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A gender based approach to study the morphometric variations of the neural arch in the thoracic vertebrae of adult human skeleton in north Indian population

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Abstract
For surgical procedures to be carried out on the human spine, the clinicians require accurate measurements of the vertebral parameters. This study was taken up to measure various linear parameters of the neural arch of all Thoracic vertebrae (T_1 to T_{12}) of adult human skeleton in different genders. The thoracic vertebrae of 30 of North Indian population (23 males and 7 females) were measured and analyzed. A Digital Vernier Caliper is used to measure the dimensions of the spinous (SP) and transverse (TP) processes, vertebral canal (VC), laminae, and isthmus. Most of the parameters are greater in males. Isthmus length increases from T_1 to T_{12} in both males and females but bilateral comparison of the isthmus shows that in females the left side lengths are greater than the right side but that of males doesn't have a continuous variation with some of the vertebrae having longer isthmus on the right side while some on the left side. Both Spinous Process Length (SPL) and Transverse Process Length (TPL) were found to be increasing in upper thoracic vertebrae from T_1 to T_6 and then decreasing from T_7 to T_{12} in both males and females. Bilateral evaluation of TPL shows that in females the right sided transverse processes are longer than their left counterpart while in males the variation of bilateral TPL was not continuous. Vertebral Superior Canal Width (VSCW) is greater than Vertebral Superior Canal length in thoracic vertebrae in both the genders. In both the sexes, VSCW was found to be decreasing from T_1 to T_7 and then increasing from T_8 to T_{12}. The difference of width and length is decreasing from T_1 (8.7 mm) to T_5 (2.82 mm), becomes minimum from T_6 (1.91 mm) to T_9 (2.93 mm) then it increases from T_{10} (5.3 mm) to L_5 (9.28 mm). The shape of vertebral canal is oval in upper thoracic vertebrae, round in middle thoracic vertebrae and again oval in lower thoracic vertebrae. In conclusion, the neural arch is systematically asymmetrical and dynamic in shape along the thoracic and lumbar spine.

Keywords: neural arch, transverse process, spinous process, isthmus, lamina, thoracic

1. Introduction
Neural arch is one of the two parts of a vertebrae, the other being the vertebral body. Both the parts are connected via pedicles. Parts involved in the formation of neural arch are two laminae and seven processes i.e. right and left transverse process, spinous process, two superior articular facets and two inferior articular facets.
In human skeleton there are 12 thoracic vertebrae. 1st, 10th, 11th, 12th thoracic vertebrae are atypical and 2nd to 9th is typical thoracic vertebrae. Female has less kyphotic vertebral body then male. The vertebral body is wedge shaped from T_1 to L_2 and peak at T_7 thoracic vertebrae. Pedicles are most symmetrical in lumbar and lower thoracic vertebrae. It is widest at T_{11} and narrowest at T_1 in sagittal plane [1-4].
Vertebral facets are oriented more vertically in thoracic vertebrae and independent of age and gender. The dimensions of facet are more in male than female. In individuals with spondylolysis there is significantly greater inter-facet width and shorter inter-facet height. The average transverse angel for facet at T_1 to T_{12} for men and women range from 74 to 108 degree [4, 6-10].
Most of the previous studies were done on vertebral shape, pedicles dimensions and facet orientation. Recent procedures of spinal surgery require spinal graft and fixation for which dimensions of the neural arch is required and hence the present study will prove to be important.

2. Materials and Method
The study is done on 30 human skeletons. 23 males and 7 female vertebrae are considered which were retrieved in the Department of Anatomy, PGIMS, Rohtak. All vertebrae and other bones are fully ossified, complete and non-pathological. The measurements include linear parameter and were taken with the help of Digital Vernier caliper. There are seven parameters:

Table 1

Parameters		Measurement Points
1.	Isthmus Length (IL)	Distance between most inferior point of superior articular facet and most superior point of inferior articular facet. Both Left Isthmus Length (LIL) and Right Isthmus Length (RIL) are measured. Holding the bone in lateral view.
2.	Spinous Process Length (SPL)	Distance between most anterior and most posterior point on superior borders of spinous process in superior view.
3.	Spinous Process	Distance between posterior most point on superior border and posterior-most point on inferior borders of spinous process in

	Height (SPH)	lateral view.
4.	Transverse Process Length (TPL)	Point A is highest point on external border of transverse process and the point B on lateral border of vertebral canal where superior artecular facets join the transverse process. The distance between point A and B is transverse process length. Both Left Transverse Process Length (LTPL) and Right Transverse Process Length (RTPL) are measured.
5.	Vertebral canal superior width (VCSW)	Maximum distance between left and right superior borders of vertebral canal.
6.	Vertebral canal superior length (VCSL)	Maximum distance between anterior most point on superior borders of spinous process and anterior most point on superior border of vertebral canal.
7.	Laminar superior length (LSL)	Distance between anterior most point on superior borders of spinous process and inferior most point on inferior border of superior facet. Both Left Laminar superior length and Right Laminar superior length are measured.

3. Observations & Result

Table 2: Showing values of parameters measured in Female Thoracic vertebrae

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
IL(R)	6.39	8.7	9.4	9.79	10.86	11.17	11.42	11.98	12.98	14.54	14.89	17.32
S. D	1.31	2.09	1.71	1.58	2.44	2.41	2.2	2.39	1.65	2.65	2.39	2.53
IL(L)	7.11	8.97	9.81	10.03	10.92	11.27	11.87	11.88	12.71	14.41	15.06	16.87
S. D	0.89	1.76	2.27	1.82	2.23	1.6	1.76	1.94	1.58	2.21	2.38	1.3
SPL	29.09	30.45+4.10	31.03	33.89	37.14	39.01+2.24	38.77+4.24	36.07	31.14	27.05	27.3	25.07
S. D	5.09		5.1	6.48	3.65			3.05	4.16	4.97	2.39	4.62
SPH	9.35	10.40+0.99	10.09+1.69	9.35	8.64	7.97	8.49	9.32	9.03	12.2	12.23	14.69+2.75
S. D	2.86			1.36	2.15	1.95	1.29	1.73	0.89	1.89	2.27	
TPL (R) S. D	14.09+2.78	16.76+3.06	18.00+1.52	18.37+1.84	18.24+2.29	18.83+1.25	18.48+3.82	19.28	17.86	16.52	12.37	11.14+3.14
								2.27	1.76	1.91	1.67	
TPL (L) S.D	14.31+3.09	16.06+3.41	17.4	18.22+2.27	18.02+1.29	19.67+1.69	19.39+1.39	18.95	17.29	15.71	10.42	10.09+2.65
			1.59					1.67	0.86	2.44	2.31	
VSCW S. D	24.41+6.54	22.52+5.58	21.29+6.36	18.75+5.46	18.75+4.29	18.24	18.42+4.83	18.49	19.88	22.27	21.96	24.48+6.44
						4.79		5.28	5.55	6.74	6.64	
VSCL S. D	16.15+3.13	16.67+3.59	17.22+3.41	16.74+4.00	16.86	16.22+3.37	16.58+3.89	15.26	15.84	16.42	17.04	20.19+5.32
					3.69			3.81	3.85	4.09	4.72	
LSL (R) S. D	14.56+5.65	13.61+5.06	13.02+4.35	11.03+3.97	10.4	10.55	10.89	10.59	11.08	12.31	11.55	14.24
					4.24	4.59	4.56	4.35	4.59	5.29	6.03	6.56
LSL (L) S. D	13.29+1.71	11.87+1.79	12.39+3.31	11.00+2.63	9.97	9.58	10.59	10.33	10.7	11.84	10.63	12.75
					3.54	3.53	4.5	3.38	3.27	3.78	2.69	2.51

Table 3: Showing values of parameters measured in Male Thoracic vertebrae

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
IL(R)	7.55	9.23	10.48	10.18	11.9	12.25	13.47	13.74	13.55	15.05	16.03	17.69
S. D	2.24	1.59	1.7	2.08	2.5	2.18	2.56	2.73	1.95	2.85	2.76	2.9
IL(L)	7.29	9.55	10.07	10.74	12.21	12.45	13.61	13.52	13.21	14.53	15.79	17.76
S. D	1.79	1.69	1.25	2.41	2.08	1.75	2.69	2.19	2.74	2.33	2.16	3.33
SPL	28.75	30.49	32.46	32.88	37.27	39.35	38.20+6.47	37.53	33.68+5.54	29.24+5.36	25.95	21.98
S. D	5.39	5.97	5.71	6.07	7.65	6.61		5.69			5.76	5.77
SPH	10.03	10.74+3.16	10.74+3.48	11.34+3.22	10.53	9.42	8.84	9.77	8.93	10.7	12.13	16.22+2.47
S. D	3.15				3.88	2.86	2.2	3.5	1.81	1.86	2.18	
TPL (R) S. D	13.75 +5.12	17.22+3.21	18.22+2.63	18.56+3.48	19.11+2.25	19.87+2.64	19.50+2.77	19.69	19.01+2.69	18.41+3.02	15.13+2.96	11.72+2.24
								2.57				
TPL (L) S. D	13.47+5.21	16.74+3.83	18.29	18.63+2.23	19.01+2.57	19.85+2.51	20.09+2.74	19.69	19.27+2.69	17.82+2.88	14.53+3.29	10.6
			2.96					3.03				3.09
VSCW S. D	27.49+5.53	25.33+3.80	24.16+2.89	21.96+2.80	20.3	20.57	21.07+2.91	21.19	20.87+2.36	23.60+4.27	24.81+2.38	26.16+2.25
					2.69	2.14		2.68				
VSCL S. D	18.79+4.54	18.36+2.28	17.61+2.82	18.63+2.06	17.48	18.66+1.65	18.18+1.87	18.31	17.94+2.28	18.30+2.67	19.17+1.96	21.43+3.62
					3.06			2.39				
LSL (R) S. D	14.04+2.73	12.02+2.41	10.94+2.53	10.49+2.35	8.89	9.08	9.95	10.38	9.74	11.63+2.78	11.53+1.92	11.78+1.94
					2.18	1.16	1.95	2.05	2.09			
LSL (L) S. D	13.18+2.46	11.80+2.00	10.62+2.56	9.92	9.04	9.27	9.58	10.18	10.04	11.58	11.36+1.68	11.79
				2.09	2.36	1.5	2.1	1.69	1.92	2.6		2.14

According to Table 2 and 3, Isthmus length increases from T_1 to T_{12} in both males and females but bilateral comparison of the isthmus shows that in females the left side lengths are greater than the right side but that of males doesn't have a continuous variation with some of the vertebrae having longer isthmus on the right side while some on the left side.

Spinous Process Length (SPL) is increasing in upper thoracic vertebrae from T_1 (28.75 mm) to T_6 (39.35 mm) and then decreasing from T_7 (38.20 mm) to T_{12} (21.98 mm). The length of spinous process in female vertebrae is more than male vertebrae as seen in Table 2 and 3.

Spinous Process Height (SPH) is increasing in thoracic vertebrae from T_1 (10.03 mm) to T_4 (11.34 mm) and then decreasing from T_5 (10.53 mm) to T_{10} (10.70 mm). Male vertebrae have greater spinous process height than female vertebrae.

Transverse Process Length (TPL) is increasing from T_1 to T_6 and decreasing from T_7 to T_{12}. Right transverse process length is more than left transverse process length. Male vertebrae are having greater transverse process length than female vertebrae.

Vertebral Superior Canal Width (VSCW) is higher than Vertebral Superior Canal Length in thoracic vertebrae. The difference of width and length decreases from T_1 to T_5. This difference becomes minimum from T_6 to T_9 and then it again increases from T_{10} to T_{12}.

Laminar Superior length (LSL) shows decreasing pattern from T_1 to T_5 and then shows an increasing pattern from T_6 to T_{12}. Bilateral comparison shows that laminar length is more on the right side as compared to left side in both the sexes.

Gender variations are significantly seen in isthmus length. Other parameters are statically insignificant as p value >0.05.

4. Discussion

As per study Masharawi *et al*. in 2011 the pattern of laminar length corresponds well with the vertebral canal width. Both decrease along the upper thoracic vertebrae (from T_1 to T_{5-6}) and increase downward with the greatest increase at T_{11}. This corresponds with the findings of present study in North Indian population. This relationship is plausible as the two laminae are part of the posterior border of the neural arch. Yet, as the right lamina extends longer than the left, the location where the two laminae join medially probably shifts to the left of the median plane. This shift might lead to a lateral shift in location of the spinous process from the median plane implying that the spinous process is not necessarily used as the midline point of neural arch for various measurements. Further, more spinous process deviation may not be an accurate indication of vertebral rotation in a clinical examination and therefore should not be regarded as a reliable diagnostic guide [1, 3-6].

The gender variation is found to be statistically non-significant in vertebral canal width, isthmus length and spinous process height. Parameters show greater value in male vertebrae than female vertebrae. This may be due to the fact that males have stronger musculature to maintain the stability of vertebral column as they do more physical work than females. This explanation is reinforced by the data that female possess relatively thinner spinous processes than male.

The right side parameters of thoracic vertebrae like transverse process length, right laminar length and right isthmus length are more than left side parameters which make the neural arch systematically asymmetrical and very dynamic in shape along thoracic. As the right laminar length is longer than the left laminar length, so, the meeting point of two laminae shift to the left of median plane. Due to this shift, spinous process is not considered as a midpoint of neural arch.

Masharawi *et al* in his study reported that the left transverse process length was more than right transverse process length [8, 9]. But in our present study it is found that the right transverse process length is more than the left transverse process length. This contrast may be due to the adoption of different method of measurements and skeletons of different populations.

5. Conclusion

The neural arch is systematically asymmetrical and very dynamic in shape along the thoracic and lumbar spine. The size of most its parts are independent of gender. The transverse processes length, isthmus length and laminar length are more on the right side of vertebrae. Because of this asymmetry the spinous process cannot be used for midpoint measurements.

6. References

1. Masharawi Y, Salame K. Shape variation of the Neural Arch in the Thoracic and Lumbar Spine: Characterization and Relationship with the Vertebral Body Shape, Clinical Anatomy. 2011; 24:858-867.
2. Abbas J, Hamoud K, Masharawi Y, May H, Hay O, Medlej B *et al*. Ligamentumflavum thickness in normal and stenotic lumbar spines. Spine. 2010; 20:1225-1230.
3. Masharawi Y, Dar G, Peleg S, Steinberg N, Medlej B, May H *et al*. A morphological adaptation of the thoracic and lumbar vertebrae to lumbar hyperlordosis in young and adult females. Eur Spine J. 2010; 19:768-773.
4. Masharawi YM, Kjaer P, Bendix T, Manniche C, May H, Mirovsky Y *et al*. Lumbar facet and interfacet shape variation during growth in children from the general population: A three-year follow-up MRI study. Spine. 2009; 34:408-412.
5. Masharawi Y, Salame K, Mirovsky Y, Peleg S, Dar G, Steinberg N *et al*. Vertebral body shape variation in the thoracic and lumbar spine: Characterization of its asymmetry and wedging. Clin Anat. 2008; 21:46-54.
6. Masharawi Y, Dar G, Peleg S, Steinberg N, Alperovitch-Najenson D, Salame K *et al*. Lumbar facet anatomy changes in spondylolysis: a comparative skeletal study. Eur Spine J. 2007; 16:993-999.
7. Andrew Williams, Richards LM Newell, Patricia Collins. Back and Macroscopic Anatomy of Spinal Cord. Gray's Anatomy 39th Edition. Churchill Livingstone (London): Harcourt publisher. 2005, 746-749.
8. Masharawi Y, Rothschild B, Dar G, Peleg S, Robinson D, Been E *et al*. Facet orientation in the thoracolumbar spine: Characterization and biomechanical interpretation. Spine. 2005; 30:281-292.
9. Masharawi Y, Rothschild B, Dar G, Peleg S, Robinson D, Been E, *et al*. Facet orientation in the thoracolumbar spine: Three dimensional anatomic and biochemical analysis. Spine. 2004; 29:1755-1763.
10. Pal GP, Routal RV. Mechanism of change in the

orientation of the articular process of the zygapophyseal joint at the thoracolumbar junction. J Anat. 1999; 195:199-209.