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Morphometric measurements in thoracal vertebral fractures

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Abstract

In this study, we aimed to compare the pedicle morphometric measurements of patients with thoracic vertebral fractures, who were admitted to the emergency department after trauma, and normal population, with the help of tomography. 252 patients with thoracic vertebral fracture between January 2017 and December 2019 were included in the study. The patients were divided into two as operated (Group 1, n: 169) and non-operated (Group 2, n: 83) groups. Transverse and sagittal pedicle diameters of all patients' thoracic vertebrae were measured by computed tomography. These values were compared with the normal population. 252 patients (148 male) were included in the study. Most of the fractures were seen in the T12 vertebrae. The least affected vertebrae were T1 and T2. In males, the thinnest transverse pedicle diameter was measured at the T4 while the thickest transverse pedicle was measured at the T12 level. In females, the thinnest transverse pedicle was measured at the T6 level while the thickest transverse pedicle was measured at the T12 level. In men, the thinnest sagittal pedicle was measured at the T3 level while the thickest sagittal pedicle was measured at the T12 level. The thinnest sagittal pedicle diameter was measured at the T7 vertebra level while the thickest sagittal pedicle was measured at the T12 level. Transverse and sagittal pedicle measurements were found to be higher in males than in females at almost all thoracic vertebra levels. Transverse and sagittal pedicle diameters of patients with thoracic vertebral fracture were significantly lesser than normal population. Pedicle diameter reveals significant individual and segmental differences in the thoracic region. Patients with similar traumas, who also have a pedicle diameter below the mean value, are more likely to develop fractures.

Keywords: Thoracic vertebral fracture, pedicle morphometric measurements, demographic distribution

Introduction

The most common surgical treatment in thoracolumbar trauma is posterior vertebral instrumentation. It was first applied by Raymond Roy-Camille [1] and now occupies an important place in neurosurgical practice [2–4]. After the introduction of computed tomography (CT) and magnetic resonance imaging (MRI) into common practice, the best treatment options for spinal degenerative diseases such as spinal fractures, scoliosis, kyphosis, spondylolisthesis were sought. Wiring, hooks, etc. were tried in this process but did not yield successful results in fusion formation as transpedicular screwing (TPS) [5,6]. In thoracic vertebral fractures, conservative treatment is preferred when there is no neurological deficit and the spine is stable. However, there are indications for surgical treatment in fractures in which the vertebral body height loss is severe with the presence of canal compression, neurological deficit and kyphotic deformity [7]. It is healthy to make surgical decisions based on accepted classifications such as TLICS. The main purpose of the surgical treatment should be to protect or improve the neurological condition, to ensure stability, to correct the deformity and to prepare the ground for early rehabilitation. [8–10]. Nowadays, TPS is the most preferred surgical method. TPS has advantages, but if TPS is performed with wrong methods and the detailed measurements on preoperative images were not made, screwing is insufficient and it can cause distressing results (such as screw loosening). The thoracic vertebrae, especially the upper thoracic (T1-T6), have thinner pedicle diameters in the normal population [11,12] and have a much lower chance of screw revision.

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Material and Methods

This study had been carried out with the decision dated 03.05.2019, and numbered 2019/167 by Afyonkarahisar Health Sciences University Clinical Research Ethical Board, between 01.01.2017-01.07.2019.

252 patients (148 males) who were followed up in our clinic with the diagnosis of thoracic fracture between January 2017 and December

2019 were included in the study. Patients under 15 years old and pathological fractures were not included in the study. Demographic distributions such as age and gender, etiologic factor and treatment modalities were recorded. The patients were divided into two as non-operated (Group 1, n: 83) and operated (Group 2, n: 169) groups. CT was performed on all patients. First, axial images with 2 mm thickness were obtained. Following the reconstruction of the bone window, the thickest section of the pedicle was found. Then the pedicle transverse diameters in this section were digitally measured on the current image (Toshiba CT UK). Afterwards, sagittal images were obtained. Following the reconstruction of the bone window, the thickest section of the pedicle was found. The pedicle sagittal diameters in this section were then measured digitally on the current image. All measurements are indicated in milimeters (Figure 1).

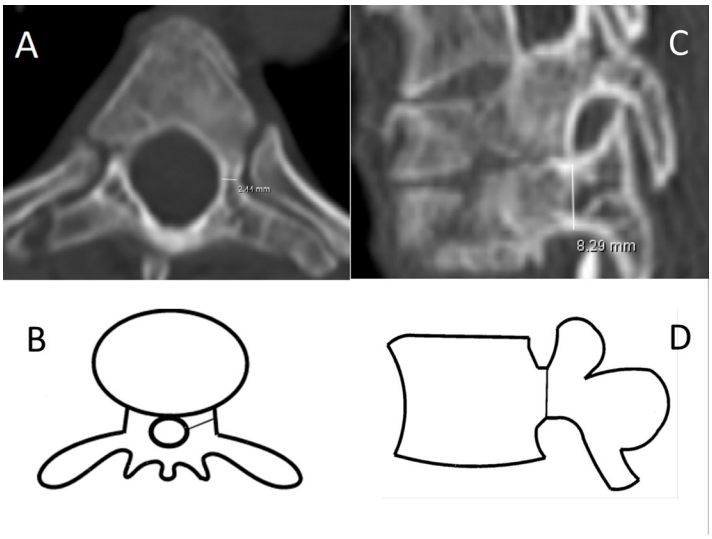

Figure 1. A: Pedicle transverse (PT) diameter in axial section by computed tomography; B: Schematic representation of left pedicle transverse diameter measurement; A: Measurements of pedicle sagittal (PS) diameter are monitored by computed tomography. D: Schematic representation of the sagittal diameter measurement of the pedicle

A total of 1008 morphometric measurements of 504 pedicle transverse diameters and 504 pedicle sagittal diameters were performed. The two groups were compared with each other and normal population values with the guide of literature. Statistical analysis was performed with "IBM SPSS STATISTICS 25". In addition to the standard descriptive calculations (mean ± standard deviation), "Wilcoxon signed ranks test" was used to evaluate the difference between right and left. The $p<0.05$ values were considered statistically significant.

Results

Of the 252 patients included in the study, 148 were male (59%) and 104 were female (41%). Age group to gender distribution was 41 males 14 females between the ages of 15-30, 32 males 14 females between the ages of 31-45, 43 males 32 females between the ages of 46-60, 27 males 32 females between the ages of 61 and 75 years, 5 males and 12 females over the age of 75. While the mean age and standard deviation of male patients were 45.5 ± 16.98 (16-85), the mean age and standard deviation of female patients were 55.2 ± 18.36 (16-84). When a distribution was made according to age groups, while 79% of males were under 60 years of age, 21% were over 60 years of age and while 56% of female patients were under 60 years of age, 32% were over 60 years of age. (Table 1).

Table 1. Distribution of the number of patients by age group

AGE	Male	Female
15-30	41	14
31-45	32	14
46-60	43	32
61-75	27	32
>75	5	12
TOTAL	148	104

The most affected spine was T12, regardless of age, sex and etiology. The least affected were observed to be T1 and T2 (Figure 2).

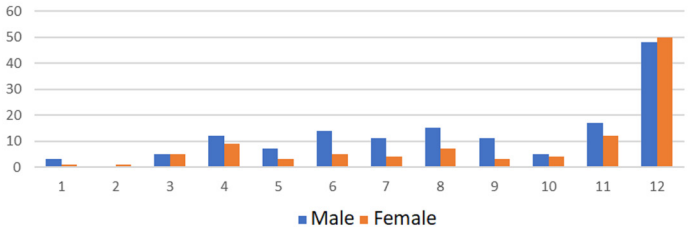

Figure 2. Level distribution of vertebral fracture by age and sex

The most common cause of trauma was falling from height with 62.6% (n: 158), while traffic accidents took the second place with 36.4% (n: 91). The reasons such as beating and being under dent were 1% (n: 3).

When examined separately in males, the thinnest right transverse pedicle diameter (TPD) was measured at the right side of the T4 vertebra with 1.72 mm, while the thinnest mean TPD was measured at the T3 vertebrae with 3.15 mm. When examined separately in males, the thinnest left TPD was measured at the T4 vertebrae level with 1.47 mm, while the thinnest mean TPD was measured at the T3 vertebra with 2.85 mm. In men, the thickest TPD was 8.63 mm on the right and 9.94 mm on the left. When examined separately in women, the thinnest right TPD was measured at the T6 vertebrae level with 2.15 mm, while the mean was measured at the T4 vertebrae level with the thinnest 3.3mm. When examined separately in women, the thinnest left TPD was at the T6 vertebrae level with 2.14 mm, and the mean thickest TPD was measured at T12 levels with 8.81 mm on the right and 9.02 mm on the left. (Table 2- 3)

In males, the thinnest sagittal pedicle diameter (SPD) was measured at the T3 Vertebrae with 5.56 mm and the thickest SPD at the T12 level with 15.20 mm. In women, the thinnest SPD was measured at the T7 Vertebrae with 5.45 mm and the thickest SPD at the T12 with 14.36 mm. (Table 2.)

In determining our treatment strategy, it was decided based on TLICS classification. Of the 252 patients, 67% (n: 169) followed the surgical route and 33% (n: 83) the conservative medical treatment. While the measurements were being made, the average of the pedicles' transverse and sagittal diameters were found to be significantly smaller in the patients who were decided to be operated (group 2). (Table 4- 5)

Table 2. Minimum and maximum of pedicle measurements included in the whole study values and levels

		Male				Female			
Patients		**Min.**	**Level**	**Mac.**	**Level**	**Min.**	**Level**	**Mac.**	**Level**
	PT-R	1.72	T4	8.63	T12	2.15	T6. T7	8.81	T12
PT	PT-L	1.47	T4	9.94	T12	2.44	T6. T7	9.02	T12
	PT Avarage	1.95		9.29		2.3		8.92	
PS		5.56	T3	15.20	T12	5.45	T7	14.36	T12
Group 2 (n: 169) operated		**Min.**	**Level**	**Mac.**	**Level**	**Min.**	**Level**	**Mac.**	**Level**
	PT-R	1.72	T4	8.63	T12	2.44	T4	7.11	T12
PT	PT-L	1.47	T4	8.45	T12	2.44	T4. T7	7.33	T12
	PT Avarage	1.92		8.62		2.44		7.22	
PS		5.56	T3	15.2	T12	5.45	T7	14.36	T12
Group 1 (n: 83) not operated		**Min.**	**Level**	**Mac.**	**Level**	**Min.**	**Level**	**Mac.**	**Level**
	PT-R	2.76	T4	8.21	T12	2.15	T6	8.81	T12
PT	PT-L	2.66	T9	9.94	T12	2.87	T6	9.02	T12
	PT Avarage	2.71		9.07		2.51		8.91	
PS		7.22	T7	15.20	T12	7.23	T6	14.36	T12

Min.: the finest value found, Mac.: the thickest value PT: pedicle transverse diameter, PT-R: right pedicle transverse diameter PT-L: left pedicle transverse diameter, PS: pedicle sagittal diameter

Table 3. Mean pedicle measurements of all patients included in the study

	Pedicle Transvers							**Pedicle Sagittal**			**Number of patients**	
	Male			**Female**								
	Right	**Left**	**Male Avarage**	**Right**	**Left**	**Female Avarage**	**Male and female total Avarage**	**Male**	**Female**	**Avarage**	**Male**	**Female**
T1	4.787±0.23	4.71±0.46	4.75	4.67±0.00	4.67±0.00	4.67	4.71	9.51±1.05	6.65±0.00	8.58	3	1
T2	4.21±0.21	4.32±0.52	4.27	4.28±0.00	4.28±0.00	4.28	4.3	8.62±0.52	7.21±0.00	7.92	2	1
T3	3.51±0.06	3.43±0.36	3.47	3.56±0.6	3.84±0.56	3.7	3.59	8.51±2.83	8.94±0.62	8.73	4	5
T4	3.66±0.89	4.05±1.23	4.08	3.58±0.55	3.63±0.58	3.605	3.82	7.98±0.92	8.02±1.42	8	12	9
T5	3.82±1.05	3.43±0.48	3.63	3.69±0.49	4.77±0.73	4.23	3.93	8.62±0.96	9.89±0.86	9.26	7	3
T6	4.03±1.03	3.79±1.09	4.07	4.5±0.00	3.90±0.28	4.2	4.14	9.10±1.65	9.84±1.91	9.47	14	5
T7	4.54±0.38	4.11±0.93	4.33	4.05±1.36	4.30±0.35	4.18	4.25	8.70±1.81	9.40±4.43	9.05	11	4
T8	4.27±0.48	3.97±1.07	4.12	3.95±0.36	4.02±1.05	3.99	4.06	8.92±1.41	9.15±1.16	9.04	15	7
T9	4.13±1.37	4.50±2.17	4.32	3.31±0.80	3.44±0.61	3.38	3.85	9.38±1.37	8.48±1.59	8.93	11	3
T10	4.58±1.65	4.45±1.05	4.52	4.28±1.38	4.29±0.42	4.29	4.41	11.24±1.14	9.65±0.60	10.45	5	4
T11	5.29±1.80	5.12±1.33	5.21	5.28±0.82	5.53±0.67	5.41	5.31	11.18±1.98	10.28±1.24	10.73	17	12
T12	5.36±1.22	5.40±1.12	5.38	5.26±1.2	5.79±1.20	5.53	5.45	12.42±1.87	11.07±1.78	11.75	48	50

Table 6. Comparison of pt and ps between our groups

Thoracic Vertebra Pedicle Transverse Mean Diameter Measurements												
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
All Patients	4.71	4.3	3.59	3.82	3.93	4.14	4.25	4.06	3.85	4.41	5.31	5.45
1. Group	4.77	4.4	3.81	4.2	4.25	4.24	4.62	4.63	*	5.5	5.34	5.83
2. Group	3.76	4.27	3.3	3.71	3.93	3.54	3.51	3.78	3.90	4.13	5.26	4.99
Mean Thoracic Vertebra Pedicle Sagittal Diameter Measurements												
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
All Patients	8.58	7.92	8.73	8	9.26	9.47	9.05	9.05	8.93	10.45	10.73	11.75
1. Group	8.45	*	9.42	9.39	9.42	9.9	8.8	9.9	10.7	12.25	12.1	12.37
2. Group	8.51	7.21	7.64	7.35	8.54	8.3	8.75	8.9	8.83	11.46	10.43	10.51

PT: Pedicle Transverse Diameter
PS: Pedicle Sagittal Diameter
*: Measurement was not taken as there is no patient.

Table 7. Comparison of our study with the measurements of transverse and sagittal diameters of pedicle made nationally and internationally

Thoracic vertebra pedicle transverse diameters												
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
Our Study Overall Average	4.71	4.3	3.59	3.82	3.93	4.14	4.25	4.06	3.85	4.41	5.31	5.45
Our Study (Group 2)	3.76	4.27	3.3	3.71	3.93	3.54	3.51	3.78	3.90	4.13	5.26	4.99
Baysal (19)	6.75	5.45	4.7	4.25	4	4	4.2	4.55	5	5.6	6.35	6.95
Araz (20)	*	*	*	*	*	*	*	*	5.5	5.9	6.9	6.8
Ugur (21)	6.7	6.2	5.3	4.6	4.7	4.9	5.3	5.7	6.2	6.4	7.8	7.9
Kim (22)	8.1	6.1	4.6	4.2	4.3	4.7	4.8	5.1	5.2	6.3	7.9	7.9
Yu (11.12)	8.7	7	5.8	5.1	5	5.4	5.7	6	6.5	7.8	9.3	9.2
Panjabi (26)	8.1	7.4	5.97	5.2	4.9	5.4	5.9	6.7	7.7	9	9.8	8.7
Vaccaro (23,24)	*	*	*	4.5	4.4	4.6	4.7	5.1	5.8	6.7	8	7.8
Sagittal diameters pedicle of thoracic vertebrae												
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
Our Study Overall Average	8.58	7.92	8.73	8	9.26	9.47	9.05	9.05	8.93	10.45	10.73	11.75
Our Study Group 2	8.51	7.21	7.64	7.35	8.54	8.3	8.75	8.9	8.83	11.46	10.43	10.51
Araz (20)	*	*	*	*	*	*	*	*	14.5	15.4	14.5	15
Panjabi (26)	9.6	11.4	11.9	12.1	11.3	11.8	12	12.5	13.8	15	17.4	16.7
Datir	9.4	12.1	12.2	11.8	11.6	11.7	12.5	13.2	14.4	16.6	17.7	18.7
Yu (11,12)	9.4	11.6	12.2	12.2	12.1	12.1	12.3	12.8	13.5	15.4	17	17.1

PT: Pedicle Transverse Diameter
PS: Pedicle Sagittal Diameter
*: Measurement was not taken as there is no patient.

Discussion

Transpedicular screwing (TPS) has been used reliably by neurosurgeons for many years in spinal traumas, degenerative deformities and diseases such as osteoporotic collapse fracture. The use of TPS in the thoracic region was started a little later due to the existence of important and vital organs and vessels adjacent to the vertebral bodies.[13–17]. Lesser pedicle diameter measurements of the thoracic vertebrae, especially upper thoracic vertebrae, are also one of the reasons.[11,18]. The main aim of our study was to investigate the pedicle morphometric dimensions of thoracic vertebrae with fracture, to compare pedicle morphometric measurements with non-fracture thoracic vertebrae at the same levels and to reveal any significant differences, and to investigate the effect of demographic factors on these dimensions.

In our study, the mean values of the pedicle diameter measurements of the fractured vertebrae of all patients were extracted first. Then, the mean values of non-operated (group 1) and operated (group 2) groups were determined as separate groups. (Table 6)

According to the results of computed tomography measurements in males TPD measurements were found to be higher than women. A statistically significant difference was found. (P = 0.006) SBD measurements were also found to be higher in males. However, no statistically significant difference was found. (P = 0.124)

There was no significant difference between right and left pedicle diameter measurements in both men and women. (Male P = 0.065, female P = 0.110)

A significant difference was found between male and female patients in terms of number (male: female = 59%: 41%). When men and women were compared in terms of the age of trauma, it was found that men were statistically traumatized at a younger age.

When the groups were compared, it was found that the transverse and sagittal diameter measurements of the pedicle were thinner in group 2. There was a significant difference between group 1 and group 2 when compared to each other. (P = 0.008) However, no significant difference was found between the SPD measurements. (P = 0.238)

No similar study was found in the literature. However, many studies have been found regarding the measurements of natural thoracic pedicle diameter without fracture. When our study was compared with those studies, a detailed analysis was performed in terms of both general point of view and the most fractured vertebrae we detected (T4-T6-T8-T11-T12) (Figure 2.) and the values of group 2 were taken as the base values.

Baysal et al[19] found mean TPD values as 4.25 at T4, 4.2 at T6, 4.55 at T8, 6.9 at T11 and 6.8 at T12 level in their study, while we found these values as 3.71 at T4, 3.54 at T6, 3.78 at T8, 5.26 at T11 and 4.99 at T12 level, and TPD measurements in our study were found to be significantly smaller.(Table 7)

While Araz et al.[20]found the mean TPD values 5.508 ± 0.483 at T9, 5.877 ± 0.380 at T10, 6.917 ± 0.411 at T11 and 6.971 ± 0.465 at T12 in their studies, we found 3.90 ± 1.137 at T9, 4.13 ± 1.165 at T10, 5.26 ± 1.20, 4.99±1.120 at T12 in our study. It was found that TPD measurements were significantly smaller in our study. (Table 7)

When Ugur et al.[21], Kim and Arak [22], Vaccaro et al.[23,24] studies were compared with our study, it was found that TPD mean values were significantly smaller in all thoracic levels in our study. (Table 7)

When the detailed measurements of both upper and lower thoracic TPD and SPD in the studies of Datir PS et al.[25]Panjab et al.[26] and Yu et al.[11,12] were compared with our values, it was found that the total TPD and SPD measurements were significantly smaller in all thoracic levels.(Table 7)

Conclusion

Transverse and sagittal pedicle diameters of patients with thoracic vertebral fracture were significantly lesser than normal population. Pedicle diameter reveals significant individual and segmental differences in the thoracic region. Patients with similar traumas, who also have a pedicle diameter below the mean value, are more likely to develop fractures.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
The financial support no have.

Ethical approval
This study had been carried out with the decision dated 03.05.2019, and numbered 2019/167 by Afyonkarahisar Health Sciences University Clinical Research Ethical Board, between 01.01.2017-01.07.2019.

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