Normal peripheral nerves around the knee on 3D high resolution MR images: Comparison with conventional 2D MR images.

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Learning objectives

1. To demonstrate the normal anatomy of peripheral nerves around knee joint seen on 3D high resolution MR images.

2. To compare MR appearances of peripheral nerves between 3D high resolution MR images (slice thickness, 0.6 mm) and conventional 2D images (thickness, 3 or 4 mm).

3. To present some cases of nerve injuries those affect the peripheral nerves around knee joint.
Background

A number of peripheral nerves are located around the knee, including saphenous nerve, infrapatellar and sartorial branch, cutaneous branch of obturator nerve, tibial nerve and its medial sural cutaneous nerve, common peroneal nerve, and its lateral sural cutaneous nerves and small branches of femoral nerve. Injuries of these peripheral nerves can be associated with knee trauma, arthroscopic or open surgeries and tendon harvesting for the reconstruction. Saphenous nerve injuries could be occurred as a complication of arthroscopy, medial approach knee injection, hamstring tendon harvest, saphenous vein harvest and fasciotomy [1]. Saphenous nerve injuries can result in minor sensory loss, painful neuralgia and can develop into painful neuroma [1, 2].

Advances of high resolution MR technique such as 3D TSE sequence allow us to discriminate the small peripheral nerves around knee joint. Thorough anatomical knowledge of these nerves on MR images may be helpful for the explanation of patient symptoms and signs and the determination of surgery and injection plan. Also anatomical information of small peripheral nerves around knee can be used for the detection of those nerves on knee ultrasonography, which frequently is used for intervention of nerve block.
Findings and procedure details

1. Saphenous nerve and its branches, infrapatellar and sartorial branches (Fig. 1 - 5)

The saphenous nerve is the terminal cutaneous branch of the femoral nerve. The femoral nerve is divided into several muscular branches and cutaneous branch, saphenous branch after entering the femoral triangle. In the proximal thigh, the saphenous nerve located lateral to the femoral artery and cross the femoral vessels and is located medially in the adductor canal [3] (Fig. 1). Below the adductor canal saphenous nerve immediately divides into the infrapatellar and sartorial branches (Fig. 2). At the level of above the adductor tubercle of the distal femur, the infrapatellar branch is located at the posterior aspect of the vastus medialis muscle and sartorial branch at the lateral aspect of the sartorius muscle (Fig. 3). The infrapatellar branch takes anteromedial course along the cortex of the distal femur and the sartorial branch is going down between the sartorius and gracilis muscles (Fig. 4). At the level of the intercondylar fossa of the femur, the infrapatellar branch is located anterior to the medial collateral ligament (Fig. 5).

2. Cutaneous branch of the obturator nerve (Fig. 6 - 7)

Through the obturator canal, obturator nerve enters the thigh and divides into the anterior and posterior branches. The anterior branch descends between the adductor brevis and longus muscles (Fig. 6). The posterior branch descends between the adductor longus and magnus muscles (Fig. 7). Its articular branch lies on the femoral artery and pierces the oblique popliteal ligament of the knee joint in the popliteal fossa. In the knee joint the articular branch innervates the cruciate ligament, capsule and synovial membrane [4].

3. Tibial nerve, medial and lateral sural cutaneous nerves (Fig. 8 - 9)

In the popliteal fossa the sciatic nerve lies between the biceps and semimembranous muscle (Fig. 8). Thereafter the sciatic nerve divides into the common peroneal and tibial nerve. The medial sural cutaneous nerve comes from the tibial nerve and the lateral sural cutaneous nerve from the common peroneal nerve. The lateral sural cutaneous nerve originated from the common peroneal nerve lies posterior to the lateral gastrocnemius muscle and medial sural cutaneous nerve lies between the medial and lateral gastrocnemius muscles (Fig. 9). Communicating nerve between the medial and lateral sural cutaneous nerve frequently is difficult to be depicted on 3D MR images with thin slice thickness.

4. Common peroneal nerve and its superficial and deep branches (Fig. 10 - 11)

Common peroneal nerve lies just posterior aspect of the fibular neck (Fig. 10). At the level of fibular neck the superficial and deep branches lies at the anterior aspect of the
fibular neck (Fig. 11). The superficial branch lies lateral to the deep branch of the common peroneal nerve.

5. Anterior cutaneous branch of the femoral nerve, its intermediate cutaneous nerve of the thigh. Posterior cutaneous nerve of the thigh (Fig. 12 - 13)

Intermediate cutaneous nerve of the thigh is the branch of the anterior cutaneous branch of the femoral nerve. The small intermediate cutaneous nerve lies posterior to the sartorius muscle (Fig. 12). The posterior cutaneous nerve of the thigh comes from the sacral plexus. At the level of end of gluteus maximus muscle and mid thigh posterior cutaneous nerve lies posterior to the hamstring muscle (Fig. 13).
Fig. 1: Saphenous nerve in the adductor canal at the level of distal thigh. On 3D proton density MR image with 0.6 mm thickness (a), the saphenous nerve (long arrow) lies medially to the femoral vessels. Aponeurosis of adductor canal (short arrow). Tendon of adductor magnus (thick arrow). Sciatic nerve (arrow head). At the level of adductor hiatus (b) femoral artery is escaping the canal laterally.

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Fig. 2: Below the adductor canal, the saphenous nerve immediately divides in the infrapatellar and sartorical branches. 3D proton density MR image (a), T2-weighted turbo
Fig. 3: 3D proton density MR image (a), T2-weighted tse MR image (b). Above the adductor tubercle of the distal femur, the infrapatellar branch (long arrow) is located at the posterior aspect of the vastus medialis muscle and the sartorial branch (short arrows) at the lateral aspect of the sartorius muscle. Nerve fascicles are more clearly demonstrated on 3D proton density image with thickness of 0.6 mm.
**Fig. 4:** 3D Proton density MR image (a), T2-weighted tse MR image (b) at the level of below the adductor tubercle. The infrapatellar branch is located just adjacent the femoral cortex (long arrows) and the sartorial branch is located between the sartorius and gracilis muscles. T2-weighted MR image with 3 mm thickness (b) shows the infrapatellar branch as a femoral cortical irregularity (long arrows in b).

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**Fig. 5:** 3D Proton density MR image (a), T2-weighted tse MR image (b) at the level of posterior cruciate ligament. The infrapatellar branch is located anterior to the medial collateral ligament (long arrow) and the sartorial branch is located between the sartorius and gracilis muscles. The infrapatellar branch is more clearly demonstrated on 3D MR image with thin thickness.

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Fig. 6: T2-weighted tse MR images with thickness of 2.5 mm at the level of proximal thigh (a) and mid thigh (b). The anterior branch of the obturator nerve descends between the adductor brevis and longus muscles (long arrow). At the mid thigh level, anterior branch is located lateral to the gracilis muscle (short arrow).

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Fig. 7: 3D Proton density MR images at the level of popliteal fossa (a), and intercondylar fossa (b). The articular branch of the posterior branch of the obturator nerve lies on the femoral artery in the popliteal fossa (long arrow). The articular branch pierces the oblique popliteal ligament of the knee and enters the knee joint (short arrow).
**Fig. 8:** T2-weighted MR image (a, b). In the popliteal fossa the sciatic nerve (long arrow) lies between biceps and semimembranous muscle (a). At the lower level, sciatic nerve divides into the common peroneal (long arrow) and tibial nerve (short black arrow).

**Fig. 9:** 3D Proton density MR image (a), T2-weighted tse MR image (b) at the level of anterior cruciate ligament. The lateral sural cutaneous nerve originated from the common peroneal nerve lies posterior to the lateral gastrocnemius muscle (long arrows) and
medial sural cutaneous nerve lies between the medial and lateral gastrocnemius muscles (short arrow).

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**Fig. 10:** 3D Proton density MR image (a), T2-weighted tse MR image (b) at the level of fibular head. The common peroneal nerve lies just posterior to the fibular head (long arrow).

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Fig. 11: 3D Proton density MR image (a), T2-weighted tse MR image (b) at the level of fibular neck. The superficial branch (long arrow) lies lateral the deep branch (short arrow) of the common peroneal nerve at the anterior aspect of the fibular neck.

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Fig. 12: T2-weighted tse MR images with thickness of 2.5 mm (a,b). Intermediate cutaneous nerve of the thigh is the branch of the anterior cutaneous branch of the femoral nerve. The small intermediate cutaneous nerve lies posterior to the sartorius muscle (long arrow).

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Fig. 13: T2-weighted tse MR images with thickness of 2.5 mm (a, b). The posterior cutaneous nerve of the thigh comes from the sacral plexus. At the level of end of the gluteus maximus muscle (a) and the mid thigh (b) posterior cutaneous nerve lies posterior to the hamstring muscle (long arrow).

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Conclusion

3D high resolution MR images with thin slice thickness allow us to identify varying peripheral nerves and their fasciculi around the knee joint. However, 2D conventional MR images with thickness of 3 or 4 mm also allow us to find various peripheral nerves around the knee joint in almost cases. Detailed interpretation of high resolution MR images can be helpful for the explanation of patient symptoms and can be used for US-guided intervention and surgical plan.
References


