Safety Entry Point, Size and Direction for Placement of Thoracic Pedicle Screw - A Cadaveric Study

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Background: *Understanding of the pedicle anatomy is necessary for pedicle screw placement; however, there have been few Thai studies reporting on thoracic pedicle morphometry.*
Objective: *To determine important anatomical measurements for thoracic pedicle screw fixation.*
Material and Method: *T1-T12 vertebral pedicles were evaluated in 27 cadavers. The diameter, angle, length and entry point of the pedicle were measured.*
Results: *The transverse diameter was smaller than the sagittal diameter at all levels. The narrowest transverse diameter was at the T5 level in males and T4 level in females. The pedicle diameter in males was statistically significantly greater than in females at all levels except at the T12 level. Most pedicles with a transverse diameter of 5.0 mm or less were found at the T4, T5, T6 and T7 levels. The transverse angle was widest at the T1 level; it faced medially at all levels. The sagittal angle was widest at the T12 level and faced cephaladly at all levels. The axis length was shortest at the T1 level. Most entry points were at the inferolateral zone.*
Conclusion: *A 4-mm diameter screw should be used carefully at the mid-thoracic levels for Thai people, especially females. Screw lengths of less than 30 mm are safe for placement at all levels. The safe zone for the pedicle entry point is in the inferolateral zone.*

Keywords: *Thoracic, Pedicular screw, Pedicle diameter, Cadaveric anatomical study*

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The posterior approach is now widely used in thoracolumbar spine surgery because of familiarity with that approach and the ability to achieve spinal surgery goals, e.g., decompression, fusion, instrumentation and correction of deformity.

The strongest posterior spinal implantation is the pedicle screw system[8,14]. However, the anatomy of thoracic vertebrae are differed at different levels. Unlike the lumbar pedicles, thoracic vertebrae have short, small pedicles and a specific direction. Furthermore, there are numerous vital surrounding structures, including the spinal cord and nerve roots, major blood vessels and pulmonary structures. Thus, the physician needs to know the details of the thoracic pedicle anatomy which are specific to Thai people to minimize the risk of the surgery.

The thoracic spine in Thai people may have a different pedicle anatomy when compare to the western people. There are few Thai thoracic pedicle anatomy studies that demonstrate merely the information about the width and length of thoracic pedicle. The purposes of this study were (1) to achieve more detail regarding to the thoracic pedicle geometry, (2) to correlate anatomical differences with surgical techniques for proper pedicle screw placement (entry point, size and direction), and (3) to compare the results in a Thai population with previous studies[4].

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Material and Method

The thoracic pedicle anatomy of 27 cadaveric specimens was studied at Faculty of Medicine, Chiang Mai University. Seventeen males (34 pedicles) and 10 females (20 pedicles) were included. The age of the specimens ranged from 38 to 80 years with an average age of 52. None of the cadavers had a history of spinal trauma, infection, neoplasm or developmental malformation.

The pedicle length and width were measured using digital vernier calipers (accuracy 0.001 mm) and the pedicle angle was measured with a digital

goniometer (accuracy 0.1 degree). Measurement performed twice by 2 observers.

Pedicle anatomy was studied by direct measurement of several parameters (Fig. 1), (1) Transverse pedicle diameter (TPD): the distance between the outer cortex (medial to lateral) of the pedicle isthmus. (2) Sagittal pedicle diameter (SPD): the distance between the outer cortex (superior to inferior) of the pedicle isthmus. (3) Transverse pedicle angle (TPA): the angle between the mid-sagittal line and the transverse pedicle axis line. (4) Sagittal pedicle angle (SPA): the angle between the superior vertebral end plate line and the sagittal pedicle axis. (5) Pedicle axis length (PAL): the distance between the anterior cortex of the vertebral body and the posterior cortex entry point along the transverse pedicle axis.

The pedicle entry point (PEP) is the point created by the intersection of the pedicle axis line in the sagittal plane (Fig. 2: P1) and the pedicle axis line in the transverse plane (Fig. 2: P2) on the posterior cortex of the vertebrae.

The reference point in this study is the point created by the intersection of the lines along the lateral and inferior edges of the superior facets. Four zones of entry points were created based on their relationship to the reference point (Fig. 3).

Statistical analysis

Means and standard deviations were calculated for all variables. Student t-test was used to analyze the difference of parameters of pedicles between male and female if data showed normal distribution. Wilcoxon rank sum test (Mann Whitney U test) was used to analyze the difference of those if data showed abnormal distribution.

The analysis was considered significant when *p*-value were less than 0.05. All statistical analyses were performed with STATA software version 10.0 (Stata corp. LP, college station, Texas, USA).

Results

Transverse pedicle diameter (TPD)

The widest average of TPD diameter was 9.12 mm (T1 level) in males and 8.34 mm (T12 level) in females. The narrowest average diamer was 5.12 mm (T5 level) in males and 4.33 mm (T4 level) in females (Fig. 4). TPD were narrower in T4 and T5 thoracic vertebrae than in the upper and lower levels.

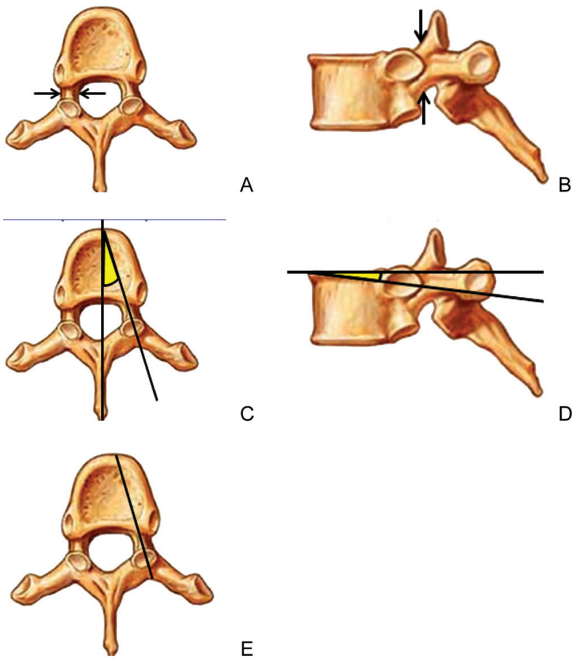

Fig. 1 Measurement parameters[13] of thoracic vertebrae. A) Transverse pedicle diameter, (TPD) B) Sagittal pedicle diameter (SPD), C) Transverse pedicle angle (TPA), D) Sagittal pedicle angle (SPA), E) Pedicle axis length (PAL).

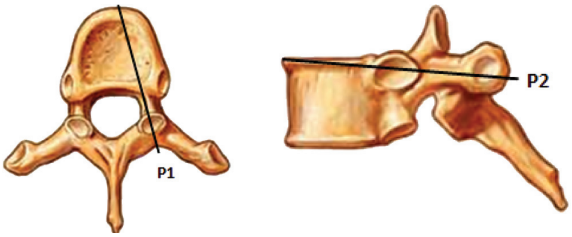

Fig. 2 The thoracic pedicle entry point in the transverse and sagittal planes[13].

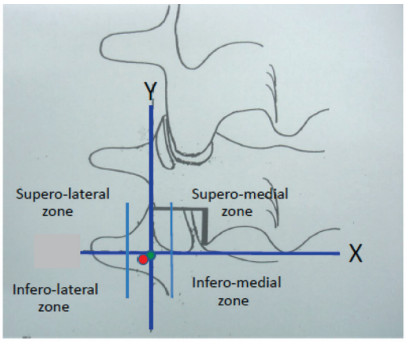

Fig. 3 The relationship of the reference point to the superior articular facet and the divided zones.

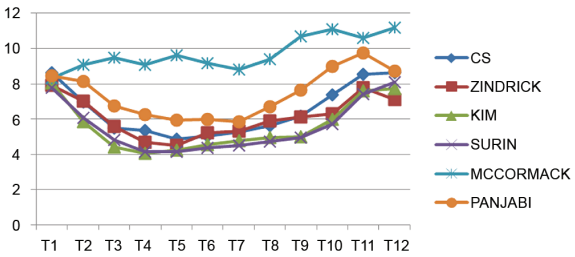

Fig. 4 Comparison of transverse pedicle diameter (TPD) between the current study (CS) and other studies.

TPD were statistically significantly larger in males than females in all thoracic levels except T12 (p-value <0.05) (Table 1). TPD was narrower than the sagittal pedicle diameter (SPD) in all thoracic levels. TPD was not statistically significantly correlated with the height of cadaveric bodies.

Sagittal pedicle diameter (SPD)

The widest average of SPD diameter was 17.39 mm (T12 level) in males and 15.87 mm (T12 level) in females. The narrowest average was 9.80 mm (T1 level) in males and 8.27 mm (T1 level) in females (Table 1). SPD was narrowest in T1 vertebrae with minor gradual increased through T3 and minor decreased from T4 to T6, followed by increased through T12. SPD was statistically significantly larger in males than in females in all thoracic levels (p-value <0.05).

Transverse pedicle angle (TPA)

The widest average angle was 30.85 degrees (T1 level) in males and 33.02 degrees (T1 level) in females. The narrowest average angle was 16.92 degrees (T8 level) in males and 17.27 degrees (T9 level) in females (Table 1). The TPA gradually decreased from T1 through T8 or T9 and then slightly increased from T10 to through T12 level. TPA was statistically significantly wider than the sagittal pedicle angle (SPA) in all vertebral levels (p-value <0.05). No statistically significant difference in TPA was found between males and females with the exception of the T4 level where females had a wider angle than males.

Sagittal pedicle angle (SPA)

The widest average angle was 13.73 degrees (T12 level) in males and 14.76 degrees (T12 level) in females. The narrowest average angle was 11.10 degree (T5 level) in males and 11.19 degrees (T7 level) in females (Table 1). SPA data in this study varied to some extent, with SPA tending to be narrower from the upper thoracic level to the mid-thoacic level and then widening slightly through the lower thoracic levels. No statistically significant differences in SPA between males and females were found with the exception of T11 level where the females had a significantly wider angle than the males.

Pedicle axis length (PAL)

The longest average PAL length was 54.78 mm (T12 level) in males and 51.39 mm (T12 level) in females. The shortest average length was 37.10 mm (T1 level) in males and 33.89 mm (T1 level) in females. No PAL was less than 30 mm (Table 1). There was a statistically significant increase in PAL from the T1 to T12 thoracic vertebrae (p-value <0.05). Male vertebrae were statistically significantly longer than in females in all thoracic levels (p-value <0.05).

Pedicle entry point (PEP)

More than 90% of PEP were present in the infero-lateral zone of the reference point with the exception of the T1 level. About 63% of PEP were located in the infero-lateral zone of T1 vertebrae, although some PEP were in the inferomedial zone but not more medial than the midline of the superior articular facets. Most PEP in each level were not more lateral than half the facet width. More than 80% of PEP were below the inferior line of the superior articular facets (range: 2-10 mm) except T1 level where some PEP were less than 2 mm) and T12 level where some PEP were more than 10 mm.

Discussion

Transverse pedicle diameter (TPD) was narrowest at the T5 level (average 5.12 mm) in males and the T4 level (4.33 mm) in females. TPD decreased from T1 level to T4 or T5 level and increased from T4 or T5 level through T12 level. This agreed with the studies by Datir et al[1], Kim et al[2], Zindrick et al[3] and Thanapipatsiri et al[4].

TPD in males was statistically larger than in females which correlates with studies of Thanapipatsiri et al[4] (which found significant differences only in T1 to T5 levels), Kim et al[2], and Hou et al[5]. The present study, however, differs from McCormack et al[6] which showed no statistically difference between males and females (Fig. 4).

TPDs less than 5 mm were frequently found from T3 to T10 levels which correlates with studies by Thanapipatsiri et al[4], Datir et al[1], Kim et al[2] and Zindrick et al[3]. The average TPD in this study was

Table 1. All measured parameters in each thoracic level

Level	Parameter	Male			Female			*p*-value
		Mean	SD	Range	Mean	SD	Range	
T1	TPD	9.12	1.20	6.79-12.00	7.74	1.09	5.76-9.55	<0.0001
	SPD	9.80	0.78	8.39-11.40	8.27	0.99	6.15-9.68	<0.0000
	TPA	30.85	4.14	20.20-37.20	33.02	3.43	26.20-40.10	<0.0539
	SPA	13.43	2.88	7.90-23.80	12.74	1.68	10.10-17.10	<0.2904
	PAL	37.10	2.81	32.98-47.02	33.89	1.88	30.60-37.24	<0.0000
T2	TPD	7.21	0.82	5.28-8.98	6.50	1.31	4.06-8.53	<0.0403
	SPD	11.86	0.98	10.41-13.91	9.55	0.96	7.84-11.32	<0.0000
	TPA	26.97	4.15	15.90-33.40	29.28	4.47	19.10-38.30	<0.1762
	SPA	12.83	2.76	9.10-21.80	12.52	2.41	9.90-19.70	<0.5131
	PAL	39.76	3.88	33.64-51.44	36.43	2.60	30.49-41.09	<0.0009
T3	TPD	5.77	0.82	4.11-7.49	5.05	1.47	2.97-7.84	<0.0251
	SPD	12.38	1.01	10.39-13.95	10.20	1.11	8.51-12.21	<0.0000
	TPA	22.82	2.88	17.30-29.30	23.57	3.32	16.20-29.70	<0.2946
	SPA	11.45	1.91	8.90-17.80	12.48	2.66	8.30-21.50	<0.0703
	PAL	42.75	3.87	35.15-54.32	39.12	3.20	33.35-46.97	<0.0006
T4	TPD	5.15	0.97	3.01-6.84	4.33	1.19	2.16-6.66	<0.0074
	SPD	11.75	0.88	9.49-13.64	9.87	1.06	8.14-12.08	<0.0000
	TPA	20.35	2.63	15.30-26.50	21.87	2.44	15.30-26.00	<0.0411
	SPA	11.54	1.76	8.30-16.40	12.02	3.27	7.00-19.20	<0.6285
	PAL	44.60	3.28	38.65-53.22	40.74	3.33	32.66-46.03	<0.0001
T5	TPD	5.12	0.81	3.72-6.45	4.44	1.16	2.49-6.73	<0.0164
	SPD	11.49	0.68	10.32-12.90	9.77	0.75	8.37-11.06	<0.0000
	TPA	19.03	2.35	13.30-24.90	20.10	3.13	15.50-28.60	<0.3071
	SPA	11.10	1.33	8.20-14.60	11.46	2.71	7.00-15.20	<0.5168
	PAL	45.95	2.58	39.85-51.70	42.25	2.42	36.94-46.64	<0.0000
T6	TPD	5.42	0.75	3.58-6.88	4.38	1.08	2.56-6.32	<0.0008
	SPD	11.35	0.73	9.79-12.56	9.59	0.92	8.07-11.10	<0.0000
	TPA	17.87	2.71	13.20-24.90	18.84	2.23	14.60-24.20	<0.1128
	SPA	11.37	1.61	8.60-14.80	11.31	1.94	7.50-14.30	<0.7401
	PAL	47.86	3.42	41.03-55.23	43.53	1.81	39.69-46.43	<0.0000
T7	TPD	5.59	0.92	3.61-7.19	4.70	1.04	2.18-6.29	<0.0039
	SPD	11.92	0.74	10.51-13.41	9.90	1.14	6.00-11.69	<0.0000
	TPA	17.33	2.17	13.40-22.70	17.92	2.41	10.20-21.10	<0.3596
	SPA	11.49	1.76	8.50-18.30	11.19	2.08	7.00-14.80	<0.9642
	PAL	48.37	4.44	32.10-56.50	45.57	2.06	14.92-48.59	<0.0107
T8	TPD	5.96	1.02	3.87-8.58	5.04	1.13	2.82-6.58	<0.0035
	SPD	12.44	0.68	10.72-13.79	10.29	1.38	5.31-12.34	<0.0000
	TPA	16.92	2.18	13.20-20.70	17.61	1.78	15.30-20.90	<0.3243
	SPA	11.22	1.57	8.20-14.70	11.23	1.55	8.40-14.40	<0.9786
	PAL	51.05	3.58	44.39-59.36	45.35	2.93	36.99-53.23	<0.0000
T9	TPD	6.56	0.92	4.71-8.60	5.49	0.97	4.05-7.61	<0.0040
	SPD	13.27	1.07	11.10-15.23	11.46	0.96	9.86-13.58	<0.0000
	TPA	17.70	2.13	14.10-20.90	17.27	2.17	14.40-23.00	<0.3798
	SPA	11.77	1.30	8.90-14.70	12.35	1.20	10.00-14.30	<0.1125
	PAL	52.16	4.65	43.26-60.30	47.70	2.48	42.98-52.39	<0.0002
T10	TPD	7.68	1.07	4.78-9.76	6.81	1.26	4.64-9.06	<0.0176
	SPD	14.96	1.33	11.50-18.07	13.15	1.03	10.65-14.53	<0.0000
	TPA	17.98	2.27	12.70-21.40	17.68	2.65	10.80-21.80	<0.7334
	SPA	12.50	1.47	10.50-16.10	12.91	2.00	8.30-16.50	<0.3468
	PAL	53.85	4.63	43.95-64.28	48.32	2.64	44.34-53.85	<0.0000
T11	TPD	8.91	1.41	6.64-12.66	7.89	0.98	6.77-10.38	<0.0134
	SPD	16.87	9.66	15.35-19.23	15.50	0.94	14.05-17.32	<0.0000
	TPA	18.88	2.36	13.90-22.50	18.89	1.84	15.20-22.50	<0.5785
	SPA	12.96	1.67	10.70-17.70	14.37	2.39	10.80-20.00	<0.0308
	PAL	54.64	4.82	44.80-63.17	49.95	2.23	45.14-53.86	<0.0002
T12	TPD	8.79	1.47	5.62-12.03	8.34	1.76	5.67-12.88	<0.3470
	SPD	17.39	1.39	15.13-20.43	15.87	1.03	14.25-17.73	<0.0000
	TPA	19.57	2.82	12.60-25.10	19.85	1.95	16.90-24.20	<0.9714
	SPA	13.73	2.20	9.70-19.20	14.76	2.65	8.30-21.10	<0.1296
	PAL	54.78	4.26	43.86-60.32	51.39	3.01	45.57-55.94	<0.0012

TPD = transverse pedicle diameter; SPD = sagittal pedicle diameter; TPA = transverse pedicle angle; SPA = sagittal pedicle angle; PAL = pedicle axis length

smaller than in most previous studies of the western people, e.g., Panjabi et al[7] and McCormack et al[6].

The present study suggests that care should be taken in choosing the thoracic pedicle screw diameter, especially for the mid-thoracic levels.

Sagittal pedicle diameter (SPD)

The widest average SPD was 17.39 mm (T12 level) in males and 15.87 mm (T12 level) in females. The narrowest average was 9.80 mm in males and 8.27 mm in females. SPD was narrowest in T1 vertebrae with only gradual increased until through T3 and slight decreased from T4 to through 6, followed by an increase through T12. This result agrees with previous studies (Fig. 5).

Male SPD were statistical significantly larger than in females in all thoracic vertebral levels which correlated with the study by Thanapipatsiri et al[4], but not with Hou et al[5] where SPD were found to be significantly larger in males than in females only on the T12 level, or with McCormack et al[6] which reported no significant difference between males and females.

As SPD is larger than TPD in all thoracic levels, it is necessary to pay closer attention to TPD than SPD when undertaking thoracic pedicle screw insertion procedures.

Pedicle axis length (PAL)

The longest average PAL was 54.78 mm (T12 level) in males and 51.39 mm (T12 level) in females. The shortest average PAL was 37.10 mm (T1 level) in males and 33.89 mm (T1 level) in females. These results correlate with most previous studies. There were statistically significant increases in PAL from T1 through T12 thoracic vertebrae which agrees with studies by Kim et al[2] and Datir et al[1], but differs from the study by Zindrick et al[3] which found PAL increased from T1 to through T7 up to T10 then slightly decreased to through T12.

The present study found that PAL was more than 30 mm in all thoracic vertebrae levels of all cases which differs from the study by Kim et al[2] which found an average PAL of 28.6 mm only in T2. Male PAL were significantly longer than for females in all thoracic levels of all studies reviewed.

PAL in the current study were a little longer than previous studies (Fig. 6). The PAL data from this study may help surgeons choose the proper pedicle screw length for each thoracic level when operating on Thai patients.

Transverse pedicle angle (TPA)

The widest average TPA was 30.85 degrees (T1 level) in males and 33.02 degrees (T1 level) in females, which agrees with previous studies. The narrowest angle was 16.92 degrees (T8 level) in males and 17.27 degrees (T9 level) in females. The finding differs from previous studies, most of which found the narrowest angles at T12 level. TPA decreased from T1 to through T8 or T9 level and then increased slightly from T10 to through T12 level, a finding that differs from several previous studies which found TPA decreased from T1 to through T12 level. All studies reviewed found that the pedicle axis was directed medially in all thoracic levels, with the exception of the study by Kim et al[2] which found that the T12 pedicle axis was directed laterally (Fig. 7). TPA were not statistically significantly different between males and females with the exception of the average TPA on T4 level which was significantly wider in females than in males. TPA data obtained in this study were quite similar to the study by Panjabi et al[7] with the exception of the T12 level where this study found a wider TPA.

Sagittal pedicle angle (SPA)

The widest average SPA was 13.73 degree (T12 level) in males and 14.76 degrees (T12 level) in females. That result differs from studies by

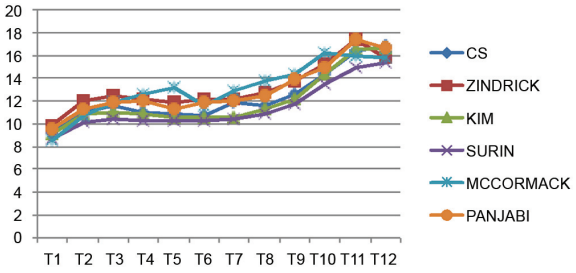

Fig. 5 Comparison of sagittal pedicle diameter (SPD) between the current study (CS) and other studies.

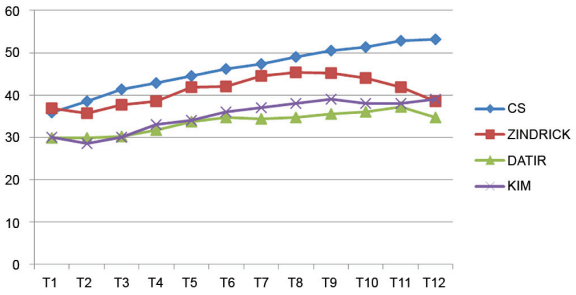

Fig. 6 Comparison of pedicle axis length (PAL) between the current study (CS) and other studies.

Zindrick et al[3], Panjabi et al[7], and Datir et al[1] which found the widest SPA in the T2 level. The narrowest average SPA was 11.10 degrees (T5 level) in males and 11.19 degrees (T7 level) in females. Again, this finding differs from studies by Panjabi et al[7] and Zindrick et al[3] which found the narrowest SPA at the T12 level and Datir et al[1] which found the narrowest SPA at the T10 level.

There was some variation in SPA in this study and other studies (Fig. 8). SPA tends to be narrower from the upper thoracic level through the mid-thoracic level, then widening slightly through the lower thoracic levels, the same as results reported by Zindrick et al[3], Datir et al[1], McCormack et al[6] and Panjabi et al[7]. The thoracic pedicle axis in all studies reviewed were directed cephaladly with the exception McCormack et al[6] which reported the pedicle axis to be directed caudally on the T2 and T3 levels.

No statistically significant differences in SPA was found between males and females with the exception of the T11 level where female SPA had a significantly wider angle than males.

Pedicle entry point (PEP)

More than 90% of PEP were in the infero-lateral zone of the reference point except in T1 level where about 63% were located in the infero-lateral zone. Some PEP were in the infero-medial zone, but not more medial than the midline of the superior articular facets. Almost all PEP in each level were not located more lateral than half the facet width. More than 80% of PEP were below the inferior line of the superior articular facets (range: 2-10 mm), except T1 level where some PEP were less than 2 mm and T12 level where some PEP were below more than 10 mm).

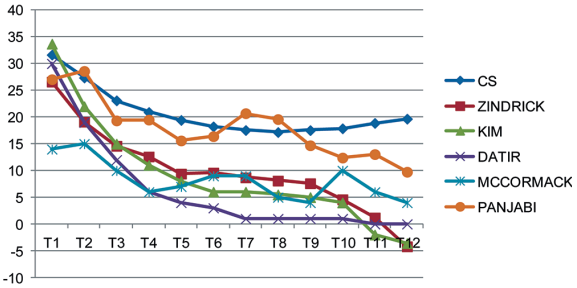

Fig. 7 Comparison of transverse pedicle angle (TPA) between the current study (CS) and other studies.

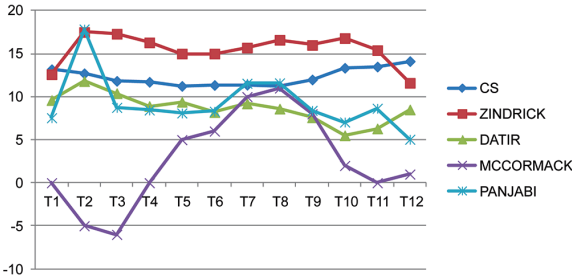

Fig. 8 Comparison of sagittal pedicle angle (SPA) between the current study (CS) and other studies.

These results are consistent with many previous studies which found most PEP were lateral to facet joints, e.g., Magerl et al[8] which reported that the PEP was located at the intersection points of the lateral facet margin and the midline of the transverse process, Datir et al[1] which found the insertion point located between the lateral area of the inferior facet line and the transverse process, Hou et al[5] which noted that the PEP of T9 to through T12 were gradually lateral to midline of the facets until lateral border of the facets, Cinnotti et al[9] who reported PEP were lateral to the midline of the superior facets. Studies which reported other results found PEP gradually lateral above inferior border of the superior articular facets from T4 to through T12 levels.

Other studies reported divergent findings included Louis et al[10] which reported PEP 3 mm medial to the lateral margin of the facet joints and 3 mm below the inferior articular facets. Ebraheim et al[11,12] which states that PEP of the T1 and T2 levels were 7-8 mm medial to the lateral border of the superior articular facet and 3-4 mm above the midline of the transverse process and that PEP of T3 to through T12 levels were 4-5 mm medial to the lateral border of the superior articular facets and 5-8 mm above the midline of the transverse process.

All studies reviewed mentioned that almost all PEP were lateral to the midline of the facet joints.

Conclusion

The TPD of Thai people were smaller than those of Western people. As a TPD smaller than 5 mm was frequntly found in mid-thoracic pedicles in Thais, surgeons have to choose the pedicle screw size very carefully. Even a 4.5 mm, or less, screw diameter is recommended for this region, cautious placement of thoracic pedicle screws is strongly required. The PAL was more than 30 mm in all thoracic levels, so surgeons can safetly use pedicle screws 30 mm or less length in all thoracic pedicles. The transverse process as well as the superior and inferior articular facets are important landmarks related to PEP. The PEP is usually located in the inferolateral zone, 2-10 mm below the inferior

margin of the superior articular facets. Care must be taken regarding the direction of insertion of pedicle screws in both the transverse and sagittal planes. Preoperative evaluation of the details of the spinal architecture of an individual patient can be aided by a CT scan.

The present study is an anatomical study of the thoracic pedicle as it directly relates to surgical technique. The important factors to consider are the insertion point, the direction of screw entry, and the pedicle screw size (diameter and length). The data from this study can help surgeons with insertion technique for placing thoracic pedicular screws safely and reducing the rate of injury to the important surrounding structures as well as providing a foundation for future study.

What is already known on this topic?

There was limited study regarding the clinical and anatomic morphology of thoracic pedicles in Thai population. Using the parameters, measured in the western population, may not be suitable for Thais.

What this study adds?

The most important clinical parameters for safety insertion of thoracic pedicle screws are transverse pedicle diameter, transverse pedicle angle and pedicle axis length. T4 through T7 transverse pedicle diameters are found less than 5.0 mm, making difficult screw placement. Placement of the smallest-sized thoracic pedicle screw system available nowadays, for instance 4.0-mm or 4.5-mm diameter, still requires careful planning and meticulous surgical technique especially at the mid-thoracic area. All 12 thoracic pedicles have medial angulation. Transverse pedicle angle is widest at T1 level. T1 pedicle also has the shortest axis length. All entry points are located lateral to the half of their superior articular facets. Proper entry point, size and trajectory of thoracic pedicle screw fixation may aid by using good intra-operative imaging for avoiding screw malposition.

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Potential conflicts of interest

None.

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ตำแหน่ง ขนาด และมุมที่ปลอดภัยในการวางตำแหน่งสกรูบริเวณกระดูกสันหลังส่วนอก

ต่อพงษ์ บุญมาประเสริฐ, อมรศักดิ์ รูปสูง, สุทธิภาศ พงศ์มณี, ทรงศักดิ์ ขุนศรี, ศิวัไกร เหล่าวัฒนพงศ์

ภูมิหลัง: *ความเข้าใจถึงลักษณะทางกายวิภาคของ thoracic pedicle มีความจำเป็นในการที่จะใส่ thoracic pedicle screw ได้อย่างปลอดภัย แต่การศึกษาลักษณะทางกายวิภาคของ thoracic pedicle ในประชากรไทยยังมีน้อย*

วัสดุและวิธีการ: *ศึกษาลักษณะทางกายวิภาคของกระดูกสันหลังส่วนอกจาก cadaver จำนวน 27 ร่าง ตั้งแต่ระดับ T1-T12 โดยวัดค่าต่าง ๆ คือ pedicle diameter, pedicle angle, pedicle length และ entry point ในการใส่ thoracic screw*

ผลการศึกษา: *Transverse pedicle diameter มีค่าน้อยกว่า sagittal pedicle diameter ในทุกระดับ transverse pedicle diameter มีค่าน้อยที่สุดที่ระดับ T5 ในผู้ชาย และระดับ T4 ในผู้หญิง transverse pedicle diamter ในผู้ชายมีค่ามากกว่าในผู้หญิงในทุกระดับยกเว้น T12, transverse pedicle diameter ที่มีขนาดน้อยกว่า 5 มิลลิเมตร พบที่ระดับ T4, T5, T6 และ T7, transverse pedicle angle มีขนาดกว้างที่สุดที่ระดับ T1 และมุมชี้เข้าหาด้านใน ในทุกระดับ sagittal pedicle angle มีขนาดกว้างที่สุดที่ระดับ T12 และมุมชี้ขึ้นด้านบนในทุกระดับของกระดูกสันหลังส่วนอก pedicle axis length มีขนาดสั้นที่สุดที่ระดับ T1, pedicle entry point ในการใส่สกรู ส่วนมากอยู่ที่บริเวณ infero-lateral zone*

สรุป: *ควรระมัดระวังในการใส่ pedicle screw ที่มีขนาดตั้งแต่ 4 มิลลิเมตรขึ้นไป ในบริเวณกระดูกสันหลังส่วนอกส่วนกลาง โดยเฉพาะในผู้หญิงไทย ความยาวของ pedicle screw ที่ไม่เกิน 30 มิลลิเมตร สามารถใช้ได้อย่างปลอดภัย จุดเข้าที่ปลอดภัยในการใส่สกรู ส่วนมากอยู่ที่บริเวณ infero-lateral zone*
