

Anatomic Variations in the Lateral Femoral Cutaneous Nerve With Respect to Pediatric Hip Surgery

Marc A. Bjurlin, BA, Kelly E. Davis, BA, Edgar F. Allin, MD, and Denise T. Ibrahim, DO

Abstract

Variations were documented in the course of the lateral femoral cutaneous nerve (LFCN) in the upper thigh relative to anatomic landmarks in 22 adult cadavers using the Smith-Petersen incision for the anterior approach to the hip. Distances from the anterior superior iliac spine (ASIS) to the point of nerve entry into the thigh were normalized as percentages of the distance from the ASIS to the pubic tubercle (PT) to relate the data to small children.

In all cases, the LFCN passed deep to the inguinal ligament, entering the thigh a mean of 2.6 cm (SD, 1.9 cm) medial from the ASIS (19%±14% of the ASIS-PT distance), with distances ranging from 0.3 to 6.5 cm (2.6%-46.4%). With the data extrapolated to children, the LFCN may commonly be found medial to the ASIS about one fifth the distance from the ASIS to the PT. In 32% of cases, the LFCN ran directly inferiorly, but in 68% it coursed inferolaterally and then turned to run inferiorly close to the distal part of the incision.

Expressed proportionally rather than only as mean measurements, these percentages provide a better estimate of the location of the LFCN in relation to patient size and thus are useful when operating in this region.

Commonly used in pediatric orthopedic surgery, the Smith-Petersen anterior approach to the hip¹ (and the contemporary, secondary Hoppenfeld anterior approach²) places the lateral femoral cutaneous nerve (LFCN) at risk for iatrogenic injury. One of the most common uses of this approach is for treatment of congenital hip dislocations and developmental dysplasia of the hip. Other uses are for synovial biopsy, intra-

articular fusion, femoral neck and pelvic osteotomies, tendon lengthening and releases, total hip arthroplasty, and tumor excision.

The Smith-Petersen incision follows the anterior half of the iliac crest to the anterior superior iliac spine (ASIS) and then runs directly inferiorly 8 to 10 cm (in adults) toward the lateral margin of the patella. The LFCN commonly pierces the deep fascia through or close to the interval between the tensor fasciae latae and the sartorius muscle and often courses close to the distal part of the incision. Surgeons using this approach must be cognizant of variations in the point of entry of the LFCN into the

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thigh in relation to anatomic landmarks, and its course in the upper thigh, to minimize risk for nerve injury. The same is true for surgeons performing several other procedures, such as inguinal herniorrhaphy.³

Several anatomic studies have documented variations of the LFCN with respect to meralgia paresthetica,⁴⁻¹⁵ hernia repair,³ trauma surgery,¹⁶ and anesthesia administration.¹⁷ Several of these studies have focused on variation in the nerve as it exits the pelvis in relation to the ASIS in adult cadavers. Because cadavers of children are not readily available, the present study also uses adults.

As mean measurements in adults are not directly applicable to pediatrics, the purpose of our study was to investigate and report the variations in the proximity of the LFCN to the ASIS in a proportional manner that will allow extrapolation from adults to small children.

To the best of our knowledge, this is the first report to present the variation in the LFCN in a proportional manner relative to pelvic anatomy landmarks, in addition to mean measurements, that will allow surgeons a best estimate of its course in pediatric cases. We express this proximity as a percentage of the distance from the ASIS to the pubic tubercle (PT), which we consider the best surgically useful estimate of its location in children. In addition, we review

Mr. Bjurlin and Ms. Davis are Medical Students, Northwestern University, Downers Grove, Illinois.

Dr. Allin is Professor, Department of Anatomy, Northwestern University, Downers Grove, Illinois.

Dr. Ibrahim is Attending Pediatric Orthopedic Surgeon, Hope Children's Hospital, Advocate Christ Medical Center, Oak Lawn, Illinois.

Requests for reprints: Denise T. Ibrahim, DO, Department of Orthopedic Surgery, Hope Children's Hospital, Advocate Christ Medical Center, 4440 W 95th St, Oak Lawn, IL 60453 (tel, 312-944-9188; fax, 312-943-9188; e-mail, dia60611@aol.com).

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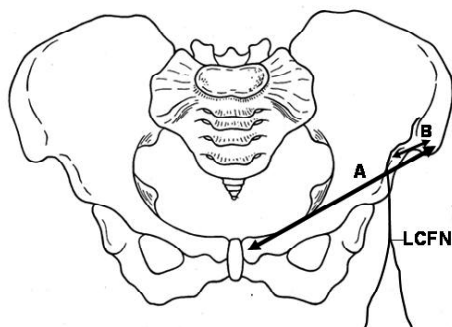


Figure 1. A = Distance from the center of the anterior superior iliac spine (ASIS) to the center of the pubic tubercle (PT) (ASIS-PT distance) and B = the distance from the center of the ASIS to the lateral femoral cutaneous nerve (LFCN) along the line of the inguinal ligament (ASIS-LFCN distance). Artist: Denise T. Ibrahim, DO.

the current literature and express other authors' measurements in our proportional calculation for comparison. Our study specifically focused on the relationship of the course of the LFCN to the incision for the Smith-Petersen anterior approach to the hip.

MATERIALS AND METHODS

Unilateral superficial dissections of the inguinal region and upper thigh were performed on 22 embalmed adult cadavers after excluding any with a pelvic incision scar, pelvic trauma, or tumor metastases to the pelvis. On each cadaver, an incision was made in the fashion of the Smith-Petersen approach,¹ along the anterior half of the iliac crest to the ASIS and then inferiorly for 10 cm toward the lateral side of the patella. Additional 4-cm incisions were made to each side of the ends of the Smith-Petersen incision to create flaps of skin and superficial fascia to allow adequate exposure. The primary branch of the LFCN (its anterior branch) was identified within the subcutaneous tissue and traced proximally through the fascia lata to the stem of the nerve at its point of entry into the thigh. The distance from the center of the ASIS to the center of the PT (ASIS-PT distance) was measured, as was the distance from the center of the ASIS to the LFCN along the line of the inguinal ligament (ASIS-LFCN distance) (Figure 1). The ASIS-LFCN distance was converted to a percentage of the ASIS-PT distance using the equation ASIS-LFCN as % of ASIS-PT = (ASIS-LFCN Distance/ASIS-PT Distance) × 100. The course of the LFCN was documented from its entry point distally for 10 cm. Of the 22 cadavers dissected, 9 were male (mean age, 79 years), and 13 were female (mean age, 76 years).

RESULTS

Mean ASIS-PT distance for males and females combined was 13.9 cm (SD, 1.8 cm; range, 11.4-18.5 cm). For males, mean distance was 14.2 cm (range, 11.5-16.9 cm); for females, it was 13.7 cm (range, 11.4-18.5 cm). In this report, all percentages given are the distance the nerve was

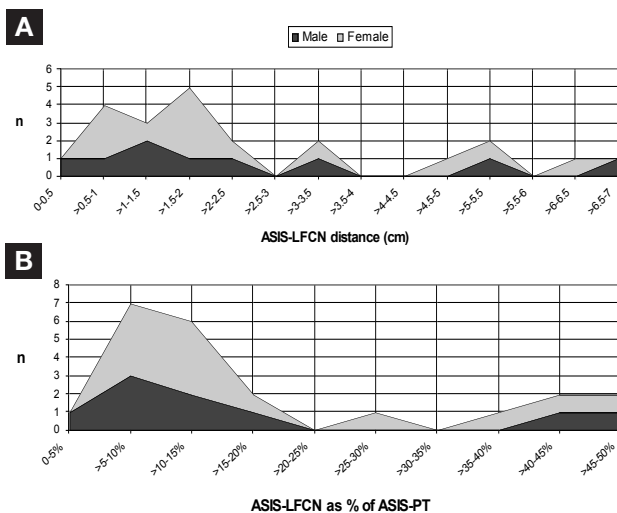


Figure 2. Distance from the anterior superior iliac spine (ASIS) to the lateral femoral cutaneous nerve along the line of the inguinal ligament (A) in centimeters and (B) as a percentage of the distance between the ASIS and the pubic tubercle to normalize for differences in body size.

medial to the ASIS (ASIS-LFCN distance) expressed as a percentage of the total distance from the ASIS to the PT (ASIS-PT distance) as determined by the equation just presented (ASIS-LFCN as % of ASIS-PT) (Figure 1). Table I and Figure 2 give all ASIS-PT and ASIS-LFCN distances in centimeters and percentage equivalents; Table II gives means, SDs, and ranges. Mean ASIS-LFCN distance for males and females combined was 2.6 cm or 19% (SD, 1.9 or 14%), and distances ranged from 0.3 to 7.0 cm (2.6%-46.7%) (Tables I, II; Figure 2). For males, mean distance was 2.5 cm (18%), and distances ranged from 0.3 to 7.0 cm (2.6%-46.7%). For females, mean distance was 2.6 cm (19%), and distances ranged from 0.7 to 6.5 cm (5.9%-46.4%). The mean distance corresponds to the LFCN most commonly coursing medial to the ASIS about 1/3 the distance of the ASIS to the PT.

We did not find the LFCN crossing the ASIS or passing over the iliac crest lateral to it in any of the 22 dissections. The course of the nerve varied extensively in the upper thigh. In 68% of the dissections (67% of males, 69% of females), the LFCN coursed inferolaterally as it entered the thigh, usually soon turning to run directly inferiorly superficial to the sartorius muscle and, in some instances, then running within the aponeurotic sheet connecting this muscle to the adjacent tensor fasciae latae. In 32% of the dissections, the LFCN coursed directly inferiorly from its point of entry into the thigh and made no marked change in direction. Mean closest approach of the nerve to the distal part of the incision (ASIS-patella line) was 0.55 cm (range, 2.5 cm medial to 2.5 cm lateral). Five nerves crossed the line from medial to lateral (obliquely). Ten nerves, in part of their 10-cm documented course, lay on (3 nerves) or within (7 nerves) the thick fascia lata between the sartorius and tensor fasciae latae muscles.

Table I. ASIS-PT Distance and Proximity of Site of Entry of LFCN Into Thigh, by Sex and Age

Sex	Age (y)	ASIS-PT Distance (cm)	ASIS-LFCN	
			Distance (cm)	% of ASIS-PT
Male	68	11.5	0.3	2.6
	n/a	13.6	0.7	5.1
	98	13.0	1.0	7.7
	77	14.4	1.3	9.0
	62	16.9	1.8	10.7
	68	14.5	2.0	13.8
	88	16.4	3.2	19.5
	81	12.3	5.4	43.9
	87	15.0	7.0	46.7
	Female	60	11.8	0.7
n/a		11.4	0.9	7.9
n/a		15.5	1.0	6.5
58		12.5	1.5	12.0
85		12.8	1.7	13.3
85		18.5	1.8	9.7
n/a		14.0	2.0	14.3
n/a		13.5	2.0	14.8
58		14.8	2.5	16.9
80		12.2	3.2	26.2
94		11.7	4.7	40.2
n/a		15.5	5.5	35.5
86		14.0	6.5	46.4

*ASIS indicates anterior superior iliac spine; PT, pubic tubercle; LFCN, lateral femoral cutaneous nerve; n/a, age not available.

DISCUSSION

The LFCN is a sensory branch of the lumbar plexus, usually derived from the posterior divisions of the anterior rami of spinal nerves L2 and L3. The LFCN emerges from the lateral border of the psoas major muscle and then crosses the iliacus muscle obliquely, between laminae of the iliac fascia. The nerve approaches the ASIS and most commonly courses deep to the inguinal ligament to gain access to

the thigh. It usually divides within the upper thigh into a smaller posterior branch and a larger anterior branch. For convenience, we refer to the stem plus the anterior branch as the LFCN.

Surgical injury to the LFCN by cutting, traction, or post-operative scarring with use of the Smith-Petersen approach to the hip can result in various abnormalities of sensation in the skin of the anterolateral thigh: hypesthesia (sometimes with a zone of total anesthesia), paresthesias, and dysesthesias (sometimes severe intermittent or continuous pain). Painful lesions of this nerve, whether resulting from surgery or other causes, are given the specific name *meralgia paresthetica*. When severe, and refractory to conservative measures, this condition may necessitate surgical intervention. The most common traumatic site for the LFCN is at the inguinal ligament.^{4,11}

The present study reinforces the conclusion from prior studies that surgeons should not assume a single, invariable location for the LFCN. To our knowledge, no other authors have presented LFCN data proportionally so that they can be applied to small children.

Sometimes the LFCN is absent, and in its place is a branch from the ilioinguinal nerve or from the femoral nerve inferior to the inguinal ligament.⁴ Several studies have documented LFCN variations in cadaveric studies with respect to spontaneous meralgia paresthetica,^{4,15} hernia repair,³ trauma surgery,¹⁶ and anesthesia administration.¹⁷ LFCNs with different courses have been reported as increasing the risk for spontaneous meralgia paresthetica⁹; as being atypical variants, including high branching¹³ and passing deep to the sartorius¹²; and as dividing into anatomic variations of "normal" and "abnormal."¹⁵ We did not find the nerves crossing the ASIS or branching high within the thigh but did see the nerves emerging deep to the inguinal ligament and passing superficial to the sartorius muscle, as is mostly commonly reported.

According to our literature review, only 5 studies have provided measurements of the distance from the ASIS to the point of emergence of the LFCN into the thigh,^{3,6,10,14,16} and none were proportional measurements, which we find most surgically useful in pediatric cases.

We calculated our proportional percentages from the ASIS-PT measurements given by Surucu and colleagues.¹⁴ Their data showed the LFCN coursing under or through the inguinal ligament in 37 of 44 cadavers at a mean distance medial to the ASIS of 1.52 cm (SD, 0.84 cm; 12.5% of the ASIS-PT distance), with distances ranging from 0.00 to 3.21 cm (0%-46.7%). This range corresponds closely to ours (2.6%-46.7%), but their mean ASIS-LFCN distance is about $\frac{1}{8}$ the ASIS-PT distance, whereas our overall mean (18.5%) is about $\frac{1}{5}$ this distance. We made a graph (not shown) of ASIS-LFCN as a percentage of ASIS-PT from their data, for comparison with our Figure 2B. The distribution was essentially unimodal, with all but 2 of the 37 nerves entering the thigh within 25% of the ASIS-PT distance. Our own distribution is similar but somewhat bimodal, with a subsidiary peak at 35% to 40%. The graph from Hospodar and colleagues¹⁶ is similar but distinctly

Table II. Summary of Mean, Range, and SD of ASIS-PT Distance, ASIS-LFCN Distance, and ASIS-LFCN Distance as Percentage of ASIS-PT*

	Male	Female	Total†
ASIS-PT distance (cm)			
Mean	14.2	13.7	13.9
Range	11.5-16.9	11.4-18.5	11.4-18.5
SD	1.7	2.0	1.8
ASIS-LFCN distance (cm)			
Mean	2.5	2.6	2.6
Range	0.3-7.0	0.7-5.5	0.3-7.0
SD	2.2	1.8	1.9
ASIS-LFCN as % of ASIS-PT			
Mean	17.7	19.2	18.5
Range	2.6-46.7	5.9-46.4	2.6-46.7
SD	15.5	13.0	14.0

*ASIS indicates anterior superior iliac spine; PT, pubic tubercle; LFCN, lateral femoral cutaneous nerve.

†Data for males and females combined.

bimodal, with a conspicuous subsidiary peak at 2.5 to 3.5 cm from the medial edge of the ASIS. Unfortunately, their data cannot be converted to percentage equivalents, which would be biologically more meaningful. This is also true for other reports describing the location of the LFCN.^{3,6,10}

The studies that have presented the course of the LFCN in relation to the ASIS generally agree with ours. Our data are directly comparable with those of Surucu and colleagues,¹⁴ who measured from the center of the ASIS, but not with those of Hospodar and colleagues¹⁶ or, apparently, Dibenedetto and colleagues,³ Dias Filho and colleagues,⁶ and Grothaus and colleagues,¹⁰ who measured from the medial edge of the ASIS. These latter 3 groups gave the mean distance from the ASIS to the point of nerve entry as 1.4, 0.7, and 3.5 cm, respectively. To adjust their figures for direct comparability would require adding half the width of the ASIS, perhaps 0.5 cm, which would bring their measurements closer to ours.

A limitation of our study, and of the majority of previous anatomic studies, is that the dissections were performed on adult cadavers. Edelson and Nathan⁷ included 10 fetuses in their cadaveric study of the LFCN and measured the angle the LFCN makes at the junction of its pelvic and femoral portions. This angle was considerably less acute than in the adults, in part because the fetal thigh is held in a flexed position. Extrapolating these data into the extended-thigh posture of postnatal limbs is difficult. Adult cadavers also have different proportions of the pelvis, but studying the variation and course in relation to anatomic landmarks provides a reasonable method to extrapolate useful measurements to pediatric surgical cases. Crelin¹⁸ found that the newborn's LFCN is in a position similar to the adult's usual position—exiting the thigh deep to the inguinal ligament close to the ASIS. Judging from our measurements and those of Surucu and colleagues,¹⁴ the LFCN should, on average, emerge medial to the ASIS about 12% to 19% ($1/8$ to $1/5$) of the distance from the ASIS to the PT in both adults and small children.

CONCLUSIONS

The Smith-Petersen anterior approach to the hip¹ poses considerable risk to the LFCN. The surgeon must be aware that the LFCN is most often situated 2.6 cm medial to the middle of the ASIS along the inguinal ligament. Furthermore, in patients whose pelvic proportions differ from adults' (eg, in pediatric cases), the LFCN is often situated medial to the ASIS approximately one fifth the distance from the ASIS to the PT. Understanding the variability in the course of the LFCN and using these proportional percentages while operating in the region of the anterior hip may provide a better estimate of the LFCN location in relation to patient size and, it is hoped, reduce the likelihood of nerve injury.

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