the lower three vertebrae compared with the upper three. No consistent linearity in the mid portions.

Table 2: Pedicle height (PH)

Vertebrae level	Pedicle Height (in mm)		RANGE (Min-Max) in mm
	MEAN±S.D	S.E.M	
T1	9.78±0.99	0.255	8.21 - 11.98
T2	11.07±1.13	0.291	9.25 - 13.12
T3	11.80±1.13	0.292	9.84 - 14.03
T4	11.78±0.54	0.139	10.73 - 12.92
T5	11.85±0.75	0.195	10.80 - 13.48
T6	11.91±0.57	0.148	11.29 - 13.53
T7	11.78±0.76	0.196	10.18 - 13.47
T8	12.31±0.81	0.210	11.29 - 14.34
T9	12.99±1.02	0.263	10.85 - 14.52
T10	14.76±1.42	0.367	12.15 - 16.73
T11	16.00±1.52	0.393	13.19 - 17.77
T12	17.34±1.59	0.410	14.75 - 19.97
Total	**12.78±2.33**	**0.174**	**8.21 - 19.97**

In the Lower third, increase in pedicle height in a craniocaudal direction, reverse is the case in the upper third.

Table 3: Maximum pedicle width (MPW)

Vertebrae level	Maximum pedicle width (in mm)		RANGE (Min-Max) in mm
	MEAN±S.D	S.E.M	
T1	8.22±1.33	0.34	5.69 - 10.71
T2	7.43±1.28	0.3	5.46 - 9.51
T3	6.35±1.24	0.32	4.13 - 8.21
T4	5.84±1.17	0.3	4.24 - 7.62
T5	6.22±2.14	0.55	3.53 - 13.1
T6	5.85±1.23	0.32	4.16 - 7.91
T7	6.45±1.33	0.34	5.08 - 9.60
T8	7.14±1.92	0.5	5.26 - 12.87
T9	7.69±1.96	0.51	6.07 - 14.02
T10	8.54±1.52	0.39	6.39 - 11.60
T11	10.00±1.54	0.4	8.04 - 12.96
T12	11.26±2.78	0.72	8.18 - 16.61
TOTAL	**7.58±2.31**	**0.17**	**3.53 - 16.61**

In the upper thoracic spine, a progressive decrease in maximum pedicle with in a craniocaudal direction; a reversal of this pattern was observed from the midpoint of the thorax to T12.

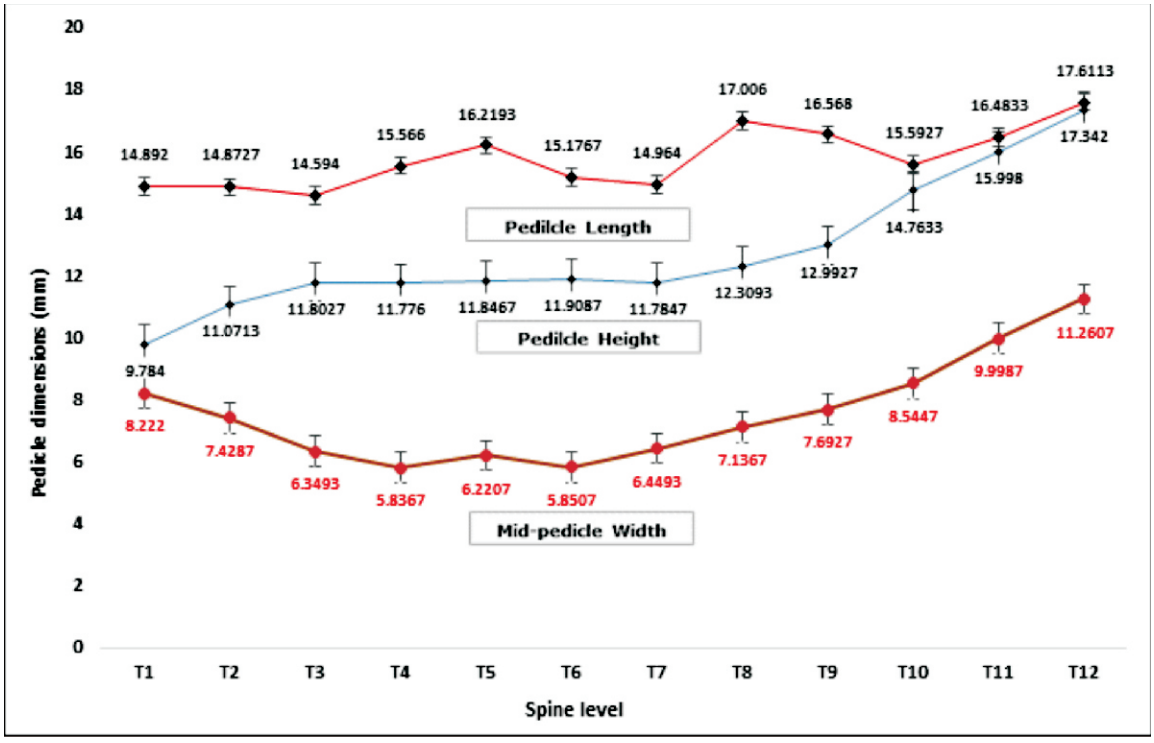

Figure 2: Mean value plots of Mid-pedicle width (MPW), Pedicle length (PL) and Pedicle height (PH)

Table 4: Mean and percentage contribution of the vertebrae divisions to the total dimension of the vertebrae pedicle

	Upper division (T1-T4)	Middle division (T5-T8)	Lower division (T9-T12)	Total
PL	14.98(31.6)	15.84(33.4)	16.56(35.0)	**47.38**
PH	11.11(29.0)	11.96(31.2)	15.27(39.8)	**38.34**
MPW	6.97(30.6)	6.41(28.2)	9.37(41.2)	**22.75**

Data are provided as *mean (in mm) and percentage (%) in bracket*

Table 5: Analysis of variance for the measured parameters of the vertebrae pedicle

		Sum of Squares	*df*	*Mean Square*	*F-value*	*P-value*	*Inference*
MPW	**Between Groups**	474.639	11	43.149	15.181	**<0.001**	**S**
	Within Groups	477.512	168	2.842			
	Total	952.151	179				
PL	**Between Groups**	154.376	11	14.034	3.322	**<0.001**	**S**
	Within Groups	709.653	168	4.224			
	Total	864.029	179				
PH	**Between Groups**	777.712	11	70.701	61.294	**<0.001**	**S**
	Within Groups	193.784	168	1.153			
	Total	971.496	179				

Table 6: Post-Hoc multiple comparison test for mean difference in the pedicle measurements of T1 –T12

TUKEY POST-HOC TEST		
PEDICLE LENGTH (PL)	**PEDICLE HEIGHT (PH)**	**MAXIMUM PEDICLE WIDTH (MPW)**
T1 vs T12 (MD= -2.72±0.75; P=0.019)	***T1 vs T2*** (MD= 1.29±0.39; P =0.055) ***T1 vs T3*** (MD= -2.01±0.39; P<0.001) ***T1 vs T4*** (MD= -1.99±0.39; P <0.001) ***T1 vs T5*** (MD= -2.06±0.39; P<0.001) ***T1 vs T6*** (MD= -2.12±0.39; P <0.001) ***T1 vs T7*** (MD= -2.00±0.39; P<0.001) ***T1 vs T8*** (MD= -2.53±0.39; P <0.001) ***T1 vs T9*** (MD= -3.21±0.39; P<0.001) ***T1 vs T10*** (MD= -4.98±0.39; P <0.001) ***T1 vs T11*** (MD= -6.21±0.39; P<0.001) ***T1 vs T12*** (MD= -7.56±0.39; P <0.001)	***T1 vs T4*** (MD= 2.39±0.62; P =0.008) ***T1 vs T6*** (MD= 2.37±0.62; P =0.009) ***T1 vs T12*** (MD= -3.04±0.62; P <0.001).
T2 vs T12 (MD=-2.74±0.75; P =0.018)	***T2 vs T9*** (MD= -1.92±0.39; P<0.001) ***T2 vs T10*** (MD=-3.69±0.39; P <0.001) ***T2 vs T11*** (MD= -4.93±0.39; P<0.001) ***T2 vs T12*** (MD= -6.27±0.39; P<0.001)	***T2 vs T11*** (MD= -2.57±0.62; P =0.003) ***T2 vs T12*** (MD= -3.83±0.62; P <0.001)
T3 vs T12 (MD=-3.65±0.75; P=0.005)	***T3 vs T10*** (MD= -2.96±0.39; P<0.001) ***T3 vs T11*** (MD=-4.20±0.39; P<0.001) ***T3 vs T12*** (MD= -5.54±0.39; P<0.001)	***T3 vs T10*** (MD= -2.20±0.62; P =0.023) ***T3 vs T11*** (MD= -3.65±0.62; P<0.001) ***T3 vs T12*** (MD= -5.00.±0.62; P<0.001)
	T4 vs T10 (MD=-2.99±0.39; P<0.001) ***T4 vs T11*** (MD=-4.22±0.39; P<0.001) ***T4 vs T12*** (MD=-5.57±0.39; P<0.001)	***T4 vs T10*** (MD= -2.71±0.62; P =0.001) ***T4 vs T11*** (MD= -4.16±0.62; P<0.001) ***T4 vs T12*** (MD= -5.42±0.62; P<0.001).
	T5 vs T10 (MD=-2.92±0.39; P<0.001) ***T5 vs T11*** (MD=-4.15±0.39; P<0.001) ***T5 vs T12*** (MD=-5.50±0.39; P<0.001)	***T5 vs T10*** (MD= -2.32±0.62; P =0.012) ***T5 vs T11*** (MD= -3.78±0.62; P<0.001) ***T5 vs T12*** (MD= -5.04±0.62; P <0.001)
	T6 vs T10 (MD=-2.85±0.39; P<0.001) ***T6 vs T11*** (MD=-4.09±0.39; P<0.001) ***T6 vs T12*** (MD=-5.43±0.39; P<0.001)	***T6 vs T10*** (MD= -2.69±0.62; P=0.001), ***T6 vs T11*** (MD= -4.15±0.62; P<0.001), ***T6 vs T12*** (MD= -5.41±0.62; P<0.001).
T7 vs T12 (MD=-2.65±0.75; P=0.026)	***T7 vs T10*** (MD=-2.98±0.39; P<0.001) ***T7*** **vs** ***T11*** (MD=-4.21±0.39; P<0.001) ***T7 vs T12*** (MD=-5.56±0.39; P<0.001)	***T7 vs T10*** (MD= -2.10±0.62; P=0.038), ***T7 vs T11*** (MD= -3.55±0.62; P<0.001), ***T7 vs T12*** (MD= -4.12±0.62; P<0.001).
	T8 vs T10 (MD=-2.98±0.39; P<0.001) ***T8 vs T11*** (MD=-3.69±0.39; P<0.001) ***T8 vs T12*** (MD=-5.03±0.39; P<0.001)	***T8 vs T11*** (MD= -2.86±0.62; P<0.001), ***T8 vs T12*** (MD= -4.12±0.62; P<0.001).
	T9 vs T10 (MD=-1.77±0.39; P=0.001) ***T9 vs T11*** (MD=-3.01±0.39; P<0.001) ***T9 vs T12*** (MD=-3.45±0.39; P<0.001)	***T9 vs T11*** (MD= -2.31±0.62; P=0.013), ***T9 vs T12*** (MD= -3.57±0.62; P<0.001).
	T10 vs T11 (MD=-1.23±0.39; P=0.08) ***T10 vs T12*** (MD=-2.58±0.39; P<0.001)	***T10 vs T12*** (MD= -2.72±0.62; P<0.001).
	T11 vs T12 (MD=-1.34±0.39; P=0.036).	

Table 7: Pearson's correlations analysis

PARAMETERS		***MPW***	***P-value (Inference)***	***PL***	***P-value (Inference)***
PL	***r***	0.134	0.073 (NS)	-	-
	R^2	0.02		-	-
PH	***r***	**0.580****	**<0.001 (S)**	**0.261****	**<0.001 (S)**
	R^2	**0.34**		**0.07**	

Note: r, *Pearson's correlation coefficient;* ***R^2****, Coefficients of determination*

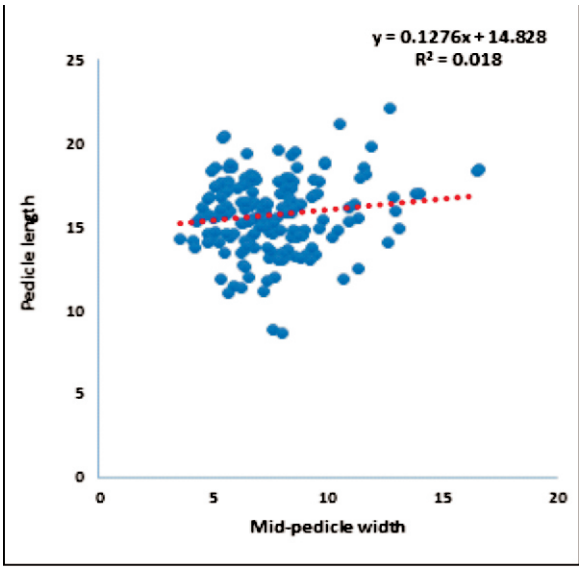

Figure 3A

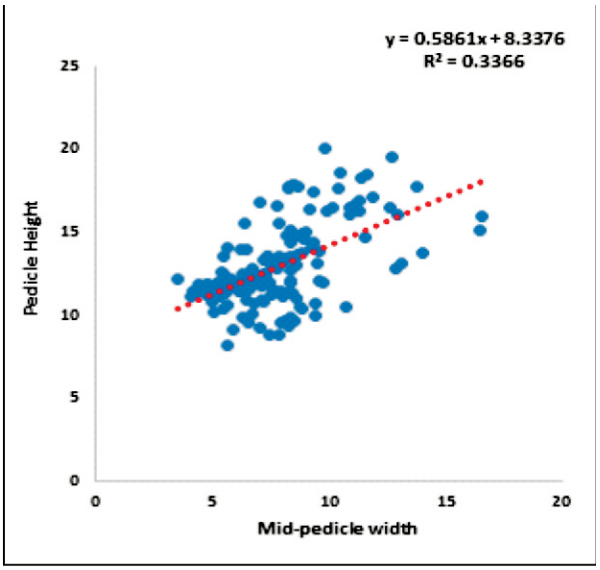

Figure 3B

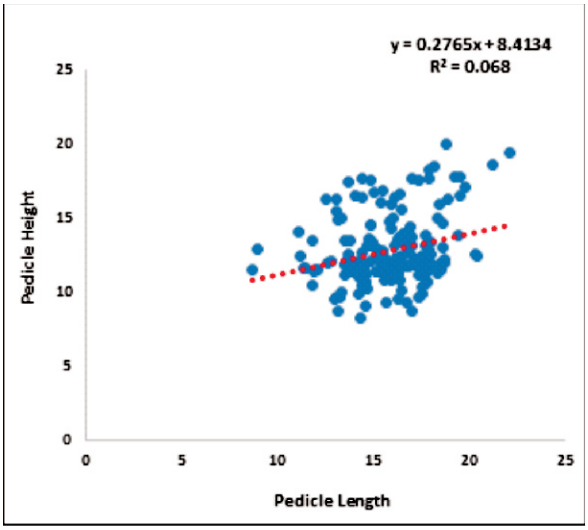

Figure 3C

Note: Figure 3A-C: Scatter plot of the vertebrae pedicle measurement with regression equations. **A**, MPW against PL; **B**, MPW against PH; **C**, PL against PH

DISCUSSION

The purpose of this study was to gain a detailed knowledge of the pedicle morphology of the thoracic spine in Nigeria.

The mean pedicle length in the current study showed a sinus pattern of increase decrease, with relatively equal length at T1 and T2; beginning with decreasing mean values from T1 to T3, followed by a slight increase from T4 to T5, and then an increase from T10 to T12. Recent study by[1,6] showed various degrees of similarities and dissimilarities compared with the current one. In the study by[1] on a sample of Koreans, the mean pedicle length increased from T1 to T6 with narrowest region at T1 (males: 16.5mm, females: 17.7mm). [6]using direct measurement in their study; observed , similar trend. They reported the maximum pedicle length to be at T12 (7.27mm) while T6 had the lowest (6.48mm). In our study the maximum mean value was at T12 and the minimum mean value was found at T3.

A steady increase in the mean pedicle height was observed from T1 to T3, followed by a decrease at T4. The mean values from T4 to T7 remained closely equal, followed by a gradual increase from T8 to T12. Previous studies found similar results; [5] analysed the anatomic morphometry of the pedicles and safe zone for through-pedicle procedures in the thoracic and lumber spine. The results showed that the mean pedicle height increased from T1 to T2. The summit for mean

pedicle height was at T12 and the smallest was at T1. Also in the study by,[6] the thoracic pedicle height increased from T1 to T3, and there was a slight fall from T4 to T6 followed by a progressive increase until T12 was reached. The similarities in pattern of values for pedicle height across the pedicle can be as a result of the fact that [6] and [5] used methodology similar to the one employed in the present study. The observed progressive changes in size of the pedicles may be due to increased muscle mass and the ongoing skeletal modification as an adaptive response necessary for weight bearing from the occipital region through the cervicothoracic and the thoracolumbar junctions of the spine to the lumbosacral transition point.

As concerns Mid-Pedicle Width (MPW), a pattern of increase–decrease was also observed; beginning from 8.22mm at T1, a dip at T2 to T4 was followed by a slight increase at T5, then a fall at T6. There was then a progressive increase till T12. Compared with previous reports, differences and similarities were also observed between the current study and literature derived values; in the research done by,[5] the pedicle width of the thoracic segment decreased dramatically from T1 to T4 and then increased gradually to T12. Pedicle width was narrowest at T4 (3.5mm or 3.8mm). In addition, the maximum and minimum mean values of the mid-pedicle width were found at T12 (11.26mm) and T4 (5.84mm). Also in the study by,[1] the Mid-Pedicle Width decreased from T1 to T4 and T5 and then increased till T12. The narrowest region was at T4 and the widest region was at T1. From the report by,[6] the mid-pedicle Width had maximum mean value of 7.9mm at T12 and the minimum mean value observed was at T5 (4.22mm).

The mean PL and PH for upper division (T1-T4) had the least contribution to the total mean pedicle length and height for thoracic vertebrae (31.6%) with a mean value of 14.98mm for PL and 11.11mm (29%) for the PH. The mean MPW for middle division (T5-T7) had the least contribution to the thoracic vertebrae (28.2%) with a mean value of 6.41mm. While the Lower third (T8-12) had the greatest proportion for all measured dimensions (35% for PL, 39.8% for PH and 41% for MPW). In predictive, estimation of dimensions for the measured parameters, there was a significantly higher positive correlation between MPW and PL ($r=0.58$; $R2=0.34$, $P<0.01$) as compared to MPW and PL ($r=0.134$; $R2=0.02$, $P=0.07$) which had no significant correlation, and PL and PH ($r=0.261$; $R2=0.07$, $P<0.01$) which had a week positive correlation.

Spine instrumentation and the Nigerian Data

Vertebral pedicle has been widely employed as a fixation site for vertebral implants since first described by Roy-Camille(4)The available sizes of pedicle screw implants for adults ranges from diameter of 4-mm to 9-mm and length ranging from 25 mm to 45mm. With reference to the data collected in this study, the smallest screw (4 mm × 25 mm) available for adult instrumentation may be bigger for 35.5% of all the pedicles observed, 71% of T5 pedicles. Therefore relying only on the available standard screw size for implant may not be safe in upper and mid-thoracic region (T3, T4 and T5) as biomechanically the smallest and shortest screws if used would render the construct weak which may fail and clinically, screws may breach both the pedicles and the anterior vertebral cortex endangering neurovascular structures. However, Posterior stabilization of pathological conditions of the thoracic spine can be accomplished using different types of instrumentation [18] which will suit the morphological characteristic of the patient.

Considering surgical interventions of the spine, findings from this study are in agreement with previous ones with regards to the narrow width of the pedicles in the mid thoracic vertebrae. There is therefore on doubt as regards the need for more research on dimensional anatomy of different segments of the vertebral column; between T4 and T8, which presents with relative vulnerability to fractures and increased possibilities of failed instrumentation.

CONCLUSION

Similar to other populations, dimensional anatomical parameters of the pedicles of thoracic vertebrae of Nigerians showed wide variations depending on the level data from this study indicate that the upper and mid-thoracic segments are peculiar and delicate.

The present study explored morphological data on thoracic spines in a sample of Nigerian population, and the data it provides can be used as reference materials in future research. For design requirements of anatomical plates, wires and pedicle screws meant for adult Nigerian patients, it has to be realized that currently available tools may not be suitable for the thoracic spine, particularly the upper and mid segments,

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