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Original Research Article

GENDER-RELATED VARIATIONS IN THORACIC PEDICLE MORPHOMETRY: A STUDY OF 1,200 PEDICLES

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ABSTRACT

Background: The pedicles exhibited significant variability in their shape and orientation, not only from region to region within the thoracic spine, but also within the same region and even within the same pedicle. Morphometric measurements of a spine in the particular geographical area will help in proper implant selection during spinal surgeries, designing of best suited implant, understanding the biomechanics and pathoanatomy of the spine

Methods: In this study sample size was 100 (58 male and 42 female) embalmed and preserved thoracic spine (T1 to T12) aged 35 to 80 years at the time of death.All the linear measurements like Vertical Interpedicular Distance (VIPD), Transverse Interpedicular Distance (TIPD), Sagital Angle (SA) measured using digital vernier calipers

Result: PH increased from T2 to T12 vertebral level in male and female subject groups. CL increased from T1 to T12 vertebral level in males and females groups in direct and CT measurement. The PW was higher at upper and lower thoracic level compare to mid thoracic region in males and females. SA showed significant difference ($p < 0.05$) between males and females in all vertebral levels except T2, T3, T11, and T12.In TIPD there was significant difference ($p < 0.05$) between males and females in all the vertebral level as except at T4, T5, T6 it was not significant as $p > 0.05$. The VIPD was increased from T1 to T12 in males and females.

Conclusion: The results of the present study can help in designing implants and instrumentations, understanding spine pathologies; and management of spinal disorder in this ethnic group with females and males.

KEY WORDS: Pedicle, Morphometry, Thoracic Vertebrae.

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INTRODUCTION

Pedicle is the most important part of the thoracic vertebrae in instrumentation of the spinal column, in the curvature corrections or in case of any spine abnormalities. Pedicles connect the vertebral bodies to the posterior elements. The pedicles exhibited significant variability in their shape and orientation, not only from region to region within the thoracic spine, but also within the same region and even within the same pedicle. The diameter of the spinal canal is also of great significance in thoracic spine fractures. The canal diameter of the thoracic spine is narrower than that of the cervical and lumbar spine. The orientation and shape of the pedicles in the thoracic spine are different from those of their lumbar counterparts and can often preclude pedicle fixation. The pedicle isthmus width is smaller in the thoracic spine than in the lumbar spine. Morphometric measurements of a spine in the particular geographical area will help in proper implant selection during spinal surgeries, designing of best suited implant, understanding the biomechanics and pathoanatomy of the spine, precise clinical diagnosis and management of the population under consideration. Furthermore, the midthoracic region is predisposed to higher rotational stress, which may have a bearing on the rate of disc degeneration. There is a demand for quantitative data concerning the thoracic pedicle using different measurement techniques. Computerized Tomography scan (CT) is preferred for evaluation of the morphometry of the thoracic spine. More precise measurements and dimensions of various anatomical parts of the selected vertebrae can be acquired from Computerized Tomography (CT) [1,2].

These factors demand for studies of the thoracic pedicle morphometry in the population of different regions. Hence this study was undertaken to analyze the pedicle morphometry from a large dataset of CT scan and direct measurement with the following objectives: To determine the morphometry changes related to normal ageing and to analyze the difference of thoracic morphometry in between the genders.

MATERIALS AND METHODS

The data were collected from the vertebra of cadavers that were available in the department of Anatomy. About 100 (58 males and 42 females) thoracic spine (T1 to T12) aged between 35 to 80 years were included in the study. The cadavers with congenital spinal deformities, had undergone surgical treatments (like implants), were excluded from the study. The Institutional Ethical Committee Clearance was taken before the study started.

Morphometric measurement of 1200 thoracic vertebrae from 100 cadavers were studied using CT scan measurement and directly on bones. The part with the intact spine was separated from the cadaver after dissection. All the organs in the anterior part of thorax and abdomen were removed. Dissection of the thoracic spine section was done in the upper back. Following measurement by the CT scan the direct measurement was carried out. The linear measurements were performed at the different vertebral levels with the digital Vernier caliper (resolution 0.01 mm) and the angular measurements were done with a goniometer (resolution 1^0) and CT scanner (GE health care).

The following parameters were measured

Pedicle width (PW): The outer cortical transverse width of the mid pedicle

Sagittal diameter of the pedicle or pedicle height (PH): The superior inferior outer cortical length of the pedicle measured at mid pedicle (minimum sagittal diameter)

Chord length (CL): Measured from the posterior cortical entry point of the pedicle to the anterior vertebral cortex along the axis of the pedicle.

Vertical interpedicular distance (VIPD): Vertical distance between the two pedicles of two vertebrae at the midpoint.

Transverse interpedicular distance (TIPD): Transverse distance between the two pedicle at the midpoint.

Transverse angle (TA) of the pedicle was measured by the angle between the pedicle axis and a line parallel to the vertebral midline measured in the transverse plane

Sagital angle (SA) of the pedicle was measured as angle between the sagittal pedicle axis and the superior border of the vertebral body in the sagittal plane.

All the linear measurements were made using digital vernier calipers with resolution (0.01mm). Angles were measured by a goniometer (resolution 1^0) and confirmed using a protractor after tracing the outline of the vertebrae onto a paper.

RESULTS

Variation between measurement of male and female thoracic vertebra in direct and CT measurements

Chord Length (CL): Mean Chord Length for males and females values recorded from direct and CT measurements are given in Table 1.1

CL increased from T1 to T12 vertebral level in males and females groups in direct and CT measurement. Male cadaver had larger mean CL than female cadaver at all thoracic spine levels in both the techniques and chord length had maximum mean value at T12 with 43.61 ± 0.08 mm in males and 30.25 ± 0.18 mm in females at direct measurement and 42.63 ± 0.28 mm in males and 30.26 ± 0.15 mm in CT measurement and observed minimum mean value at T1 with 28.38 ± 0.39 mm in males and 20.36 ± 0.16 mm in females in CT measurement an 29.56 ± 0.19 mm in males 21.68 ± 0.19 mm in females at direct measurements. The differences were statistically significant ($p < 0.05$) at the spine levels from T1 to T12.

Pedicle height (PH): Mean pedicle height for males and females values recorded from direct and CT measurements are given in Table 1.2. PH was maximum at T12 vertebral level in direct measurement and CT measurement in males (11.46 ± 0.16 mm in DM), (11.59 ± 0.26 mm in CT) and in females (11.55 ± 0.219 mm in DM) (11.48 ± 0.19 mm in CT) and PH increased from T2 to T12 vertebral level in male and female subject groups.PH was more in females compare to males at all the vertebral levels. There was no significant difference ($p > 0.05$) between males and females except at T10 and T12 there are significant difference ($p < 0.05$) between males and females.

Pedicle width (PW): Mean pedicle width for males and females values recorded from direct and CT measurements are given in Table 1.3

PW was maximum at T1 in males (7.63 ± 0.18 mm in DM) (7.60 ± 0.21 mm in CT) and females (7.67 ± 0.14 mm in DM) (7.67 ± 0.22 mm in CT) and maximum value observed at T11 in males 7.58 ± 0.17 mm and females 7.64 ± 0.205 mm in direct measurement and T12 in males (7.63 ± 0.21 mm) and females (7.64 ± 0.25 mm) in CT measurement. Minimum value observed at T5 in males 4.49 ± 0.18 mm and at T4 vertebral level in females 4.49 ± 0.17 mm in direct measurement, whereas minimum value observed in males (4.50 ± 0.16 mm) and females (4.57 ± 0.30 mm) in CT measurement at T6 vertebral level. The PW was higher at upper and lower thoracic level compare to mid thoracic region in males and females in direct and CT measurements. There was no significant difference ($p > 0.05$) between the males and females in all the vertebral level except at T8 ($p < 0.05$)

Sagital Angle(SA): Mean sagittal angle for males and females values recorded from direct and CT measurements are given in Table 1.4

SA showed significant difference ($p < 0.05$) between males and females in all vertebral levels except T2, T3, T11, and T12. SA was maximum at T4 vertebral level in males in direct measurement (17.84 ± 0.24 degree) and in CT measurement (17.78 ± 0.26 degree) and in females direct measurement showed maximum value of (17.75 ± 0.23 degree) and CT measurement (17.59 ± 0.39 degree) at T4 vertebral level.

Transverse angle (TA): Mean transverse angle for males and females values recorded from direct and CT measurements are given in Table 1.5

The TA decreased from T1 to T12 vertebral levels in males and females. The maximum TA observed at T1 vertebral level (30.51 ± 0.16 degree) in males in direct measurement and (29.59 ± 0.17degree) in CT measurement and (30.54 ± 0.26 degree) in females in direct and (29.73 ± 0.44 degree) in CT measurements. Minimum TA observed in T12 vertebral level in males (8.53 ± 0.19 in DM) (8.55 ± 0.25 degree in CT) and females (8.56 ± 0.15 degree in DM) (8.61 ± 0.17 degree in CT).There was no significant difference ($p > 0.05$) between the males and females in the TA at all the vertebral level except at T9 and T11 it was significant ($p < 0.05$)

Transverse Inter Pedicular Distance (TIPD): Mean Transverse Inter Pedicular Distance (TIPD) for males and females values recorded from direct and CT measurements are given in Tab.1.6

The TIPD was increased from T4 to T12.The maximum TIPD was at T12 vertebral level in males (31.73 ± 0.20 mm in DM, 31.82 ± 0.12 mm in CT) and females (31.59 ± 0.22 mm in DM, 31.77 ± 0.13 in CT).The minimum TIPD was observed at T4 vertebral level in males (18.36 ± 0.06 mm in DM) (18.55 ± 0.19 mm in CT) and females (18.39 ± 0.11 mm in DM)(18.60 ± 0.26 mm in CT).There was significant difference ($p < 0.05$) between males and females in all

Table 1.1: Variation in the male and female thoracic vertebral morphometryfor chord length in direct measurement and CT measurement. Values are Mean ± SD (n=100).

Thoracic vertebral level	Sex Male-58 Female-42	Chord length: Direct measurement Mean ±SD	Direct measurement 'p' Value	CT measurement Mean ± SD	CT measurement 'p' Value
T1	Male	29.56±0.18	<0.001**	28.38±0.40	<0.001**
	Female	21.67±0.18		20.37±0.15	
T2	Male	32.29±0.11	<0.001**	31.45±0.27	<0.001**
	Female	22.62±0.14		22.77±0.14	
T3	Male	33.21±0.14	<0.001**	32.60±0.26	<0.001**
	Female	23.33±0.27		23.71±0.22	
T4	Male	34.86±0.17	<0.001**	33.94±0.36	<0.001**
	Female	24.74±0.31		23.81±0.20	
T5	Male	35.45±0.07	<0.001**	34.63±0.35	<0.001**
	Female	23.47±0.08		23.38±0.14	
T6	Male	38.61±0.05	<0.001**	37.71±0.36	<0.001**
	Female	24.38±0.21		24.24±0.23	
T7	Male	40.24±0.14	<0.001**	39.47±0.26	<0.001**
	Female	25.39±0.10		25.26±0.19	
T8	Male	42.30±0.13	<0.001**	41.52±0.30	<0.001**
	Female	26.59±0.13		26.68±0.11	
T9	Male	42.19±0.19	<0.001**	41.94±0.28	<0.001**
	Female	27.39±0.21		27.40±0.10	
T10	Male	42.65±0.14	<0.001**	41.64±0.37	<0.001**
	Female	28.83±0.17		28.42±0.06	
T11	Male	42.69±0.12	<0.001**	41.78±0.32	<0.001**
	Female	29.36±0.19		29.47±0.05	
T12	Male	43.61±0.08	<0.001**	42.63±0.28	<0.001**
	Female	30.25±0.19		30.26±0.16	

**Statistically significant difference (p<0.001)

Table 1.2: Variation in the male and female thoracic vertebral morphometry for pedicle height in direct measurement and CT measurement. Values are Mean ± SD (n=100).

Thoracic vertebral Level	Sex Male-58 Female 42	Pedicle height: Direct measurement Mean ± SD	Direct measurement 'p' Value	CT measurement Mean ± SD	CT measurement 'p' Value
T1	Male	8.38± 0.36	p > 0.05	8.46 ± 0.45	p > 0.05
	Female	8.39± 0.37		8.43 ± 0.49	
T2	Male	8.32± 0.39	p > 0.05	7.70 ± 0.49	p < 0.05*
	Female	8.35± 0.38		7.99 ± 0.64	
T3	Male	8.45± 0.16	p > 0.05	8.42 ± 0.41	p > 0.05
	Female	8.50± 0.18		8.55 ± 0.41	
T4	Male	8.50± 0.17	p > 0.05	8.53 ± 0.15	p > 0.05
	Female	8.51± 0.18		8.55 ± 0.17	
T5	Male	8.47± 0.18	p > 0.05	8.51 ± 0.18	p > 0.05
	Female	8.50± 0.20		8.56 ± 0.20	
T6	Male	9.45± 0.16	p > 0.05	9.56 ± 0.19	p > 0.05
	Female	9.42± 0.22		9.55 ± 0.24	
T7	Male	9.49± 0.18	p > 0.05	9.68 ± 0.20	p > 0.05
	Female	9.50± 0.18		9.73 ± 0.19	
T8	Male	9.52± 0.16	p > 0.05	9.52 ± 0.19	p < 0.05*
	Female	9.57± 0.14		9.60 ± 0.17	
T9	Male	9.52± 0.18	p > 0.05	9.54 ± 0.16	p > 0.05
	Female	9.53± 0.20		9.55 ± 0.19	
T10	Male	10.52± 0.15	p < 0.05*	10.63 ± 0.18	p < 0.05*
	Female	10.61± 0.20		10.71 ± 0.24	
T11	Male	10.59± 0.21	p > 0.05	10.61 ± 0.19	p > 0.05
	Female	10.56± 0.18		10.59 ± 0.17	
T12	Male	11.47± 0.17	p < 0.05*	11.49 ± 0.19	p < 0.05*
	Female	11.56± 0.22		11.59 ± 0.26	

*Statistically significant difference (p<0.05) between male and females.

Table 1.3: Variation in the male and female thoracic vertebral morphometry for pedicle width in direct measurement and CT measurement. Values are Mean ± SD (n=100)

Pedicle width					
Thoracic vertebral Level	Sex Male-58 Female-42	Direct measurement		CT measurement	
		Mean	'p' Value	Mean	'p' Value
T1	Male	7.63±0.12	> 0.05	7.61±0.21	> 0.05
	Female	7.66±0.14		7.68±0.22	
T2	Male	5.64±0.16	> 0.05	5.67±0.30	> 0.05
	Female	5.71±0.25		5.77±0.32	
T3	Male	4.55±0.14	> 0.05	5.10±0.52	> 0.05
	Female	4.62±0.28		5.26±0.51	
T4	Male	4.50±0.18	> 0.05	4.60±0.18	> 0.05
	Female	4.50±0.17		4.61±0.16	
T5	Male	4.50±0.15	> 0.05	4.53±0.24	> 0.05
	Female	4.56±0.28		4.64±0.38	
T6	Male	4.59±0.15	> 0.05	4.50±0.17	> 0.05
	Female	4.63±0.26		4.57±0.31	
T7	Male	4.57±0.19	> 0.05	4.84±0.38	> 0.05
	Female	4.61±0.26		4.94±0.40	
T8	Male	4.57±0.17	< 0.05*	4.72±0.38	< 0.05*
	Female	4.67±0.27		4.92±0.42	
T9	Male	5.59±0.19	> 0.05	5.65±0.20	> 0.05
	Female	5.62±0.18		5.70±0.18	
T10	Male	7.42±0.35	> 0.05	7.44±0.42	> 0.05
	Female	7.32±0.54		7.34±0.63	
T11	Male	7.59±0.17	> 0.05	8.38±0.58	< 0.05*
	Female	7.65±0.21		8.60±0.48	
T12	Male	7.53±0.18	> 0.05	7.64±0.21	> 0.05
	Female	7.51±0.25		7.64±0.26	

*Statistically significant difference (p<0.05)

Table 1.4: Variation in the male and female thoracic vertebral morphometry for sagittal angle in direct measurement CT measurement. Values are Mean ± SD (n=100).

Sagittal angle					
Thoracic vertebral level	Sex Male-58 Female-42	Direct measurement		CT measurement	
		Mean ± SD	'p' Value	Mean ± SD	'p' Value
T1	Male	16.11±0.13	<0.001**	16.13±0.14	<0.001**
	Female	16.28±0.32		16.30±0.36	
T2	Male	17.47±0.36	> 0.05	17.59±0.30	> 0.05
	Female	17.38±0.38		17.53±0.39	
T3	Male	17.42±0.22	> 0.05	17.29±0.08	> 0.05
	Female	17.43±0.33		17.28±0.11	
T4	Male	17.84±0.21	< 0.05*	17.79±0.26	<0.05*
	Female	17.75±0.24		17.65±0.34	
T5	Male	17.35±0.04	< 0.001**	17.34±0.05	<0.001**
	Female	17.42±0.10		17.39±0.09	
T6	Male	15.92±0.28	< 0.05*	15.85±0.30	<0.05*
	Female	16.06±0.39		15.99±0.42	
T7	Male	16.34±0.15	< 0.05*	16.46±0.25	<0.05*
	Female	16.42±0.16		16.58±0.27	
T8	Male	15.21±0.25	< 0.001**	15.37±0.23	<0.001**
	Female	15.41±0.31		15.52±0.26	
T9	Male	10.24±0.24	< 0.001**	10.35±0.20	<0.001**
	Female	10.63±0.64		10.63±0.45	
T10	Male	10.50±0.22	< 0.05*	10.28±0.15	<0.001**
	Female	10.60±0.24		10.38±0.14	
T11	Male	7.56±0.32	> 0.05	7.45±0.13	<0.05*
	Female	7.67±0.28		7.50±0.13	
T12	Male	5.51±0.33	> 0.05	4.57 ±0.46	<0.05*
	Female	5.59±0.37		4.66±0.51	

*Statistically significant difference (p< 0.05), **Statistically significant difference (p < 0.001)

Table 1.5: Variation in the male and female thoracic vertebral morphometryfor transverse angle in the direct measurement and CT measurement. Values are Mean ± SD (n=100)

*Statistically significant difference (p<0.05).

Transverse angle					
Thoracic vertebral Level	Sex Male-58 Female-42	Direct measurement		CT measurement	
		Mean ± SD	'p' Value	Mean ± SD	'p' Value
T1	Male	30.51 ± 0.17	< 0.05*	29.59±0.17	< 0.05*
	Female	30.54 ± 0.26		29.74±0.44	
T2	Male	23.47 ± 0.16	<0.05*	23.53±0.31	> 0.05
	Female	23.50 ± 0.17		23.62±0.25	
T3	Male	18.55 ± 0.19	<0.05*	18.60±0.20	> 0.05
	Female	18.50 ± 0.17		18.57±0.20	
T4	Male	16.50 ± 0.18	<0.05*	16.50±0.25	> 0.05
	Female	16.55 ± 0.16		16.54±0.25	
T5	Male	15.55 ± 0.16	<0.05*	15.60 ±0.21	> 0.05
	Female	15.52 ± 0.14		15.62±0.20	
T6	Male	14.54 ± 0.18	<0.05*	14.50±0.18	> 0.05
	Female	14.57 ± 0.17		14.55±0.16	
T7	Male	14.55 ± 0.22	<0.05*	14.61±0.20	> 0.05
	Female	14.60 ± 0.18		14.65±0.20	
T8	Male	13.52 ± 0.27	> 0.05	13.60±0.28	> 0.05
	Female	13.60 ± 0.20		13.70±0.18	
T9	Male	11.50 ± 0.25	<0.05*	11.62±0.14	<0.05*
	Female	11.66 ± 0.39		11.69±0.13	
T10	Male	10.51± 0.24	> 0.05	9.97±0.57	> 0.05
	Female	10.57 ± 0.19		10.10±0.57	
T11	Male	9.45 ± 0.18	< 0.05*	8.77±0.45	<0.05*
	Female	9.53 ± 0.17		9.02±0.45	
T12	Male	8.54 ± 0.20	> 0.05	8.55±0.25	> 0.05
	Female	8.56 ± 0.16		8.62±0.17	

Table 1.6: Variation in the male and female thoracic vertebral morphometry for transverse interpedicular distance in the direct measurement and CT measurement. Values are Mean ± SD (n=100)

*statistically significant difference (p < 0.05), ** statistically significant difference (p < 0.001).

Transverse Interpedicular Distance (TIPD)					
Thoracic vertebral Level	Sex Male-58 Female-42	Direct measurement		CT measurement	
		Mean ± SD	'p' Value	Mean± SD	'p' Value
T1	Male	23.36 ± 0.03	< 0.001**	23.36±0.09	< 0.001**
	Female	23.43 ± 0.12		23.47±0.23	
T2	Male	23.87 ± 0.18	< 0.05	23.04±0.45	> 0.05
	Female	23.78 ±0.23		22.89±0.56	
T3	Male	19.21± 0.13	< 0.05*	19.47±0.30	> 0.05
	Female	19.29 ± 0.19		19.59±0.32	
T4	Male	18.36 ± 0.06	> 0.05	18.55±0.19	> 0.05
	Female	18.39 ± 0.11		18.61±0.26	
T5	Male	18.38 ± 0.07	> 0.05	18.57±0.19	> 0.05
	Female	18.42±0.16		18.59±0.26	
T6	Male	23.46± 0.06	> 0.05	23.71±0.21	> 0.05
	Female	23.46 ±0.11		23.67±0.25	
T7	Male	25.78±0.15	< 0.05*	24.82±0.27	< 0.001**
	Female	25.70± 0.17		24.66±0.24	
T8	Male	26.89 ±0.13	< 0.001**	26.67±0.25	< 0.001**
	Female	26.79±0.21		26.52±0.29	
T9	Male	27.82 ±0.22	< 0.05*	27.80±0.27	< 0.05*
	Female	27.72±0.22		27.68±0.34	
T10	Male	28.25±0.24	< 0.05*	27.66±0.36	< 0.001**
	Female	28.35±0.19		27.85±0.31	
T11	Male	29.23±0.15	< 0.001**	29.83±0.94	< 0.001**
	Female	29.38±0.22		30.48±1.05	
T12	Male	31.73±0.20	< 0.001**	31.82±0.12	> 0.05
	Female	31.60 ±0.23		31.77±0.13	

Table 1.7: Variation in the male and female thoracic vertebral morphometry for vertical interpedicular distance in direct measurement and CT measurement. Values are Mean ± SD (n=100)

Vertical interpedicular distance (VIPD) (mm)					
Thoracic vertebral Level	Sex Male-58 Female-42	Direct measurement		CT measurement	
		Mean ± SD	'p' Value	Mean ± SD	'p' Value
T1	Male	21.70 ± 0.16	>0.05	21.40 ± 0.59	<0.05*
	Female	21.69 ± 0.13		21.11 ± 0.76	
T2	Male	22.65 ± 0.13	>0.05	22.66 ± 0.15	>0.05
	Female	22.61 ± 0.15		22.61 ± 0.17	
T3	Male	23.28 ± 0.23	<0.05*	23.34 ± 0.18	<0.001**
	Female	23.39 ± 0.24		23.44 ± 0.18	
T4	Male	23.91 ± 0.75	<0.001	23.50 ± 0.32	<0.001**
	Female	23.53 ± 0.62		23.31 ± 0.27	
T5	Male	23.42 ± 0.13	>0.05	23.47 ± 0.13	>0.05
	Female	23.39 ± 0.21		23.45 ± 0.18	
T6	Male	24.33 ± 0.16	<0.05*	24.46 ± 0.24	<0.001**
	Female	24.41 ± 0.19		24.62 ± 0.25	
T7	Male	25.38 ± 0.11	<0.001**	25.31 ± 0.12	<0.05*
	Female	25.49 ± 0.23		25.39 ± 0.18	
T8	Male	26.60 ± 0.11	>0.05	26.65 ± 0.23	>0.05
	Female	26.56 ± 0.16		26.58 ± 0.27	
T9	Male	27.33 ± 0.17	<0.001**	27.37 ± 0.18	<0.05*
	Female	27.46 ± 0.23		27.46 ± 0.25	
T10	Male	28.83 ± 0.21	>0.05	28.77 ± 0.23	>0.05
	Female	28.74 ± 0.25		28.69 ± 0.25	
T11	Male	29.33 ± 0.17	>0.05	29.50 ± 0.16	<0.05*
	Female	29.39 ± 0.17		29.58 ± 0.18	
T12	Male	30.21 ± 0.14	p<0.001**	30.38 ± 0.28	<0.001**
	Female	30.36 ± 0.24		30.58 ± 0.39	

Statistically significant difference (p<0.05), **statistically significant difference (p<0.001)

the vertebral level as except at T4, T5, T6 it was not significant as p > 0.05

Vertical Inter Pedicular Distance (VIPD): Mean Transverse Inter Pedicular Distance (TIPD) for males and females values recorded from direct and CT measurements are given in Table 1.7

The VIPD was increased from T1 to T12 in males and females. There was minimum value of VIPD in males (21.70 ± 0.16 mm in DM, 21.40 ± 0.58 in CT) and females (21.69 ± 0.13 mm in DM, 21.11± 0.76 mm in CT) was at T1. A significant difference (p < 0.05) between males and females were at T3, T6, T7, T9, T12 vertebral level and there was no significant difference (p > 0.05) between males at T1, T2, T4,T5.

DISCUSSION

Advancement in the instrumentation for the morphometric measurements have advanced with the invent of CT scan machines. However, given variation in the morphometry of population and possibility of artifacts influencing the morphometric analyses of the thoracic spine and it was necessary to develop database on the thoracic vertebral morphometry for different population. the present study were compared with the previous published studies from India [1,2], Asia [3-6] and western world [7-13]. It included more number of cadaveric specimens in comparison to other studies which included 6-40 cadaveric specimens.

In the current study CL was significantly smaller when we compared with Scoles *et al.* [14] in the direct measurements. To avoid violation of anterior cortex of the vertebral body, the pedicular screw length of 25 mm at the upper thoracic level and 30 mm at mid and lower thoracic levels should be safe. Furthermore the fact that there is significant difference between the males and females in each spinal level in direct and CT measurements. In the present study the pedicle dimensions in the thoracic level vertebrae of females were lower than those of the same vertebrae in males, also the age has been considered as important variables in describing the pedicular morphometry. The assessment and comparison of direct and CT measurements showed in the chord length a significant difference between the two measurements for all the thoracic vertebral level (T1-T12) and it is inferred that direct measurement value is higher compared with CT value.

Transverse diameter of the pedicle is the important dimension as this decides size of the screw to be inserted. Pedicle width decreased from T1 to T5 and gradually increased from T6 to T12 in the present study. Then 35% of all pedicles, 48% of those from T4 through T8 and 68% of those at T6, measured less than 5 mm in a study reported by Cinnotti *et al.* [15]. In another study by McLain *et al.* [7] 25% of T1 pedicles, 17% of T2 pedicles, 42% of the T3 pedicles, 61% of T4 pedicles, 67% of T5 pedicles and 75% of T6 pedicles were too small to accept a 5.5 mm screw.

Lieu et al. [16] reported that the 67.8% male and 94.4% females had transverse outer pedicle diameter less than 5-mm at T4; and 62.2% males and 90.0% females at T5 level

Acharya *et al.* showed that at the lower thoracic spine, pedicles faced more laterally [17]. Going for pedicle screw instrumentation on the basis of other study groups would have lead to the risk of injury to cord and other neural structures. Because of the more lateral angulation of T12 pedicle the CL of the T12 vertebra was also less as compared to other lower thoracic vertebrae.

The present study group had maximum sagittal angle at T4 level (17.8° in DM and 17.7 in CT), where as Zindrick *et al.* [18] and Datir and Mitra [19] had maximum value at T2 level (17.5° and 17.8° respectively). Sagittal and transverse angles show a significant difference between DM and CT measurements except T4 level

The interpedicular distance was also found to be higher in females in all levels except at T1, T2 and T7 vertebrae. Thus, it was observed that the vertebral canal in female vertebrae was wider than male vertebrae in the present study group. This was in contradiction to other dimensions where values in male vertebrae were found higher than female vertebrae values. The female horizontal and vertical diameters of the pedicles have shown a tendency to increase throughout normal aging [17]. Due to normal ageing, the intervertebral disc height decreases and consequently causes the facet joints to place an increased pressure on each other. This type of overloading is the most common causes of facet hypertrophy (an enlargement of the facet joint) and is also thought to increase the growth of osteophytes in the facet joints [20]. Also this is reflected in our analyses. Understanding this effect is of particular importance with respect to spinal stenosis where a narrowing of the spinal canal causes the impingement of the spinal nerve. In older females, the co-existence of osteoarthritis and osteoporosis has been reported in a study by Verstraeten et al., where the mean age of subjects was 71.5 y. Furthermore, Roaf demonstrated that compressive loading of older disc specimens resulted in collapse of vertebral bodies in addition to greater changes. So most of the changes in the parameters from T1 to T12 can be explained on the basis of local musculoskeletal anatomy and biomechanical stress.

The results of the present study can help in designing implants and instrumentations, understanding spine pathologies; and management of spinal disorder in this ethnic group. The regression analysis lead to the development of an equation for calculating the actual morphometry of the thoracic vertebrae when the equation was applied with the data obtained for the actual patients, it is correlated well.This will enable the clinical decision maker to take appropriate measure before any invasive interventions as per age and gender.

Conflicts of Interests: None

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