The lateral femoral cutaneous nerve canal

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OBJECTIVE Meralgia paresthetica causes dysesthesias and burning in the anterolateral thigh. Surgical treatment includes nerve transection or decompression. Finding the nerve in surgery is very challenging. The author conducted a cadaveric study to better understand the variations in the anatomy of the lateral femoral cutaneous nerve (LFCN).

METHODS Twenty embalmed cadavers were used for this study. The author studied the LFCN’s relationship to different fascial planes, and the distance from the anterior superior iliac spine (ASIS).

RESULTS A complete fascial canal was found to surround the nerve completely in all specimens. The canal starts at the inguinal ligament proximally and follows the nerve beyond its terminal branches. The nerve could be anywhere from 6.5 cm medial to the ASIS to 6 cm lateral to the ASIS. In the latter case, the nerve may lodge in a groove in the iliac crest. Other anatomical variations found were the LFCN arising from the femoral nerve, and a duplicated nerve. A thick nerve was found in 1 case in which it was riding over the ASIS.

CONCLUSIONS The variability in the course of the LFCN can create difficulty in surgical exposure. The newly defined LFCN canal renders exposure even more challenging. This calls for high-resolution pre- or intraoperative imaging for better localization of the nerve.

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KEY WORDS anatomy; canal; lateral femoral cutaneous nerve; meralgia paresthetica; sartorius muscle; peripheral nerve

THE lateral femoral cutaneous nerve (LFCN) has a variable course. This represents a surgical challenge when decompression or transection is required for meralgia paresthetica.2,8,11,19 This study was conducted to define the variability of the nerve’s relationship to the anterior superior iliac spine (ASIS), and also the relationship to the fascial planes superficial and deep to the nerve.

Methods

Twenty embalmed cadavers were dissected. The LFCN was identified as it enters the thigh under the inguinal (Poupart) ligament, and the distance between this entry point and the ASIS was measured. The fascial planes superficial and deep to the nerve were also dissected. The dissection was performed in the thigh in all specimens. In 2 cases, the nerve was followed toward the retroperitoneum. Anatomical landmarks were used to search for the nerve medial to the ASIS first. When the nerve was not found medial to the ASIS, the dissection was carried lateral to the ASIS. In 2 cadavers, 1 side was not available for dissection or the nerve was damaged by the embalming process.

Results

A total of 38 extremities were dissected. In 1 specimen the nerve was duplicated on 1 side, so a total of 39 nerves were found. Right-to-left symmetry was the exception rather than the rule (3 of the 18 specimens in which both sides were available: 16.7%). The relationship of the LFCN to the ASIS varied from 6.5 cm medial to 6 cm lateral to the ASIS (Table 1). This distance was measured from the point where the LFCN crossed the inguinal liga-
ment (medially) or the iliac crest (laterally). Four nerves (10%) were lateral to the ASIS; interestingly they were all on the left side. In 1 case the nerve was coursing through a groove over the iliac crest (Fig. 1). Three nerves (7.7%) were riding over the ASIS. Ten nerves were within 5 mm from the ASIS (25.6%). One nerve that was riding over the ASIS had significant enlargement distal to the ASIS; histological analysis revealed thickened perineurium and Renaut bodies (Fig. 2). In 1 case, when the nerve was followed up to the retroperitoneal space, it joined the femoral nerve (Fig. 3). In another case the nerve was doubled, with 1 component medial and 1 component lateral to the ASIS (Fig. 4).

A unique finding in this study is that it defined a new fascial canal that completely ensheathes the nerve in the thigh. This was observed in all specimens (100%). There is 1 fascial plane superficial to the nerve that separates it from the skin and superficial fascia, and attaches proximally to the inguinal ligament. There is a second fascial plane (Fig. 5) deep to the nerve that separates it from the muscles (sartorius and tensor fasciae latae); this plane is continuous proximally with the posterior lamina of the iliac fascia. This floor thickens toward the inguinal ligament. The 2 fasciae blend on the sides of the nerve, where they become thicker, to be continuous with the deep fascia of the thigh, forming a complete canal that surrounds the nerve at 360°. It extends distally until the nerve branches pierce its walls toward the subcutaneous tissue. A transverse section was performed in 1 of the specimens that confirmed this observation (Fig. 6). The LFCN canal was also obvious on ultrasound studies performed in patients with meralgia paresthetica, with a clear definition of the fascia superficial and deep to the nerve (Fig. 7).

### Table 1. Variability of the LFCN distance from ASIS

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Rt (cm)</th>
<th>Lt (cm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.5</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9</td>
<td>−1.3</td>
<td>Lt: lat to ASIS</td>
</tr>
<tr>
<td>4</td>
<td>2.7</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NA</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.5</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3.5</td>
<td>−6.0</td>
<td>Lt: lat to ASIS</td>
</tr>
<tr>
<td>12</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0.5</td>
<td>5.0, −0.7</td>
<td>Duplicate nerve on lt, one medial &amp; the other lat to ASIS</td>
</tr>
<tr>
<td>14</td>
<td>1.0</td>
<td>0</td>
<td>Lt: over ASIS, swollen nerve</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
<td>Over ASIS bilat</td>
</tr>
<tr>
<td>16</td>
<td>4.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>3.0</td>
<td>−0.5</td>
<td>Lt: lat to ASIS, groove in iliac crest</td>
</tr>
<tr>
<td>18</td>
<td>3.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>2.0</td>
<td>6.5</td>
<td>Lt: off femoral nerve in retroperitoneum</td>
</tr>
<tr>
<td>20</td>
<td>2.5</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

NA = not available.
The variability in the course of the LFCN has been previously well documented. In their study of 205 nerves, Murata et al. found the LFCN lateral to the ASIS (Types A and B) in 12.8%, medial to the ASIS (Type C) in 28.8%, and over the ASIS (Type D) in 58.4%. In the present study, the LFCN was found lateral to the ASIS in 10% of cases. In 52 cadavers, Aszmann et al. found the LFCN lateral to the ASIS in 4% of cases. They also describe a groove on the iliac crest when the nerve is just medial to the ASIS. In the present study, a groove was found in the iliac crest in 1 specimen in which the nerve was just lateral to the ASIS, and in 1 patient treated for meralgia paresthetica. This groove was previously described by Ghent. It is illustrated here in a picture for the first time (Fig. 1), and the name “supra-iliac groove” is proposed. Carai et al. found a complete iliac bony canal in 4.4% of cases. The supra-iliac groove and the iliac bony canal, although rare, are comparable to the suprascapular notch and suprascapular foramen for the suprascapular nerve. Ray et al. described the LFCN passing deep to the inguinal ligament in 76.6%, piercing the inguinal ligament in 13.9%, and superficial to the inguinal ligament in 8.5% of specimens.

A few papers described a “pseudoneuroma” of the LFCN. However, correlation with proximity to the ASIS was unclear. In the present study, in the single specimen in which a thick nerve was found, the nerve was riding over the ASIS (Fig. 2). The term pseudoneuroma is a misnomer; these are simply thickened nerves. Histological investigation revealed thick perineurium and Renaut bodies. The latter are frequently associated with nerve compressions or entrapments. Jefferson and Eames described histological changes suggestive of nerve irritation in 5 of 12 cadavers examined for routine autopsy. In the present study 25.6% of nerves were found within 5 mm of the ASIS, which probably puts the nerve at a higher risk of trauma, especially in individuals wearing tight, heavy belts or lying in a prone position.
The aberrant origin of the LFCN from the femoral or genitofemoral nerves has been previously described, and has been rated as high as 30%. In the present study a duplication of the LFCN was found in 1 extremity of 38. The exact incidence of this is unknown. In most specimens, once an LFCN was found a second one was not sought. This is probably also why duplication of this nerve has remained underreported in the previous literature. A duplication of the LFCN was also observed in 1 patient undergoing decompression for meralgia paresthetica. Dias Filho et al. reported a 30% incidence of an “accessory” LFCN.

The lateral femoral cutaneous nerve canal is described here for the first time (Figs. 5–7). The closest description in the literature is by Soulié, where he describes the LFCN coursing within a duplication of the deep fascia of the thigh. Ecker and Woltman describe injury to the nerve as it passes through the “fascial canal in the upper thigh,” without any actual description of the canal. Aszmann et al. found that the nerve can be ensheathed within the tendinous origin of the sartorius muscle in 23% of cases, thus describing a floor deeper to the nerve as it crosses the inguinal ligament. Keegan and Holyoke as well as Jefferson and Eames described the nerve going through a tunnel or narrow canal between 2 “slips of attachment” from the inguinal ligament. These papers describe a tunnel at the level of the inguinal ligament. Similarly, Gatt describes an occasional tunnel at the level of the inguinal ligament that can cause spread of intraabdominal sepsis into the thigh.

These previous descriptions focused on the presence of an occasional tunnel at the level of the inguinal ligament. In this study, all specimens (100%) had a floor deep to the nerve, thus forming a complete canal that followed the nerve into the thigh, beyond its bifurcation into its terminal branches. This is the most common place where the nerve is exposed surgically, and understanding this anatomical fact is extremely important. The LFCN canal can be viewed as a continuum with what Dias Filho et al. de-
scribed as a duplication of the iliac fascia\textsuperscript{4} that encases the nerve. However, there is usually a significant amount of retroperitoneal fat around the nerve in its abdominal portion, allowing a better cushion and more mobility of the nerve than in the thigh, where the nerve has a tight relation to its canal. At the level of the inguinal ligament, there is maximum tethering and angulation of the nerve, where the anterior wall of the canal blends with the inguinal ligament and the iliopubic tract, and the posterior wall could be reinforced by a slip from the inguinal ligament or the sartorius tendon (Fig. 8). Histological sections also revealed that the canal thickens on the sides of the nerve (Fig. 9).

The difficulty in localizing the LFCN surgically when treating patients with meralgia paresthetica doesn’t reside solely in the varied relationship to the ASIS. The old concept of a single fascial layer overlying the sartorius is very misleading. According to the old concept, opening this fascia anywhere close to the nerve and searching between the fascia and the sartorius will eventually lead to finding the nerve (Fig. 10A). The reality is that there is a second fascia deep to the nerve forming a full canal. This means that, unless the first layer of fascia is opened within the LFCN canal, it is very difficult to find the nerve. Opening the fascia outside the canal will put the surgeon in a plane deeper to the nerve, with the fascia underneath the nerve shielding it from the surgeon’s eyes (Fig. 10B).

**Conclusions**

The LFCN has a variable course and relation to the

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**FIG. 7.** A: Transverse ultrasound revealing the left LFCN (arrow) in its individual canal. B: Longitudinal ultrasound revealing the left LFCN (arrow) within the LFCN canal (arrowheads).

**FIG. 8.** A: Diagrammatic representation of the LFCN canal in an oblique sagittal view at the level of the anterior inferior iliac spine. 1 = skin; 2 = subcutaneous tissue; 3 = external oblique muscle and aponeurosis; 4 = internal oblique; 5 = transversus abdominis; 6 = transversalis fascia; 7 = fascia iliaca superficial lamina; 8 = retroperitoneal fat; 9 = LFCN; 10 = fascia iliaca deep lamina; 11 = iliacus; 12 = iliac bone; 13 = femur; 14 = rectus femoris; 15 = sartorius; 16 = fascia lata; 17 = LFCN canal; 18 = inguinal ligament; 19 = iliopubic tract; 20 = thickening of the fascia deep to the LFCN (here by the tendinous origin of the sartorius; can also be a slip from the inguinal ligament, or periosteum if the nerve is riding over the ASIS or iliac crest). B: Axial section through the retroperitoneal segment of the LFCN. 1 = anterior lamina of fascia iliaca; 2 = LFCN; 3 = retroperitoneal fat; 4 = posterior lamina of fascia iliaca; 5 = iliacus muscle. C: Axial section through the floor of the LFCN canal (arrowheads), showing a thick layer separating the nerve from the muscle in the region of the inguinal ligament. Trichrome stain (B and C), no magnification (B). Copyright Aemag Hanna (Panel A). Published with permission.
ASIS. It also has its individual canal as it enters the thigh. This was never fully described in the past. The combination of these 2 factors renders surgical localization of the nerve extremely difficult and time-consuming. However, in most symptomatic cases the nerve is proximal to the ASIS. Because of the fascia deep to the nerve, opening the sartorius fascia away from the nerve may cause the surgeon to be in a plane deeper to the nerve. Advanced imaging techniques can be used to localize the nerve pre- or intraoperatively.

**FIG. 9.** Axial section approximately 4 cm distal to the ASIS showing the LFCN (arrow) and its branches (arrowheads) within the LFCN canal. With van Gieson stain, elastic fibers are black and collagen is red; with trichrome stain, collagen is blue and nuclei are purple. 1 = fascia superficial to the LFCN; 2 = fascia deep to the LFCN; 3 = lymph node; 4 = vein; 5 = muscle. Note that the fascia superficial to the nerve is thicker than the one deep to it. The 2 fasciae get closer to each other and become thicker on either side of the nerve. The fat content of the LFCN canal is much less than in the retroperitoneal space (Fig. 8B), thus significantly limiting the nerve’s mobility in the thigh. Elastic van Gieson (A and C) and trichrome (B and D), no magnification (A and B).

**FIG. 10.** A: Wrong concept illustrating a single layer of fascia superficial to the LFCN. Based on this, opening the fascia in any location will allow access to the nerve (green arrows). B: Correct concept illustrating the LFCN canal with its 2 components superficial and deep to the nerve. Based on this, opening the fascia on top of the nerve is the only way to find the nerve (green arrow). Opening on either side of the nerve canal (red arrows), not only will miss the nerve but also will make the search for the nerve extremely difficult because the second deeper layer is still intact and shields the nerve from the surgeon’s eyes. Copyright Amgad Hanna. Published with permission.
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References


Disclosures

The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Supplemental Information

Previous Presentations

This work was presented in part to the American Society of Peripheral Nerves (ASPN) annual meeting at Kauai, Hawaii, in January 2014.

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