

# Study of anatomical variation and branching pattern of the femoral nerve in 25 cadavers

Urmila N Patel<sup>1</sup>, Rakesh M Rajat<sup>2</sup>, Kanan P Shah<sup>3</sup>, Monica Chudasma<sup>1</sup>, Jitendra Patel<sup>3</sup>

<sup>1</sup>Anatomy Department, Smt. N.H.L. Municipal Medical College, Ahmedabad, Gujarat, India.

<sup>2</sup>Microbiology Department, GMERS Medical College, Gandhinagar, Gujarat, India.

<sup>3</sup>Anatomy Department, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat, India.

Correspondence to: Dr. Rakesh M Rajat, Email; rakeshrjt@gmail.com

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## Abstract

**Background:** Femoral nerve is used for nerve block in several surgeries. The knowledge of femoral nerve in thigh is important for anatomist, anesthetists, and surgeons to prevent iatrogenic femoral nerve palsy. We dissected 25 human cadavers to study the anatomy of femoral nerve. We dissected the femoral nerve bilaterally in Anatomy Department of Smt N H L Municipal Medical College, and recorded the branching pattern of femoral nerve with digital photography.

**Objective:** To highlight the variation in branching pattern of the femoral nerve.

**Materials and Methods:** We measured the distance from the anterior superior iliac spine (ASIS) to the pubic symphysis bilaterally on each cadaver as an anatomical landmark. We located the femoral nerve through transverse incisions from the ASIS to the pubic symphysis and incisions originating from the midpoint between the ASIS and the pubic symphysis extending longitudinally to the patella. We chose the inguinal ligament as a proximal limitation for dissection of the femoral nerve in the thigh. The distance from the inguinal ligament to the first branching point of the femoral nerve was measured. We traced and dissected all femoral nerve branches to the insertion points.

**Result:** The mean medial–lateral distance from the ASIS to the pubic symphysis was  $14.50 \pm 1.34$  cm (range 13–16). We found the femoral nerve near the midpoint,  $46 \pm 5\%$  from the ASIS. We did not measure in cadaver specimen 5 since bony landmarks were difficult to palpate because of excessive adipose tissue. The distance from the inguinal ligament to the first branching point of the femoral nerve was  $1.50 \pm 0.47$  cm (range 1–2cm).

**Conclusion:** The anatomy and morphology we observed remained consistent with the established literature, suggesting that our chosen specimens did not differ from the standard population and that we may consider the results representative of the general population.

**KEY WORDS:** Femoral nerve, anatomical variation, branching pattern

## Introduction

The femoral nerve is the largest branch of the lumbar plexus. It arises from the dorsal branches of second to fourth ventral rami.<sup>[1,2]</sup> Passing behind the inguinal ligament into

the thigh it is split into anterior and posterior division by the lateral circumflex femoral artery.<sup>[1,2]</sup> The femoral nerve block is performed on the main stem of the nerve, inferior to the inguinal ligament, before it divides into anterior and posterior branches.<sup>[3]</sup> The femoral nerve originates from the second, third, and fourth lumbar spinal nerves and innervates the anterior thigh muscles, hip and knee joints, and skin on the anteromedial thigh.<sup>[3,4]</sup>

The objective of this study was to dissect, identify, and document variations in the anatomy of the femoral nerve and its branching pattern. This knowledge could then be used to validate previously described anatomy and various surgical approaches to expose the femoral nerve.

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## Materials and Methods

The femoral nerve was studied during routine educational dissection of 25 human cadavers in Smt. NHL Municipal medical college, Department of Anatomy Ahmedabad over a period of 3 years. There were 20 men and 5 women cadavers with mean age of 60 years. There were no signs of trauma, surgery, or wound scars in the thigh regions of any of the cadavers.

We measured the distance from the anterior superior iliac spine (ASIS) to the pubic symphysis bilaterally on each cadaver as an anatomical landmark. We located the femoral nerve through transverse incisions from the ASIS to the pubic symphysis and incisions originating from the midpoint between the ASIS and the pubic symphysis extending longitudinally to the patella. We chose the inguinal ligament as a proximal limitation for surgical dissection of the femoral nerve in the thigh.

We traced and dissected all femoral nerve branches to the insertion points. We also traced sensory branches (saphenous and medial cutaneous nerves) for completeness of study. We examined and characterized the branching patterns of all 25 femoral nerves by the order of branching, both medial to lateral and proximal to distal.

## Result

The mean medial–lateral distance from the ASIS to the pubic symphysis was  $14.50 \pm 1.34$  cm (range 13–16). We found the femoral nerve near the midpoint,  $46 \pm 5\%$  from the ASIS. We did not measure either leg in cadaver specimen 5 since bony landmarks were difficult to palpate because of excessive adipose tissue. The distance from the inguinal ligament to the first branching point of the femoral nerve was  $1.50 \pm 0.47$  cm (range 1–2 cm).

The branching pattern of the femoral nerve remained consistent between specimens. Table 1 shows the branching patterns for all specimens, including the order and medial–lateral location of each branch leaving the femoral nerve. Most branching occurred within a small length of the nerve. Branches to the pectineus muscle, sartorius muscle, and sensory nerves (saphenous and medial cutaneous) branched first and 'medially in 20 out of 25 specimens. The sartorius muscle branched laterally in two specimens. In all but one specimen, the branch to the sartorius originated on the ventral surface of the nerve. The vastus medialis, vastus intermedius, and vastus lateralis muscles were centrally located and the rectus femoris muscle was lateral in the branching pattern of all specimens.

## Discussion

### Anatomy and Morphology

As per standard textbooks of anatomy, the femoral nerve is the largest branch of the lumbar plexus and it arises from the posterior division of the anterior (ventral) rami of the second, third and fourth lumbar nerves.<sup>[2,5]</sup> The femoral nerve descends on the psoas major muscle and enters the thigh deep to the inguinal ligament at the lateral edge

of the femoral sheath, which separates it from the femoral artery.<sup>[6]</sup> A branch to the pectineus muscle is given off as the femoral nerve enters the femoral triangle. Distally to the inguinal ligament, the femoral nerve divides into two branches: the anterior and the posterior division by the lateral circumflex femoral artery.<sup>[1,2]</sup>

The branches from the anterior divisions are mainly to the sartorius muscle and two cutaneous branches, that is, the medial cutaneous nerve of thigh and the intermediate cutaneous branch of thigh. The saphenous nerve, nerve to quadriceps femoris and branch to knee joint are the branches from the posterior division.<sup>[2]</sup> We found the saphenous nerve arose from the anterior division in two cadavers.

The anatomy and morphology we observed remained consistent with the established literature, suggesting that our chosen specimens did not differ from the standard population and that we may consider the results representative of the general population.

We always found the major branches involved in standing (vastus medialis, vastus intermedius, and vastus lateralis nerves) centrally located, whereas the sensory branches and the branches not implicated in standing (saphenous, medial cutaneous, sartorius, and rectus femoris nerves) located in the medial or lateral part of the branching pattern. Furthermore, branches not beneficial for standing often branched off the femoral nerve first [Table 1]. The femoral nerve branching patterns we observed in this study generally remained consistent with the literature with a few exceptions.

Aizawa<sup>[9]</sup> reported that the medial cutaneous nerve branches and vastus medialis, vastus intermedius, vastus lateralis, and rectus femoris nerves were arranged medially to laterally, respectively. Gustafson<sup>[10]</sup> reported this pattern except in two specimens where the sartorius nerve was located between two cutaneous branches.

Nerve to pectineus arose from the femoral nerve within the abdomen in three plexuses. In two plexuses, nerve to pectineus arose from the main trunk of the femoral nerve and in one plexus it arose from the anterior division of the femoral nerve.<sup>[6]</sup>

When the branch to the pectineus nerve was present, it was the most medial branch off the femoral nerve in all but one specimen, where it was the second most medial branch to leave the compound femoral nerve after the sartorius nerve.<sup>[10]</sup>

Pectineus nerve was the most medial branch of the femoral nerve in the thigh. We also found that pectineus was most medial and first branch of femoral nerve in thigh.

However, Aizawa reported that the branch to the pectineus nerve was the most superficial or anterior portion of the femoral nerve. While we found the branch to the pectineus nerve to generally be located on the superficial or anterior portion of the nerve, the branch to the sartorius nerve was always more superficial than the branch to the pectineus nerve.

Aizawa reported that the medial cutaneous nerve branch and the adductor longus branches were the first two branches to leave the femoral nerve in the thigh.<sup>[9]</sup> However, in our specimens the branch to the medial cutaneous nerve was never more proximal than the second branch, and usually occurred after the branches to the pectineus and sartorius

**Table 1:** pattern of the femoral nerve in 25 cadaver

Specimen	Medial								Lateral
1R	1 Pect	2 Sart	4 MCut	5 Saph	6 VastMed	6 VastInt	6 VastLa	3 RectFem	
1L	–	1 Sart	–	2 Saph	2 VastMed	2 VastInt	2 VastLat	2 RectFem	
2R	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
2L		1 Sart		2 Saph	3 VastMed	3 VastInt	3 VastLat	4 RectFem	
3R		1*, 2 Sart	3 Saph	3 MCut	3 VastMed	3 VastInt	3 VastLat	3 RectFem	
3L	1* Pect	2 MCut	3, 4 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	5 RectFem	
4R	1 Sart	2 Pect	3 Saph	3 MCut	3 VastMed	3 VastInt	3 VastLat	3 RectFem	
4L	2 Pect	3 MCut	3 Saph	3 VastMed	3 VastInt	3 VastLat	3 RectFem	1* Sart	
5R	1 Pect	2 MCut	3 Saph	3 VastMed	2 Sart	3 VastInt	3 VastLat	2 RectFem	
5L	1 Pect	2 MCut	3 Saph	3 VastMed	2 Sart	3 VastInt	3 VastLat	2 RectFem	
6R	1 Pect	3 Saph		3 VastMed	3 VastInt	3 VastLat	2 RectFem	2 Sart	
6L	1 Pect	3 Saph		3 VastMed	3 VastInt	3 VastLat	2 RectFem	2 Sart	
7R	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
7L	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
8R	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
8L	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
9R	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
9L	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
10R	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
10L	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
11R	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
11L	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
12R	1 Pect	2 MCut	3 Sart	4 Saph	4 VastMed	4 VastInt	4 VastLat	3 RectFem	
12L	1 Pect	2 MCut	3 Sart	4 Saph	4 VastMed	4 VastInt	4 VastLat	3 RectFem	
13R	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
13L	1 Pect	2 MCut	3 Sart	4 Saph	4 VastMed	4 VastInt	4 VastLat	3 RectFem	
14R	1 Pect		2 Sart	3 Saph	3 VastMed	3 VastLat	3 VastInt	2 RectFem	
14L	1 Pect		2 Sart	3 Saph	3 VastMed	3 VastLat	3 VastInt	2 RectFem	
15R	1 Pect	2 Sart	4 MCut	5 Saph	6 VastMed	6 VastInt	6 VastLa	3 RectFem	
15L	–	1 Sart	–	2 Saph	2 VastMed	2 VastInt	2 VastLat	2 RectFe	
16R	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
16L		1 Sart		2 Saph	3 VastMed	3 VastInt	3 VastLat	4 RectFem	
17R		1*, 2 Sart	3 Saph	3 MCut	3 VastMed	3 VastInt	3 VastLat	3 RectFem	
17L	1* Pect	2 MCut	3, 4 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	5 RectFem	
18R	1 Sart	2 Pect	3 Saph	3 MCut	3 VastMed	3 VastInt	3 VastLat	3 RectFem	
18L	2 Pect	3 MCut	3 Saph	3 VastMed	3 VastInt	3 VastLat	3 RectFem	1* Sart	
19R	1 Pect	2 MCut	3 Saph	3 VastMed	2 Sart	3 VastInt	3 VastLat	2 RectFem	
19L	1 Pect	2 MCut	3 Saph	3 VastMed	2 Sart	3 VastInt	3 VastLat	2 RectFem	
20R	1 Pect	3 Saph		3 VastMed	3 VastInt	3 VastLat	2 RectFem	2 Sart	
20L	1 Pect	3 Saph		3 VastMed	3 VastInt	3 VastLat	2 RectFem	2 Sart	
21R	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
21L	1 Pect	2 MCut	3 Sart	5 Saph	5 VastMed	5 VastInt	5 VastLat	4 RectFem	
22R	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
22L	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
23R	1 Pect	2 MCut	4 Saph	4 VastMed	4 VastInt	4 VastLat	2 Sart	3 RectFem	
23L	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
24R	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
24L	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
25R	1 Pect		3 Saph	3 VastMed	4 VastInt	4 VastLat	3 RectFem	2 Sart	
25L	1 Pect	2 MCut	3 Sart	4 Saph	4 VastMed	4 VastInt	4 VastLat	3 RectFem	

– = branch not present, L = left side, MCut = medial cutaneous, Pect = pectineus, R = right side, RectFem = rectus femoris, Saph = saphenous, Sart = sartorius, VastInt = vastus intermedius, VastLat = vastus lateralis, VastMed = vastus medialis.

Numbers denote order of branching off compound femoral nerve proximally (1) to distally (6). Italic lettering denotes deviation from normal medial to lateral branching pattern.

\*Branched off ventral portion of nerve as opposed to medial or lateral sides.

nerves. None of our specimens had branches to adductor longus originating from the femoral nerve.

The majority of the literature states that the adductor longus is innervated by the obturator nerve<sup>[1]</sup>. In addition, we did not identify the pectineus nerves in three specimens or the medial cutaneous nerves in two specimens. The pectineus muscle may have been innervated by the obturator nerve.<sup>[1]</sup>

## Conclusion

The anatomy and morphology we observed remained consistent with the established literature, suggesting that our chosen specimens did not differ from the standard population and that we may consider the results representative of the general population.

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