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Anatomy of The Human Lumbar Interspinous Ligaments: A Cadaveric Study

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Abstract

Objective: Different views are available on the anatomy of the interspinous ligaments. In depth study was done on the lumbar interspinous ligaments to study the anatomy of the lumbar interspinous ligaments and co-relate the function with their anatomy.

Materials and methods: Lumbar regions of thirty formalin fixed cadavers were dissected. The direction of the fibres and their attachments were noted and their function was co-related with their anatomy.

Results: The anatomy of ligaments in the upper space (b/w L1-L2 and L2-L3) was same and for the ligaments in the middle space (b/w L3-L4 and L4_L5) was also same and the ligaments of the lower space i.e. (b/w L5-S1)were different from both the above space ligaments.As we moved from above downwards the postero-cranial direction of fibres in the upper space became horizontal in the middle space and then vertical in the lowest space.

Keywords: Interspinous ligaments, upper space ligaments, middle space ligaments, lower space ligaments.

Introduction

The different ligaments which hold the spinous processes of the vertebrae are interspinous and supraspinous ligaments.[1]

Interspinous ligaments are present between the facing edges of consecutive spinous processes, and extend ventrally till the ligamentum flavum and dorsally upto the supraspinous ligament, if this ligament is present. They vary structurally in the thoracic, lumbar and cervical levels. In the lumbar ligaments, collagen fibres can be seen running obliquely inferiorly and ventrally and the deepest fibres are truly ligamentous. The more dorsal fibres come from tendons of longissimous thoracis that dip into the interspinous space to attach to the superior edge of the spinous process instead of its tip.[2]

The lumbar interspinous ligaments are composed of bundle of fibres arranged in a specific pattern. Together they present an oblique orientation from anterior to posterior in a caudo-cranial direction. In their ventral part the bundles are thicker and arranged in an italic S shape.

The collagenous bundles of fibres in the lumbar interspinous spaces belong to different anatomical structures: the true interspinous ligaments, connecting two consecutive spinous processes in a postero-cranial direction, and fibres, lying in dorso-caudal part, belonging to the thoracolumbar fascia.[3]

The interspinous ligament is important for the stability of the spine .It represents a major structure for the posterior

column of the spine,and often is disrupted in traumatic cases, in which the posterior column becomes unstable .[4]The interspinous ligament is exposed to increasing tension with increasing degree of flexion at the lumbar spine.[5]

The variations of interspinous ligaments in the lumbar region have anatomical and clinical implications.Thus adequate knowledge of these variations is important for understanding local musculo-skeletal disorders associated with low back ache.

Material And Methods

The material for this study comprised of thirty previously fixed formalin cadavers obtained from the Department of Anatomy, Government Medical College, Patiala for the purpose of this study. The skin incisions were given on the back at the approximate level of the lumbar spine. The skin along with the superficial fascia was reflected to expose the posterior layer of the thoracolumbar fascia. After reflecting the posterior layer of thoracolumbar fascia we reached the erector spinae muscle. All the parts of muscles coming in the way of exposing the interspinous ligaments were dissected out. Special care was taken to preserve the supraspinous ligament while exposing the interspinous ligaments. During exposure of the lumbar interspinous ligaments the interspinous and intertransverserii muscles on each side were carefully removed to preserve the collagen fibres in the interspinous ligaments. This was aided with the help of a magnoscope.

For the purpose of observation, anatomical and functional co-relation observations were made in light of the classification made by Mahato NK [(5)] as under:

Upper space fibres- below L1

Middle space fibres- below L3 and L4

Lower space fibres- between L5 and S1

Observations were taken with the help of a magnoscope, the latter was essential for careful separation of loose connective tissue from the surface of the supraspinous ligament and lumbodorsal fascia. Attachments of the ligaments were noted. The orientation of the fibres in the lumbar interspinous ligaments was seen with the help of magnoscope. With the help of digital vernier caliper the thickness of each interspinous ligament was measured. Also the fat in the ventral parts of the ligaments was seen and noted. After careful examination of the interspinous ligaments, the supraspinous ligament were removed to check for the the midline cavity between the two laminae of the lumbar interspinous ligaments. The variations seen during the dissection were noted.

Results

The attachment of each and every ligament (except one of them in the lower space ligament serial no -27) was observed and noted as described by the following table:

Table No 1: Attachments of Lumbar Interspinous Ligaments

Attachments	**Site of attachment**
Superior	Lower border of spine of vertebra above
Inferior	Upper border of spine of vertebra below
Ventral	Ligamentum flavum
Dorsal	Supraspinous ligament and thoracodorsal fascia

The interspinous ligaments in the lumbar region were made up of relatively complex character. Although the structural principle of ISL was same in whole of the spaces but the direction of the fibres kept changing as we moved down the interspinous spaces as shown in the following table:

Table no 2: Direction of fibres in each interspinous space

Ligaments	Direction of fibres	Percentage (%)
Between L1-L2	Postero-cranial	93.33
	Postero-caudal	3.33
	V-shaped with V opened posteriorly	3.33
Between L2-L3	Postero-cranial	96.66
	Bi-laminar	3.34
Between L3-L4	Horizontal	100
Between L4-L5	Horizontal	96.66
	Bi-laminar	3.34
Between L5-S1	Vertical	100

The thickness of all the ligaments was measured which increased gradually as we moved down the spaces as described by the table below:

Table no 3:Mean thickness of lumbar interspinous ligament of each space

Interspinous ligaments	Minimum Thickness (mm)	Maximum Thickness (mm)	Mean Thickness (mm)
Between L1-L2	0.19	0.30	0.23
Between L2-L3	0.20	0.29	0.24
Between L3-L4	0.29	0.40	0.35
Between L4-L5	0.28	0.41	0.37
Between L5-S1	0.67	0.83	0.76

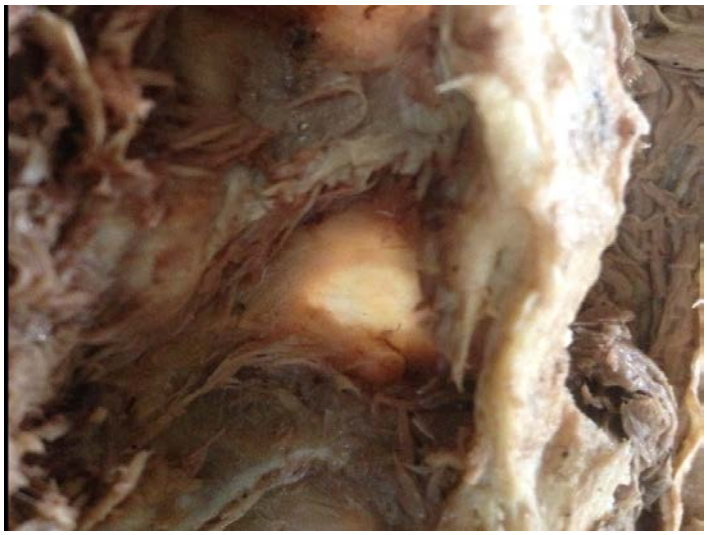

Figure no 1: Photograph of left side of ISL b/w L1-L2. (Direction of fibres is typically Postero-cranial).

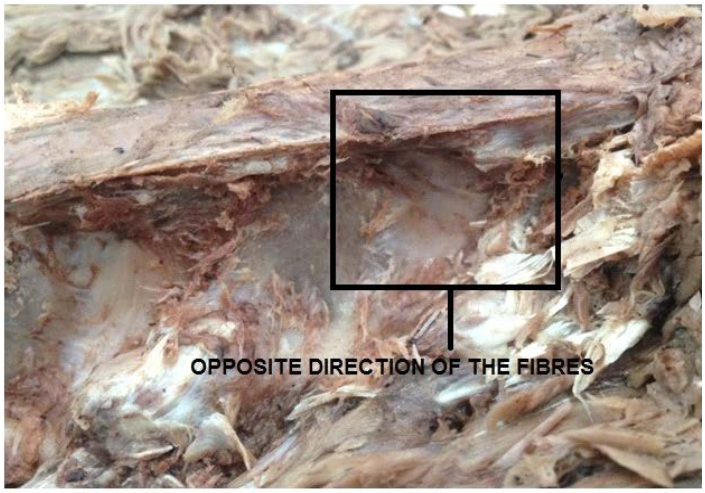

Figure no 2: Photograph of right side showing (postero-caudal) ISL b/w L1-L2

Figure no 3: Photograph of left side of ISL b/w L1-L2. (Direction of fibres is V shaped).

Figure No 4: Photograph of left side of bi-laminar ISL between L3-L4.

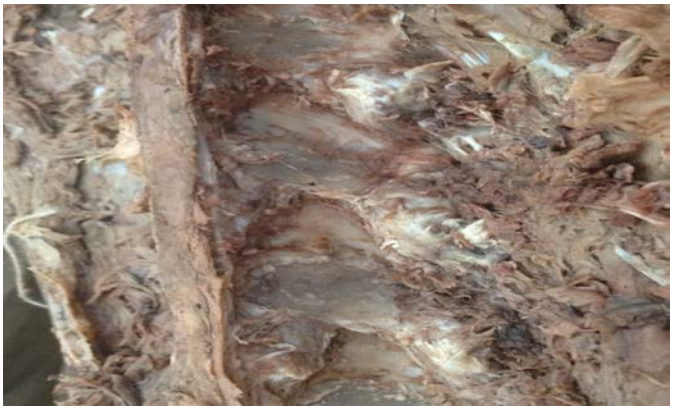

Figure no 5: Photograph of left side showing ISL b/w L3-L4. (Direction of fibres nearly horizontal).

Figure no 6: Photograph of left side of ISL showing absent Supraspinous ligament b/w L5 and S1

Discussion

Almost all of the ligaments extended throught the space and were attached anteriorly to the ligamentum flavum and posteriorly to the supraspinous ligament which supports many standard books i.e. Cunningham's Manual of Practical Anatomy (Romanes, 1968) [6] and Gray's Anatomy (Warwick and Williams). [7] The observations were related to the previous studies and their mechanical function was co-related. The pattern as described by D. J. A. Heylings [8] was followed by almost all of the interspinous ligaments except in few cases which represented the different pattern. Also, it was noted that every normal ligament was bilateral anteriorly, and there was a slit-like mid-line cavity filled with the fat. Only the separated bi-laminar ligaments were devoid of the fat in their ventral aspect. There was no any cavitation or ruptured interspinous ligament in any of the space.

The individual interspinous ligaments are discussed below:

Upper Space Ligaments

ISL between L1 and L2 were oriented in a postero-cranial direction i.e. the collagen fibres in these ligaments were oriented in a backwards and upward direction but in curved manner as also noted by Rissanen [9] and D J Heylings. [16] This orientation also supports the Grant (1972). [10] But in one of the cadaver the direction of the fibres was totally different i.e. fibres passed posterocaudally (downwards and inferiorly). This followed the pattern as described by the standard anatomy books i.e.Cunningham's Manual of Practical Anatomy (Romanes, 1968) and Gray's Anatomy (Warwick and Williams). In one of the ligament in this space the totally different pattern of the fibres were noted. It was a different V shaped orientation with the mouth of V opened posteroirly. In this ISL all the fibres were more or nearly horizontal which supported the study done by R M Aspeden (1987). [9] R M Aspeden noted the horizontal pattern of the fibres in which they ran parallel to the spinous processes of the corresponding lumbar vertebrae. It was against the observations as observed by Mahato N.

K. [11] He noted the direction of the fibres to be horizontal with respect to the ISL in the middle space i.e. (L3-L4 and L4-L5) which were aligned postero-superiorly. But in the present study the middle space ligaments were nearly horizontal and upper space ligaments were directed postero-superiorly. In one of the ligament the orientation of the fibres was totally different. It was a different V shaped orientation which has not been reported by any author or book till now. The table below shows the comparison between the orientation of the fibres as observed by different authors and our own findings in the upper space ligaments:

Table No 4: Comparison of present study (upper space ligaments) with work done by previous workers

S.No	Authors & Year	Direction of fibres	
		Between L1-L2	**Between L2-L3**
1	P. M. Rissanen, 1960	Postero-cranial	Postero-cranial
2	D J Heylings, 1978	Postero-cranial	Postero-cranial
3	Prestar F J 1985	Postero-cranial	Postero-cranial
4	R M Aspeden, 1987	Horizontal	Horizontal
5	Mahato N K, 2013	Horizontal	Horizontal
6	Present study, 2015	Postero-cranial (93.33%)	Posterocranial (96.66%)
		Horizontal (V shaped) (3.33%)	Bilaminar (3.34%)
		Postero-caudal (3.33%)	----

ISL (b/w L2 and L3)-

ISL between L2 and L3 were same as that of the upper space with one exception, where the ligament was bilaminar with absent midline cavity in its ventral part. So fat in the ventral part was also absent.

Middle Space Ligaments

Almost all of the middle space ligaments (b/w L3-L4 and L4-L5) were nearly horizontal except one of them which was bilaminar (b/w L4-L5) with absent mid line cavity in its ventral aspect. These ligaments followed the pattern as described by the R M Aspeden. The fibres were parallel to the spinous processes. It was also observed that the fibres changed their direction acutely in the midway of the interspinous space to be aligned more horizontally which supports the Mahato N K's description. The table given below shows the comparison between our findings and the previous workers-

Table no 5: Comparison of present study (middle space ligaments) with work done by previous workers

S.no.	Authors and Year	Direction of fibres	
1	R M Aspeden 1987	Horizontal	
2	Mahato N K 2013	Between L3-L4	Between L4-L5
		Postero-superior (96%)	Posterosuperior 100%
		Bilaminar (	-----

		4%)	
3	Present work 2015	Between L3-L4	Between L4-l5
		Horizontal (100%)	Horizontal (96.66%)
		-----	Bi-laminar (3.34%)

Lower Space Ligaments

These ligaments were oriented as described by MAHATO N K and D J A HEYLINGS in their studies. These were aligned vertically and extended throught the space. But in one of the case the supraspinous ligament was absent, here the dorsal portion of the interspinous ligament was attached to the thoracolumbar fascia. The study done by D J A Heylings supports that the supraspinous ligament is absent in the lower lumbar spine. But it was the only case in which the supraspinous ligament was absent.

Thickness

It was observed that the mean thickness of the ligaments was less in case of the females as compared to the males. The thickness also increased as we moved down the lumbar spaces and also the values were very closely related to the thickness as observed by MAHATO N K. Following is the table showing the comparison between the observations noted by Mahato N K and our own findings.

Table No 4: Table showing comparison of thickness of ISL's in present study and study done by Mahato N K:

S.No	Thickness of the ISL (mm)	Mahato N K	Present study
1	UPPER SPACE	0.22	0.23
2	MIDDLE SPACE	0.37	0.35
3	LOWER SPACE	0.72	0.76

Conclusion

The interspinous ligaments in the lumbar region were basically bilateral anteriorly. The two laminae of the ISL's joined to form a single lamina posteriorly and enclosed a space anteriorly which was filled with fat. The fibres of the ISL's traversed the interspinous space in a posterocranial direction. Anteriorly the ligaments were attached to the ligamentum flavum. Posteriorly they were attached to the supraspinous ligament and thoracolumbar fascia. Superior attachment was to the inferior border of the upper spinous process and inferiorly to the upper border of the lower spinous process. The structure of the ISL's between L1-L2 and L2-L3 were found to be same, structural similarity was also seen between L3-L4 and L4-L5. But ISl's between L5-S1 were totally different in their structure.

The posterocranial direction of the ligaments in the upper space ligaments became horizontal in the middle space ligaments and it was vertical in the lower space ligaments.

After studying the anatomical structure it can be concluded that the interspinous ligaments are specifically designed to limit flexion and prevent backward displacement of the upper lumbar vertebrae over the lower ones. They also transmit the tension from the thoracolumbar fascia to the spine. Thus maintaining the stability of the spine. The proteoglycans help in holding the collagen fibres together and Ruffini corpuscle's help in maintaining the stability of spine through the spinal control system.

Thus it can be concluded that the aims and objective of the present study which was to study the anatomy of the lumbar ISL's in 30 adult human cadavers was carried out. Their function was co-related with their anatomy according to the composition as found by the earlier workers.

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