

Original article

Morphometry of Human Thoracolumbar Vertebral Facets

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Abstract

Background- Articular facets play an important role in the weight transmission through spines. Measurements of articular facets reveals the importance in understanding the mechanics of spinal anatomy and its application with respect to transmission of weight.

.Methodology- Present study was carried on adult human 60 thoracic and 60 lumbar vertebrae from Osteology section of Anatomy department of Rural Medical College Pravara Institute of Medical Sciences, Loni (Maharashtra) India. Different parameters of Superior, Inferior Articular Facets of thoracic and lumbar vertebrae were measured with digital sliding calliper.

Observations- 1) Thoracic vertebrae-Maximum length of SAF observed was on T1, while least on T3. Maximum width of SAF was found on T2, while least on T3. Maximum length of IAF observed on T1, while least on T3. Maximum width IAF found on T1, while least on T3.

2) Lumbar vertebrae - Maximum length of SAF observed was on L5, while least on L1. Maximum width of SAF found on L5, while least on L1. Maximum length of IAF found on L5, while least on L1. Maximum width of IAF found on L5, while least on L1.

Results – Length and width of SAFs, IAFs of thoracic vertebrae showed a variable trend. In lumbar vertebra length and width of SAFs, IAFs increased from L1-L5. Distance between two SAFs was highest at T12 (14.25mm) and L5 (20.05mm). Distance between two IAFs was more as compared to distance between two SAFs at various thoracic and lumbar vertebral level.

Conclusion – Morphometric study on articular facets may helpful to provide useful information while performing posterior spinal surgery and in developing new implant system. Dimensions of articular facet serves as a useful data for orthopaedic surgeon while proper placement of implant and in designing instruments of intervention for lumbar spines.

Key-words - Articular facets, Lumbar vertebra, Spine

Introduction:

Low back pain is a widespread problem affecting both athletic and nonathletic populations. [1] Osteoarthritis of facet joints is a common source of back pain and its prevalence increases with age.[2]

The direction and size of articular facet joint changes at different parts of the vertebral column.[3] In thoracic region the superior articular facets are circular with flat surface. The inferior articular facets are oval shaped directing forward,

slightly downwards medially.[4] In lumbar region, the articular facets are convex, stout facing anterolaterally.[5] The clinical importance of thoracic & lumbar articular facets considered in clinical setting and understanding basic spinal mechanics.[6] Measurements of articular facet joints plays a major role in spinal deformities like scoliosis, while mathematical modelling of spine.[7] Thus, purpose of the current study to perform morphometric analysis of superior and inferior articular facets of human thoracic, lumbar vertebrae and to ascertain morphometric difference between thoracic and lumbar vertebrae.

Material and method:

The study was carried out on 60 (Right & Left sides of each) adult, dry, thoracic and 60 (Right & Left sides of each) lumbar vertebrae of unknown sexes in the Anatomy Department of Rural Medical college, Pravara Institute of Medical Sciences Deemed University; Loni (Maharashtra), India. Present research has been approved by ethical committee of our Medical Institute. The different thoracic and lumbar vertebrae were labelled from T1 to L5 depending on their specific external features. Damaged and pathologically abnormal vertebrae were excluded from the study.

Different morphometric parameters on the both right, left sided superior and inferior articular facets of thoracic and lumbar vertebrae were studied. Length of superior and inferior articular facets of both thoracic and lumbar vertebrae was measured as the maximum superoinferior extent of the facet surface. The width of both superior and inferior articular facets was estimated as the maximum distance between the anterior and posterior margins of the facet surface. Distance between two superior articular facets measured as the distance between the medial borders of the right and left superior articular facets. Distance between two inferior articular facets measured as the distance

between the medial borders of right and left inferior articular facets. All the parameters on the superior and inferior articular facets of the thoracic, lumbar vertebrae were measured with the help of digital sliding calliper.

The mean and range of all parameters was calculated at each vertebral level. The results obtained were tabulated to compare morphometric difference between different thoracic and lumbar vertebrae.

Observations:

The present study showed that the length and width of superior articular facets was more in upper thoracic region. In midthoracic region the length and width of the same were almost similar. While in lumbar region, the superior articular facets showed length and width were higher in lower lumbar region as compared to upper lumbar region. The length and width of inferior articular facets was observed more in upper thoracic region. In lumbar region opposite trend; the length and width of inferior articular facets found higher in lower lumbar region as compared to upper lumbar region.

Highest length, width of superior and inferior articular facets in thoracic vertebrae observed on T1, T2; while lowest length, width of same facets found on T3. In case of lumbar vertebrae highest length, width of superior and inferior articular facets observed on L5; while minimum length, width of superior and inferior articular facets found on L1, L2 of vertebral column. Length of superior articular facets of thoracic and lumbar vertebrae found more than the width of same. In case of inferior articular facets of thoracic, lumbar vertebrae; length found more than the width.

Results:

Superior articular facets-

A] Thoracic vertebrae - The length of the superior articular facets of thoracic vertebrae

ranged from 7 - 14 mm. The length of thoracic vertebrae at all levels shows variable range. The highest length of superior facet was found at T1(14mm.) and least at T3(7mm.) The width of superior articular facets ranged from 7-15 mm. The width of superior articular facets showed variable range. Highest width of superior articular facets found at T1 (17mm) and least at T2 (7mm) Thus, length and width of superior articular facets in thoracic vertebrae found highest at T1 level. Distance between right and left superior articular facets showed variable range and it is highest at T12 level.

B] Lumbar vertebrae - The length of the superior articular facets of lumbar vertebrae ranged from 8 - 19 mm. The length lumbar vertebrae increased gradually from L1-L5. Highest length of superior articular facet observed on L5 (21mm.) and least at L1 (8mm) The width of superior articular facets showed variable range. The width ranges from 8-19 mm. It is highest at L5 (19mm) and least at L2 (8mm). Both length and width found highest at L5 as compared to other lumbar vertebrae. Distance between right and left superior articular facets of lumbar vertebrae showed variable range and is highest at L5 level.

Inferior articular facets-

A] Thoracic vertebrae- Length of inferior articular facets ranged from 6 to 17mm. The length of the inferior facet showed variable range. The length was maximum at T1(14mm) and least at T3(6mm.) The width of the inferior facets ranged from 7 to 16 mm. The width of the inferior facet was maximum at T1 (16mm) and least at T3 (6mm.) Thus, both length, width observed highest at T1 level. Distance between right and left inferior articular facets of the thoracic vertebrae showed

variable range. Highest distance between right and left inferior articular facets found at T5 level.

B] Lumbar vertebrae- The length of the inferior articular facets of lumbar vertebrae ranged from 8 - 19 mm. The length of the inferior facet increased from L1-L5. Highest length observed at L5 (21mm) and least at L1 (8mm). The width of the inferior articular facet showed variable range. The width of inferior articular facet ranges from 8-16 mm. Highest width of inferior articular facet found in L5 (17mm) and least at L1 (6mm). Thus, both length, width observed highest at L5 level. Distance between right and left inferior articular facets of lumbar vertebrae raised from L1-L5. It is highest at L5 level.

Comparison of dimensions of articular facets between thoracic and lumbar vertebrae-

Length and width of superior articular facets in lumbar vertebrae is more as compared to thoracic vertebrae. Inferior articular facets of lumbar vertebrae showed higher length and width as compared to thoracic vertebrae. Distance between two superior articular facets more in lumbar vertebrae as compared superior articular facets of thoracic vertebrae. Distance between two inferior articular facets more in lumbar vertebrae as compared to inferior articular facets more of thoracic vertebrae. All parameters of morphometric study possess higher value in lumbar vertebrae as compared to thoracic vertebrae.

The results of this study provide a basis for designing a facet instrument and defining the normal and abnormal sizes of the facet. Dimensions of superior and articular facets of human thoracic and lumbar vertebrae were mentioned in table 1 and 2.

Table 1: Length and width of superior articular facets of thoracic and lumbar vertebrae-

Vertebra No.	Right (R) or Left (L) superior articular facets	Length of superior articular facets		Width of superior articular facets		Distance between two superior articular facets	
		Mean	Range	Mean	Range	Mean	Range
T1	R	10.59	9-14	10	9-13	12	11-14
	L	10.57	10-12	10	9-17		
T2	R	10	9-13	9.75	8-12	9.5	9-10
	L	10	8-14	10.25	9-11		
T3	R	9.16	7-11	9.16	7-11	9.5	9-10
	L	8.83	7-10	8.83	8-10		
T4	R	10	9-12	10.16	9-11	12.16	9-18
	L	9.66	9-10	10	9-11		
T5	R	9.8	8-12	10.2	8-13	11	10-14
	L	10	9-11	10.4	9-14		
T6	R	10.33	10-11	10.33	9-11	9.66	7-12
	L	10.66	8-12	12	10-15		
T7	R	10.5	9-12	9.83	9-11	12	10-14
	L	10.66	9-13	9.83	9-11		
T8	R	9.25	7-11	9.5	7-11	11.75	9-15
	L	9.5	8-12	10	9-12		
T9	R	10.4	9-12	11	8-14	13.6	10-17
	L	9.8	8-11	10.6	8-13		
T10	R	11	9-12	11.3	7-14	13.7	11-22
	L	10.4	9-14	10.9	7-14		
T 11	R	10.6	10-11	10.4	10-11	10.6	9-13
	L	11	10-12	10.2	9-11		
T12	R	10.75	10-12	10.75	10-11	14.25	11-18
	L	10.5	9-11	11	10-12		
L1	R	11.72	8-16	11.6	9-17	16.33	11-21
	L	13.13	9-18	12.26	9-17		
L2	R	13.33	9-18	13	8-16	18.83	16-23
	L	11.83	8-16	13	11-16		
L3	R	13.33	11-15	13	11-14	16.55	14-20

	L	13.55	11-16	13.44	11-18		
L4	R	13.37	9-18	13.37	9-17	17	15-21
	L	14	10-18	14	10-18		
L5	R	16.05	14-21	15.16	14-19	20.05	17-23
	L	15.83	12-20	15.33	14-19		

Table 2 : Length and width of inferior articular facets of thoracic and lumbar vertebrae-

Vertebra No.	Right(R) Or left (L) inferior articular facets	Length of inferior articular facets		Width of inferior articular facets		Distance between two inferior articular facets	
		Mean	Range	Mean	Range	Mean	Range
T1	R	10	9-11	11.57	10-14	13.28	12-14
	L	10.57	9-13	10	9-16		
T2	R	10.75	10-12	9.75	9-10	10.5	9-12
	L	10.5	10-11	12.25	9-11		
T3	R	7.5	6-10	9.16	7-10	9.5	8-11
	L	9.5	7-11	9.83	8-11		
T4	R	9.33	8-11	10.33	10-11	11.16	9-13
	L	8.33	9-11	9.83	9-11		
T5	R	10.4	9-12	10.4	9-13	13.4	13-19
	L	11.4	10-17	10.4	9-12		
T6	R	10	9-12	9.66	9-10	10.66	10-12
	L	9.33	8-10	9.66	9-10		
T7	R	10.5	10-11	10.83	9-13	12.83	11-14
	L	10.16	9-11	10.33	8-12		
T8	R	10	9-11	10	9-12	14.5	11-22
	L	10.25	10-11	10.25	10-11		
T9	R	11	9-14	10.8	9-12	12.4	10-14

	L	10.6	10-13	10.2	8-11		
T10	R	10.4	9-12	10.9	8-13	12.4	9-20
	L	10.2	7-13	9	7-16		
T11	R	10.6	8-12	10	7-14	11.8	11-13
	L	10.6	9-12	8.8	7-11		
T12	R	9.75	9-11	10.75	8-12	15.75	13-18
	L	12.5	11-13	12	10-15		
L1	R	13.13	9-18	9.73	6-12	16.26	10-21
	L	12.26	8-17	9.33	8-16		
L2	R	13.33	9-17	10.66	9-13	16.5	10-19
	L	13	10-17	10.66	9-13		
L3	R	14.11	11-17	10.4	8-12	15.11	12-18
	L	13.55	10-16	11	9-13		
L4	R	10.75	9-11	10.75	9-12	17.87	16-21
	L	10.25	9-13	11.5	9-13		
L5	R	15.05	12-19	13.16	11-16	24.72	17-31
	L	14.61	11-17	13.38	11-16		

Discussion:

Present study was structured on the morphometric dimensions of T1- L5 facets and it was demonstrated that all the anatomical landmarks of vertebral articular facets can be defined accurately macroscopically. The normal values of the dimensions of the T1-L5 facets were obtained at the end of the study. The superior and inferior articular facets of facet joints play an important role in weight transmission through vertebral column.[8],[9] According to Pal and Routal in 1987 the mechanism of weight transmission in the thoracic & lumbar region of vertebral column

depends upon three factors: (i) zygapophyseal or facet joints (ii) forces acting at right angles to the articular surface (iii) line of gravity.[10] Dhall was concluded that the size of the articular facet is correlated with the magnitude of stress imposed on them.[11] Mechanical strength of facets can be used safely and effectively for facet spacer insertion. The spacer size varied from 2 to 4 mm in height and 8mm in diameter. [12] The facet joint involvement is a major cause of chronic spinal pain. [13] The zygapophyseal or facet joints are extremely important in the biomechanical and clinical behaviour of the spinal column. [14]

In 2014, S. Satoskar et al has studied the morphometric analysis of articular facets of lumbar vertebrae. She observed that length and width of superior articular facets raised from L1-L5, while in case of inferior articular facets same trend has observed. [15] He concluded that knowledge obtained from the measurements of articular facets may be applied for patient-specific modelling of the spine based on x-ray images. [16] The present study had compared their readings in tabulated form with osteometric study of Patel M.M. on adult, human dried 920 third cervical to first sacral vertebrae of Gujrat state.[17] He observed that width of superior articular facets of thoracic region decreased from T1-T12; whereas in our study width of superior articular facets showed variable range in thoracic region.17 In lumbar region width

of superior articular facets raised from L1-L5, While in our study width showed variable range from L1-L5. In case of inferior articular facets width possesses similar range from T1-T12 whereas in our study width showed variable range in thoracic region.

Length of inferior articular facets showed variable range from T1 –T12; which is similar with our finding. In lumbar region length of inferior articular facet showed variable range from L1-L5 whereas, in our study length and width of inferior articular facets increased from L1-L5. Table 3 and 4 showed comparison between dimensions of superior and inferior articular facets of human thoracic, lumbar vertebrae with present findings and study of Patel M.M

Table3: Comparison of inferior articular facets dimensions of thoracic and lumbar vertebrae with Patel et al.

Vertebra No.	Length of Superior articular facet				Width of superior articular facet			
	Patel et al		Present Study		Patel et al		Present Study	
	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
T1	9.30	9.67	10.59	10.57	13.30	13.41	10	10
T2	9.85	10.22	10	10	10.48	10.52	9.75	10.25
T3	9.52	10.48	9.16	8.83	9.80	9.56	9.16	8.83
T4	14.71	9.25	10	9.66	9.50	9.17	10.16	10
T5	8.96	9.24	9.8	10	9.44	9.17	10.2	10.4
T6	9	9.15	10.33	10.6	8.96	8.58	10.33	12
T7	8.78	9.11	10.5	10.6	8.56	8.74	9.83	9.83
T8	8.63	9.07	9.25	9.5	8.74	8.78	9.5	10
T9	8.62	9.12	10.4	9.8	9.04	8.5	11	10.6
T10	8.76	9.16	11	10.4	9.68	9.52	11.3	10.9
T11	9.32	9.52	10.6	11	10.08	9.88	10.4	10.2
T12	9.42	9.48	10.75	10.5	9.29	9.16	10.75	11
L1	10.33	11	11.8	13.13	10.25	11	11.6	12.26
L2	11.85	12.46	13.33	11.83	13.04	13.31	13	13
L3	12.69	12.77	13.33	13.55	13.85	13.92	13	13.44
L4	12.77	12.85	13.37	14	15.04	14.96	13.37	14
L5	12.85	13.20	16.05	15.83	15.20	15.10	15.16	15.33

Table 4: Comparison of inferior articular facets dimensions of thoracic and lumbar vertebrae with Patel et al.

Vertebra No.	Length of Inferior articular facet				Width of Inferior articular facet			
	Patel et al		Present Study		Patel et al		Present Study	
	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
T1	9	9.31	10	10.57	9.71	9.88	11.57	10
T2	9.09	9.09	10	10.75	9.22	9.28	9.75	12.25
T3	9.67	8.63	7.5	9.5	8.96	8.85	9.16	9.83
T4	8.77	8.67	9.33	8.33	8.73	8.57	10.33	9.33
T5	8.31	8.28	10.4	11.4	8.16	8.13	10.33	9.83
T6	8.21	8.33	10	9.33	8.21	8.18	9.66	9.66
T7	8.26	8.24	10.5	10.16	8.24	8.18	10.83	10.33
T8	8.18	8.33	10	10.25	8.33	8.36	10	10.25
T9	9	9	11	10.6	9.36	9.48	10.8	10.2
T10	9.50	9.60	10.4	10.2	9.63	9.67	10.9	9
T11	9.32	9.52	10.6	10.6	9.40	9.43	10	8.8
T12	9.42	9.48	9.75	12.5	9.50	9.47	10.75	12
L1	10.33	11	12.66	12.26	10.60	10.77	9.33	12.26
L2	11.85	12.46	13.33	13	11.63	10.66	10.66	13
L3	12.69	12.77	14.11	13.55	12.33	10.4	11	13.44
L4	12.77	12.85	10.75	11.4	12.97	12.83	10.75	11.5
L5	12.85	13.20	15.05	14.61	13.61	13.58	13.16	13.38

Conclusion:

The morphometric knowledge obtained regarding articular facets can be utilised during facet spacer technique in the treatment of spinal degenerative canal stenosis. The measurements obtained by the present study reveals the importance of articular facets in understanding mechanics of spinal anatomy. Vertebral articular facet parameters could be useful while modelling of the spine in spinal

deformities like scoliosis. It may improve clinical diagnosis and treatment. Facet spacer technique in the treatment of degenerative spinal stenosis utilises the valuable information regarding articular facet measurements. Findings of the present study may be useful for Orthopaedic Surgeons in designing facet instrumentations for various surgical techniques.



Fig. 1. Length of superior articular facet (Lumbar Vertebra).



Fig 2. Width of superior articular facet (Lumbar Vertebra).



Fig.3. Distance between superior articular facets (Lumbar Vertebra).

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