The Lumbosacral Ligament

An Autopsy Study of Young Black and White People

Patrick Hanson Henrik Sørensen

Department of Medical Anatomy C, Laboratory for Functional Anatomy and Biomechanics, The Panum Institute, University of Copenhagen, Denmark

Key Words

Lumbosacral ligament · Vertebral column · Black and white young men

Abstract

The lumbosacral ligament (LSL), situated between the L5-vertebra and the sacrum, was studied in autopsy material. Twenty-eight cadaveric specimens from 12 black and 16 white persons aged 17–30 years were studied during routine forensic autopsies. The ligaments were measured and determined in situ. Thereafter, the ligaments were removed for histologic preparation. The ligament in the black subjects was thicker compared with the white (7.5 ± 1.4 vs. 5.7 ± 1.2 mm), and wider (11.7 ± 1.6 mm in the black vs. 9.2 ± 0.5 mm in the white), yielding a greater cross-sectional area in the black group

(70.7 ± 22.8 vs. 34.5 ± 11.4 mm², $p < 0.001$). However, no histological differences were noted. The previously described fibro-osseous tunnel could not be detected in any of the subjects. In all instances, the ligament was situated medial to the L5 nerve. Compression of the L5 nerve under the previously presented fibro-osseous tunnel could not be confirmed.

Copyright © 2000 S. Karger AG, Basel

Introduction

The anatomy of the lumbo-ilio-sacral ligaments (LISL) has been studied extensively in the past [Luk et al., 1986; Uhthoff, 1993; Hanson and Sonesson, 1994; Basadonna et al., 1996]. The descriptions of the ligaments, however, vary greatly. The LISL have been described as one large iliolumbar ligament (ILL) with as many as five parts [Shellshear and Macintosh, 1949; Bogduk, 1997], while others have described this ligament to be made up of three parts [Williams, 1995]. In contrast, Hanson and Sonesson [1994] described the ILL to consist of only two parts, which is in accordance with others [Basadonna et al., 1996; Rucco et al., 1996]. The lumbosacral ligament (LSL) has received less attention and is therefore not as well described. While some authors do not recognize the

Abbreviations used in this paper

LALL	lumbar anterior longitudinal ligament
ILL	iliolumbar ligament
LISL	lumbo-ilio-sacral ligaments
LSL	lumbosacral ligament

KARGER

Fax + 41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

© 2000 S. Karger AG, Basel
1422-6405/00/1664-0373\$17.50/0

Accessible online at:
www.karger.com/journals/cto

Patrick Hanson, MD
Department of Medical Anatomy C, Laboratory for
Functional Anatomy and Biomechanics, University of Copenhagen
Blegdamsvej 3
DK-2200 Copenhagen N (Denmark)

Table 1. Age, weight and height distribution of the subjects used in this study

	Age	Weight, kg	Height, cm
Black (n = 12)	21.9 ± 4.1 (17–29)	76.0 ± 3.7	176.4 ± 2.7
White (n = 16)	23.2 ± 4.9 (18–30)	75.8 ± 3.5	175.7 ± 3.0

Mean ± SD (range). No significant differences existed between the groups with respect to age, height and weight.

ligament as a separate structure [Williams, 1995; Bogduk, 1997], others describe the ligament as clinically important [Nathan et al., 1982; Briggs and Chandraraj, 1995]. The few available studies that describe the LSL, present it as consisting of one to three distinct parts. The most commonly described part attaches to the ventro-inferior aspect of the L5 transverse process (costal process), and courses inferolaterally to attach to the ala of the sacrum [Nathan et al., 1982; Olsewski et al., 1991; Briggs and Chandraraj, 1995]. Other, less common variations have described the ligament to course between the L5 transverse process and the promontorium of the sacrum [Nathan et al., 1982]. Briggs et al. [1995] described the ligament to be divided in two parts, yielding two separate inferior attachments under which the 5th lumbar nerve traversed. From a clinical stand point, the LSL has been described as being a cause of entrapment of the 5th lumbar nerve [Nathan et al., 1982; Briggs and Chandraraj, 1995; Pecina et al., 1997]. However, if the relationship between the LSL and the 5th lumbar nerve can result in entrapment has not yet been firmly established. Therefore, the aim of the study was to investigate the anatomical attachments, length and width of the LSL in black and white young people, and to determine if the LSL could cause compression of the 5th lumbar nerve.

This is the first study presenting data from LSL in fresh, unembalmed young, black and white autopsy subjects.

Materials and Methods

The LSL was studied during autopsies of 28 black and white young men aged 17–30 years. The subjects included 12 black and 16 white men without any known history of low back pain and/or pathology. Apart from the selection for gender, age, height and weight, all subjects were recruited consecutively during routine forensic autopsies. Subject characteristics are presented in table 1. The subjects were grouped into black or white both from the records

of the individual who declared the subject dead, i.e. police, coroner or physician, and by records from the medical examiner’s office. The person who declared the subject dead was unfamiliar with the study at hand. The autopsies took place at the Arkansas State Crime Laboratory, Little Rock, Ark., USA and Department of Forensic Medicine, Lund University, Sweden during 1994–1997.

All autopsies were carried out by first removing the internal organs. The nerves and vessels of the region were identified prior to the careful division and removal of the psoas muscles. The LSL was hereby visualized (fig. 1), and the attachments of LSL could be determined. The sites of attachment were marked with pins to simplify the measuring of the ligaments. Thereafter, the ligaments were measured in length, width, and thickness. The measurements were done in situ. The ligament was also measured after removal from the body. The measurements were done with a digital sliding caliper which measured an accuracy of ± 0.1 mm. After measuring the shape of the ligaments, the cross-sectional area was calculated. Since the cross-sectional area of the ligament was roughly elliptic, the anatomic cross-sectional area was calculated using the area formula for an ellipse, πab , where a is half the width and b is half the thickness. The same person (P.H.) performed all measurements and dissections to minimize measuring errors.

Samples of the ligaments were prepared for histology. The ligaments were placed in a 10% formaline solution for histological preparations. Both cross-sections and length sections were prepared. The specimens were stained with hematoxylin and eosin. Van Gieson (iron-hematoxylin, picric acid and acid fuchsin), and Masson-trichrome stains (iron-hematoxylin; Ponceau acid fuchsin; azophloxine) were used to visualize the collagen fibers, and possible concentrations of elastic fibers [Hammersen, 1980].

Results

The LSL was made up of one single strong ligament which was present bilaterally in all the subjects. The LSL originated by a firm attachment on the pedicle of the L5 vertebra, and a firm attachment on medial part of the ala just below the promontorium of the sacrum (fig. 1). In the black group the LSL attachment on the pedicle was located close the site of attachment for the ILL, which is made up of only one long part (fig. 1). In black subjects, the LSL and the ILL were connected by a thin fascia. In one black subject, the LSL and the ventral sacroiliac ligament was connected by a similar thin fascia. However, in the white subjects, the ILL is made up by two bands. Both ILL parts originated as one large part from the lateral, inferior aspect of the transverse process of the L5 vertebra (fig. 1). In the white group there was no connection between the LSL and other ligaments in the region. However, in one subject from the white group a thin, almost transparent, membrane-like structure covered the L5 nerve. The membrane-structure appeared to originate from the LSL and attach to the ventral sacroiliac ligament.

Fig. 1. **A** The lumbar sacral ligament (below) in the white group, and its relation to the iliolumbar ligament (above). **B** The lumbar sacral ligament (below) in the black group, and its relation to the iliolumbar ligament (above).

Table 2. Length and width of the lumbar sacral ligament in the black and the white group

Ethnicity	Length mm	Width mm	Thickness mm	Cross-sectional area, mm ²
Black (n = 12)	28.3 ± 2.8	11.7 ± 1.6*	7.5 ± 1.4*	70.7 ± 22.8*
White (n = 16)	27.7 ± 2.0	9.2 ± 0.5	5.7 ± 1.2	34.5 ± 11.4
Mean ± SD. Significantly different from white men: * p < 0.001.				

Macroscopically, the LSL revealed several morphological differences between the groups (table 2). Although the LSL essentially originated and attached on the same sites in both groups, the LSL in the black group was considerably broader ($p < 0.01$) and thicker ($p < 0.01$) than in that of the white group. The difference yielded a greater cross-sectional area (table 2) in the black group ($p < 0.01$) compared to that of the white. Microscopically, no differences between the groups were detected.

Apart from the observed membrane-like structure that covered the L5 nerve, there was no sign of a fibro-osseous tunnel formed by the LSL. Hence, no compression of the 5th spinal nerve root could be verified anatomically. In all 28 cases the nerve passed lateral to the LSL, bilaterally (fig. 1). Further, there was no sign of osteophytes in any of the subjects.

Discussion

This study examined the anatomy of the LSL in young black and white people. The two groups were comparable in age, weight and height. The LSL was found to have a considerably greater cross-sectional area in the studied black group than in that of the white. Further, the ligament was found to be present bilaterally in all the studied subjects without a fibro-osseous tunnel.

The vertebral origin of the LSL has been presented to vary considerably. The ligament is most commonly described to originate from the body of the L5 and its transverse process, and less often only from the transverse process [Nathan et al., 1982]. Although Nathan et al., 1982] describe the LSL to attach to the body of the vertebra, the authors did not find the ligament to do so. According to Nathan et al., [1982], the ligament always has a transverse process attachment. Olsewski et al. [1991] describe the LSL not to attach to the body of the L5 vertebra. In contrast, the sites of attachments found in previous studies [Nathan et al., 1982; Olsewski et al., 1991; Briggs and Chandraraj, 1995; Pecina et al., 1997] could not be confirmed in the current study in which the vertebral attachment in all subjects was on the pedicle of the vertebra, with no connection to the transverse process.

The previously described divided attachment of the LSL on the ala of the sacrum is believed to form a fibro-osseous tunnel [Nathan et al., 1982; Olsewski et al., 1991; Briggs and Chandraraj, 1995; Pecina et al., 1997]. Further, the fibro-osseous tunnel is thought to compress and cause entrapment of the 5th lumbar nerve. Apart from the membrane-like, thin structure covering the L5 nerve which was found in one subject, the presence of a fibro-osseous tunnel could not be verified in the current study. Entrapment of the 5th lumbar nerve is, therefore, not possible, since the ligament was situated medial to the nerve in all instances.

Several studies have described the presence of osteophytes in the vertebral column [Vernon-Roberts, 1992], which may cause compression of the 5th lumbar nerve [Nathan et al., 1982; Olsewski et al., 1991]. In the present study, no osteophytes were found in any of the subjects. The absence of osteophytes is probably due to the young age of the subjects. Osteophytes are usually associated with degenerative changes in the intervertebral disc or the vertebral body. Osteophytes usually occur after middle age has been reached [Vernon-Roberts, 1992]. Since only young subjects were studied, the possible influence of osteophytes in compression of the 5th lumbar nerve remains to be studied further.

Previous studies of the LSL have not presented its length, width, and thickness. The ligament was measured with a highly accurate digital sliding caliper, which measured ± 0.1 mm. Previous studies [Neumann et al., 1992] have shown the measurement of the LALL by using calipers to be highly reproducible (approximately 5%). The accuracy of the sliding caliper has been confirmed in studies of the iliolumbar ligament [Hanson et al., 1998], and the lumbar anterior longitudinal ligament [Hanson and Magnusson, 1998].

Determined from the position of the ligament, it is suggested that its primary mechanical function is to restrict lateral flexion and probably also extension. Considering that the axes of rotation for both of these movements pass through the center of the L5-S1 intervertebral disc, the first few degrees of either movement will cause the ligament's attachment on L5 to move upwards relative to its attachment site on sacrum. Thus, a vertically aligned LSL will be best suited to restrict these movements.

Whether the observed differences in the LSL in the black and white groups have any clinical implications remains to be studied further.

The current study differs from others in that it investigates the LSL in young unembalmed cadavers from two ethnically different groups. Only two previous studies have presented similar results in lumbar ligaments. Hanson et al., [1998] presented racial differences in the iliolumbar ligament between black and white people. The lumbar anterior longitudinal ligament has also been presented to be different between black and white people [Hanson and Magnusson, 1998]. Further, the results in the study are different compared with others in that racial discrepancies in the LSL are presented. Moreover, no previous study has investigated the LSL in fresh, young, unembalmed cadavers.

In conclusion, the present study investigated the anatomy of the LSL in fresh, young black and white cadavers with similar height and weight. The results show that the LSL is always present and attaches to the pedicle of the L5 vertebra and to the ala of the sacrum. The ligaments is thicker and wider in the black group. The ligament was, in all instances, located medial to the 5th lumbar nerve and can, therefore, not cause compression of the nerve.

References

- Basadonna, P.T., D. Gasparini, V. Rucco (1996) Iliolumbar ligament insertions: In vivo anatomic study. *Spine* 21: 2313–2316.
- Bogduk, N. (1997) *Clinical Anatomy of the Lumbar Spine and Sacrum*, ed 3. London, Churchill-Livingstone.
- Briggs, C.A., S. Chandraraj (1995) Variations in the lumbosacral ligament and associated changes in the lumbosacral region resulting in compression of the fifth dorsal root ganglion and spinal nerve (see comments). *Clin Anat* 8: 339–346.
- Hammersen F. (1980) *Sobotta/Hammersen Histology. A Color Atlas of Cytology, Histology and Microscopic Anatomy*, ed 2. Baltimore, Urban & Schwarzenberg.
- Hanson, P., S.P. Magnusson (1998) The difference in anatomy of the lumbar anterior longitudinal ligament in young African-Americans and Scandinavians. *Arch Phys Med Rehabil* 79: 1545–1548.
- Hanson, P., S.P. Magnusson, H. Sorensen, E.B. Simonsen (1998) Differences in the iliolumbar ligament and the transverse process of the L5 vertebra in young white and black people. *Acta Anat (Basel)* 163: 218–223.
- Hanson, P., B. Sonesson (1994) The anatomy of the iliolumbar ligament. *Arch Phys Med Rehabil* 75: 1245–1246.
- Luk, K.D., H.C. Ho, J.C. Leong (1986) The iliolumbar ligament. A study of its anatomy, development and clinical significance. *J Bone Joint Surg* 68: 197–200.
- Nathan, H., M. Weizenbluth, N. Halperin (1982) The lumbosacral ligament (LSL), with special emphasis on the 'lumbosacral tunnel' and the entrapment of the 5th lumbar nerve. *Int Orthop* 6: 197–202.
- Neumann, P., T.S. Keller, L. Ekstrom, L. Perry, T.H. Hansson, D.M. Spengler (1992) Mechanical properties of the human lumbar anterior longitudinal ligament. *J Biomech* 25: 1185–1194.
- Olsewski, J.M., E.H. Simmons, F.C. Kallen, F.C. Mendel (1991) Evidence from cadavers suggestive of entrapment of fifth lumbar spinal nerves by lumbosacral ligaments. *Spine* 16: 336–347.
- Pecina, M.M., J. Krmpotic-Nemanic, A.D. Markiewicz (1997) *Tunnel Syndromes. Peripheral Nerve Compression Syndromes*, ed 2. Boca Raton, CRC Press.
- Rucco, V., P.T. Basadonna, D. Gasparini (1996) Anatomy of the iliolumbar ligament: A review of its anatomy and a magnetic resonance study. *Am J Phys Med Rehabil* 75: 451–455.
- Shellshear, J.L. N.G.W. (1949) *Surveys of Anatomical Fields*. Sydney, Grahame.
- Uhthoff, H.K. (1993) Prenatal development of the iliolumbar ligament. *J Bone Joint Surg* 75: 93–95.
- Vernon-Roberts, B. (1992) Age-related and degenerative pathology of intervertebral discs and apophyseal joints; in Jayson, M.I.V. (ed): *The Lumbar Spine and Back Pain*. London, Churchill-Livingstone, vol 4. pp 17–41.
- Williams, P.L. (ed) (1995) *Gray's Anatomy: The Anatomical Basis of Medicine and Surgery*; ed 36. Edinburgh, Churchill-Livingstone.