

The furcal nerve revisited

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Abstract

Atypical sciatica and discrepancy between clinical presentation and imaging findings is a dilemma for treating surgeon in management of lumbar disc herniation. It also constitutes ground for failed back surgery and potential litigations thereof. Furcal nerve (Furcal = forked) is an independent nerve with its own ventral and dorsal branches (rootlets) and forms a *link* nerve that connects lumbar and sacral plexus. Its fibers branch out to be part of femoral and obturator nerves in addition to the lumbosacral trunk. It is most commonly found at L4 level and is the most common cause of atypical presentation of radiculopathy/sciatica. Very little is published about the furcal nerve and many are unaware of its existence. This article summarizes all the existing evidence about furcal nerve in English literature in an attempt to create awareness and offer insight about this unique entity to fellow colleagues/professionals involved in spine care.

Introduction

The nerve supply to the lower extremity sclerotomes is by the lumbar and lumbosacral plexus. Compression of nerve roots/rootlets due to lumbar disc herniation may present as sciatica with radicular symptoms.¹ There exists a consistent and predictable correlation between level of compression on MRI or CT myelogram with clinical symptoms and presentation. However atypical presentation and disagreement between imaging studies and clinical symptoms are also not uncommon and constitutes a dilemma to a treating surgeon.² Such a scenario may be due to: i) a single lesion (*i.e.* disc herniation) compressing two nerve roots; ii) congenital anomalies of either nerve or nerve root or rootlets; iii) presence of *furcal* nerve.³

Very little is written about furcal nerve and this article summarizes all the existing evidence from published articles in English literature. A thorough understanding of anatomical variations and insight into the anomalies of the lumbosacral plexus reduces the incidence of failed back surgery and enhances surgical success. Macnab recommends anomalous

nerve roots should be suspected and actively investigated in all failed back surgeries.² It also minimizes risk of potential litigations and its socio-economic burden thereof. Selective nerve root blocks (SNRB) is of both diagnostic and therapeutic utility in functional diagnosis of radicular symptoms.⁴ Dorsal root ganglion (DRG) and spinal nerve is targeted and the epiradicular sheath is bathed with a local anesthetic. Care is taken to avoid placement of needle tip beyond DRG (*i.e.* at 6-o'clock in relation to pedicle) which may cause a potential dural puncture.⁴ The DRG is inferior to pedicle in 90% of cases (medial 2%; inferolateral 8%).¹

Anatomy

The lumbar plexus is located within the psoas muscle anterior to the transverse process of lumbar vertebrae.⁵ It is formed by ventral and dorsal rami of L1-L4 nerve roots with contribution from 12th thoracic nerve (*i.e.* subcostal nerve). A branch from ventral ramus of L4 along with ventral rami of L5 forms the lumbosacral trunk. Sacral plexus is formed by lumbosacral trunk and anterior divisions of 1st-3rd sacral nerves. However variation in the form of both prefix (contribution from L3) and postfix (contribution from L5) sacral plexus is also described.⁶ Figure 1 depicts both lumbar and lumbo-sacral plexus.

Questions

The questions we tried to address are: i) what is *furcal* nerve?; ii) what is its anatomical course and variations in its anatomy?; iii) what is its applied surgical anatomy and clinical significance in low back surgeries?

Discussion

Furcal nerve (furcal = forked)⁷ is an independent nerve with its own ventral and dorsal rootlets that most commonly arises at L4 level.³ The second most common site of its location is at L3. It could be called as a *link* nerve that connects lumbar and sacral plexus and could be found at any level from L1 to S1 levels though there are no reports of its presence at L1 level. Microscopic examination revealed that its dorsal root has a separate DRG and its dimensions are similar to that of its neighboring nerve root.⁸ Kikuchi *et al.* described detailed anatomy, course of 85 furcal nerves from 43 cadavers and found 78 (*i.e.* 93%) were found at L4 level, three at L3 and four at L5 levels.⁹ Double furcal nerves have an incidence of 0.8% (L3 and L4

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more common than L4 and L5). It is most commonly located superior and ventral to L4 nerve root and ran besides it in the intervertebral foramen. It gives branches to: i) femoral nerve, ii) lumbosacral trunk and iii) obturator nerve. The ratio of fibers from furcal nerve to femoral nerve was highest (60%) and least for obturator nerve (10%).³

Furcal nerves could be classified into two sub-types based on their bifurcation in relation to a vertical tangent along the lateral border of pedicle:⁷ i) intra-foraminal; ii) extra-foraminal. In an MRI based evaluation of root anomalies involving 376 patients, Haijiao *et al.* reported incidence of root anomalies to be 17.3% (65 patients) and 88% of them were due to furcal nerves (*i.e.* 57/65).⁷ Overall there were 98 furcal nerves in 57 patients of which a majority of them had extra-foraminal divisions (65/98). Bilateral furcal nerves were seen in 30 and unilateral in 27 patients. 41 of them had furcal nerve at a single level where as 13 patients had them at two levels. The remaining 3 patients had furcal nerve at 3 levels. It is also present in fetuses at as early as 24 weeks of gestation. Yasar *et al.* undertook a cadaveric study of 10 fetuses with a mean gestational age of 26±1.3 months and found furcal nerve at L4 level in all of them.¹⁰ Table 1 summarizes the incidence of congenital nerve root anomalies and percentage of furcal nerves observed by independent researchers.^{3,9-12}

Furcal nerves are the most common cause of atypical presentation of sciatica/radicular symptoms. They may also be part of conjoined nerve roots and combined with intradural anomalies. Despite its high incidence, they haven't created much interest or attention amongst spinal surgeons. It causes disparity between imaging and clinical presentation characteristics demonstrated by motor weakness and sensory involvement at different levels not explained by normal anatomy/neurology. An awareness of furcal nerve's existence and insight into potential double root contribution with meticulous evaluation of MRI is important in recognizing these subset of patients.

There were two instances wherein the authors encountered this potential condition while performing a selective nerve root block (SNRB) in awake patients for symptomatic disc herniation which reproduced radicular pain at a different dermatomal distribution (atypical sciatica). Figure 2a-c depicts a L5 SNRB in a 32 year old male who had radiculopathy in both L4 and L5 dermatomes suggestive of a post-fixed furcal contribution (furcal nerve at L5). Figure 2d,e shows AP and lateral fluoroscopy images of a L4 SNRB that reproduced radicular pain at L5 dermatome in a 38 year old female (*i.e.* furcal nerve at L4 – the most common/classical presentation). Transitional features in lumbosacral junction may be present in 6-8% of patients and other spine-segmentation irregularities in up to 20-25% of the population.¹³ This may also influence the nerve root projection to a limb and contribute to variable presentation of sciatica. Bartynski *et al.* performed adjacent double root injections in a series of 132 patients based on pre-op MRI characteristics and 62% (*i.e.* 82/132) had reproduction of radicular pain.¹⁴

Conclusions

Furcal nerve is an independent nerve that is present most commonly at L4 level and majority of them bifurcate extra-foraminally. They run parallel to L4 nerve root in intervertebral foramen and are the most common cause of double nerve root contribution in unilateral radiculopathy. Diagnostic SNRB in conjunction with meticulous history and physical examination would guide a surgeon to perform decompression at the *correct* level to relieve radicular symptoms. Pre-operative evaluation MRI or/and CT myelography for nerve root anomalies is mandatory for all patients undergoing low back surgery to optimize surgical outcomes.

Table 1. Incidence of congenital nerve root anomalies and incidence of furcal nerve reported by independent investigators.

Author	A/M	Incidence Congenital nerve root anomaly	Furcal nerve
Kikuchi <i>et al.</i> ^{3,9}	A	8.5% (5/59)	100% (138/138)
Haijiao <i>et al.</i> ⁸	M	17.3% (65/376)	15.1% (57/376)
Yasar <i>et al.</i> ¹⁰	A	None	100% (20/20)
Chotigavanich <i>et al.</i> ¹¹	A	30% (18/60)	Not reported
Kadish <i>et al.</i> ¹²	A	14% (14/140)	Not reported

A, anatomical cadaveric dissections; M, magnetic resonance imaging studies.

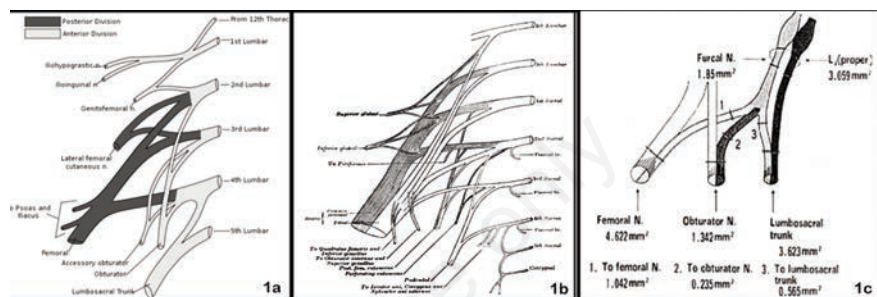


Figure 1. Lumbar and lumbosacral plexus. (Reproduced with permission: Kikuchi S, *et al.* 1986).³

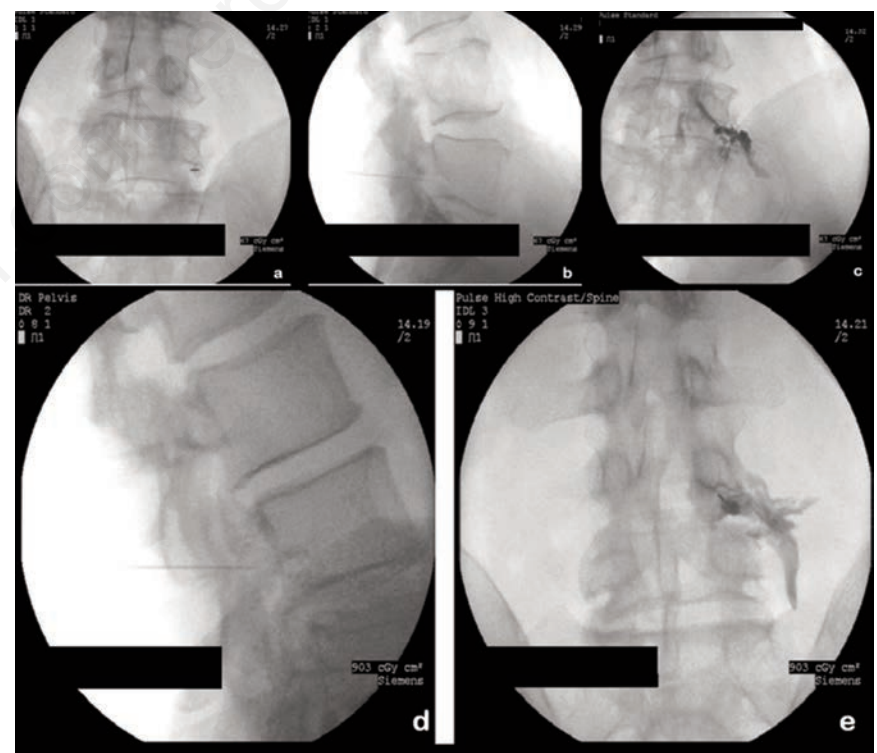


Figure 2. The two instances wherein the authors potentially encountered the symptomatic furcal nerve as possible cause of atypical sciatica/radiculopathy. a-c) A post-fixed L5 furcal nerve wherein the SNRB at L5 reproduced pain in both L4 and L5 dermatomes. d,e) Possible L4 furcal nerve. A selective L4 nerve root block reproduced pain in L5 dermatomal distribution.

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