Nerve Injuries in Total Knee Arthroplasty

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KEYWORDS

• Nerve injury • Total knee • Arthroplasty • Common peroneal nerve

KEY POINTS

- The common peroneal and geniculate sensory nerves are at risk with knee arthroplasty.
- The incidence of nerve injury after TKA is generally believed to be in the range of 0.12% to 0.4%.
- Dysfunction of the common peroneal nerve may result in sensory impairment (lack of normal sensory to nerve, hypersensitivity and chronic pain) and/or motor dysfunction ("drop-foot").
- The extent of recovery depends on the type and severity of the initial nerve palsy, having most patients achieving some degree of recovery.
- Surgical nerve repair, including tendon transfers, is sometimes required.

BACKGROUND

Nerve injury is one of the potential complications of total knee arthroplasty (TKA). Generally speaking, neurologic injury may be temporary or permanent, can affect either or both motor and sensory branches and unlike most intraoperative complications, becomes apparent only after resolution of the operative anesthesia. Nerve injury can dramatically affect mobility and posture and is sometimes irreversible. This injury may be associated with pain, allodynia, neuroma formation, and cold sensitivity.[1,2] The risk of intraoperative complication is elevated in patients presenting with complex problems, such as the case of the multiply revised knee or one which requires correction of severe deformity. Primary TKA, however, is generally expected to result in high patient satisfaction and proceed in an uneventful manner for both patient and surgeon. Therefore, nerve injury, a devastating complication at any time, is even more dramatic in the context of primary TKA.

Although the consequences of nerve injury may be dramatic, the probability of occurrence during the course of primary knee arthroplasty is low. The incidence of nerve injury after TKA is generally believed to be in the range of 0.12% to 0.4%.[3,4] However, it should be noted that this incidence is based on large databases that included both primary and revision TKAs.

The following sections will review the anatomy of the nerves around the knee relevant to TKA, histopathology of nerve damage, incidence, treatment, and prognosis of neurologic injury.

NERVE ANATOMY AND POTENTIAL FOR INJURY

The nerves in the surgical zone of the knee, which are at greatest risk of injury during TKA, are the common peroneal nerve and the superficial sensory nerves around the skin incision (Fig. 1). The common peroneal nerve, one of the terminal branches of the sciatic nerve, has both motor and sensory functions. This nerve contains both the anterior tibial and peroneal nerves, which provide dorsiflexion and eversion power to the foot. It provides sensation to the lower lateral leg and dorsum of the foot. This nerve lies approximately 1.5 cm from the posterolateral tibial plateau and is interposed with the lateral gastrocnemius muscle at that

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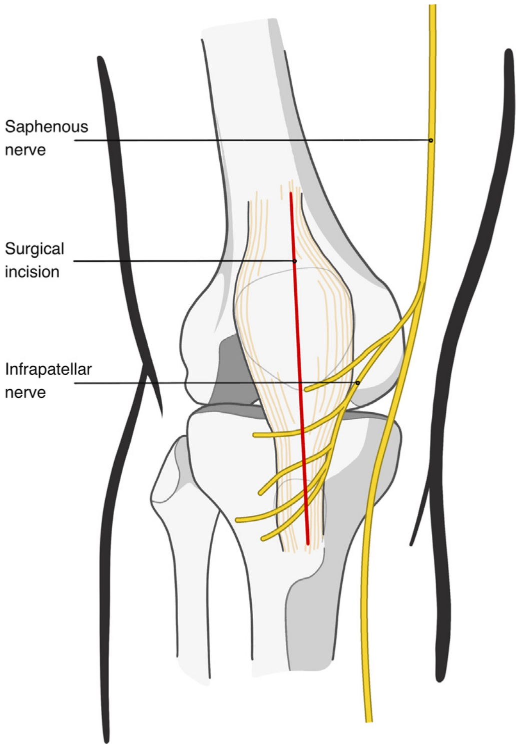

Fig. 1. Total knee arthroplasty incision crossing superficial sensory nerves.

level.[5] This provides relative protection of the nerve, although it is still at risk from stray surgical saw blades, and cautery. For example, the "pie-crust" technique, commonly used to release lateral soft tissue contractures in valgus knees, places the surgical blade near this nerve.

Both direct and indirect insults can injure the common peroneal nerve. Sources of direct insult include scalpel blades, cautery, saw blades, retractors, and other sharp instruments that may cause direct harm. Indirect injury may occur from forceful manipulation or elongation of the nerve, such as in the correction of severe valgus deformities.[3]In such deformity cases, the nerve and surrounding tissues are shortened because of the abnormal alignment anatomy. Correcting the alignment will elongate the course of the nerve, possibly causing a tension type of injury. Current understanding indicates that a maximal nerve elongation of 4% to 11% (up to 3 cm) can occur before nerve injury.[6]

The more common, generally unavoidable, nerve injury that occurs during the course of TKA relates to the superficial skin sensory nerves originating from the saphenous nerve. These nerves surround the knee from all sides and provide superficial sensation of the anterior knee. With the most common medial parapatellar surgical approach, the incision itself divides these nerve fibers, and many patients describe a numb sensation around the surgical scar on either the medial or lateral side. It is possible for such nerve injuries to result in a neuroma formation, a possible etiology of postoperative pain. Much more common than the peroneal nerve insult, this deficit is sensory only, often transient, and generally has no impact on outcomes.

NERVE HISTOPATHOLOGY, DAMAGE AND REGENERATION

The peripheral nervous system is based on neurons, the primary cell, built of dendrites that receive information and axons which send it on. Some axons are wrapped with myelin covering to reduce the action potential dissipation. Myelinated and unmyelinated nerve fibers are bundled together in fascicles, covered with 3 layers of tissue—the endoneurium, perineurium, and epineurium. These layers provide structural support and protection to the neurons, and nerve injury classification is based on the injury to these specific layers.

Neuropraxia is the simplest form of nerve injury and is most likely to result in complete recovery. With this injury pattern, the nerve's myelin covering is damaged, hence the diminished signal. However, the actual nerve pathway is not harmed. Once the Schwann cells rebuild the myelin sheath, the nerve function should fully recover. This pattern is commonly found in chronic compression injuries.

The intermediate nerve injury level is axonotmesis. Here the actual nerve pathway, as opposed to the covering only, is damaged. The surrounding nerve sheath is still intact, but there is axonal discontinuity. Crush injuries exemplify this type of nerve damage. Wallerian degeneration occurs, and partial to full recovery can be expected.

Finally, neurotmesis occurs when the axon, myelin, and connective tissue components are damaged, disrupted, or transected, and is the most severe form of nerve injury. Recovery from neurotmesis requires surgical intervention, and the likelihood of full recovery is much lower. Transection of a nerve with a surgical saw blade or cautery would cause this devastating nerve insult.

NERVE REPAIR

During the recovery process from nerve injury, the damaged segment is first phagocytosed and degenerated, a process that takes up to several months.[7] In mild cases, the regenerative and repair processes begin almost immediately, but nerve regeneration will start only after the Wallerian degeneration has finished in more severe injuries. Sprouting of new axons by nerve fibers could take up to 6 weeks, reforming the nerve pathway. Depending on the extent of injury and defect size, axons may regenerate and begin to remyelinate at 6 to 8 weeks; however, the original thickness will never be achieved. On average, axonal growth occurs at a rate of 1 to 2 mm/d with a decreased rate in distal regions.[8] In severe injuries, prolonged denervation may lead to muscle atrophy. In the case of neurotmesis, surgical repair is imperative to restore the nerve infrastructure and align the correct nerve pathways for minimal scarring and adequate axonal recovery. Sometimes the use of nerve conduits or allografts is required.[9,10]

NERVE INJURY OUTCOME

Dysfunction of the common peroneal nerve may result in sensory impairment in the relevant anatomic distribution—ranging from lack of normal sensory to nerve hypersensitivity and chronic pain. Injury to the motor aspect could cause a "drop-foot"—the inability to dorsiflex the foot properly. Such an impairment may severely affect the patients' gait because raising the foot while walking is imperative. The severity of the insult (both functionally and visually) with the delayed recovery (sometimes irreversible damage) turns this nerve insult into one of the most significant potential surgical complications in knee arthroplasty. As mentioned earlier, the recovery is sometimes partial and may take months.

In contrast, injury to the geniculate sensory nerves around the surgical incision causes only local numbness around the incision and may recover within weeks to months.

INCIDENCE AND RECOVERY

The incidence of injury to the common peroneal nerve in knee arthroplasty is between 0.12% and 0.4%.[3,4] The combination of spinal conditions and valgus deformity holds the highest rate for postoperative nerve palsy.[3,11] Rheumatoid knees have also been associated with an elevated incidence of nerve injury.[12] The extent of recovery depends on the type and severity of the initial nerve palsy. At the 3.5-year mark, Schinsky and colleagues[12] found that 39% of patients with *complete* palsy had a full recovery, and 56% had partial recovery. In contrast, 66% of patients with incomplete palsy recovered completely, and approximately 30% had an incomplete recovery. While awaiting recovery, treatment is supportive, initiating an ankle-foot orthosis to prevent falls.

The incidence of injury to the superficial skin sensory nerve is much higher (0.5%-53%) and occurrence is, to a large degree, inevitable.[13–15] There is no recommendation for specific treatment as the odds for sensation recovery are high, and the clinical implications are minimal.

PREVENTION

It is critical for all TKA surgeons to keep in mind the potential for nerve injury, particularly when performing complex surgery. Likewise, it is important for patients to fully understand the risks and implications of such an injury. In case of anatomic deformity, the surgeon must plan the maximal elongation that may be performed safely, at times necessitating under-correction of the alignment in the most severe cases. During the procedure, the surgeon and all assistants must be aware of the location of the peroneal nerve and prevent direct pressure and sharp contact. Owing to the necessity for anesthesia, there is currently no practical immediate marker informing dangerous closeness to the nerve. Several decades back, such neuromonitoring was suggested,[16] but as of today, no practical implication is in use.

EVALUATION AND TREATMENT

Patients should be assessed for nerve function as soon as the anesthetic effect allows. With any suspicion of nerve dysfunction, any dressing which might be causing local pressure should be removed, and the knee should be evaluated for a hematoma.[6] The leg should be positioned with the hip extended and knee flexed, to achieve maximal nerve relaxation.[6]

In the unfortunate case of peroneal nerve injury, the patient should be treated with an ankle-foot orthosis, holding the ankle in a neutral position, thus minimizing the risk of Achilles tendon shortening and improving posture. Anatomic evaluation of the nerve and surrounding anatomy to locate local structural compression and to assess nerve integrity should be performed by ultrasound or MRI.[17] A walking aid will often be needed for balance. Electromyography and nerve conduction studies should be performed for an objective assessment of the extent of the injury.[18]

Some authors have advocated for urgent surgical management in the scenario of direct damage to the common peroneal nerve, with relatively good results.[19] Others have found the surgical results to be suboptimal, with nerve recovery in about half the cases, depending on timing of intervention and extent of injury.[20,21] Combining nerve repair with tendon transfers achieves better outcomes. Posterior tibial tendon transfer to the dorsum of the foot has shown substantial improvement in functional outcomes.[22,23]

SUMMARY

When peroneal nerve injury occurs during elective TKA surgery, resulting in common peroneal palsy, it is a complication for both patient and surgeon. Prevention with all due precautions should be prioritized to prevent nerve injury from occurring. However, in the event of postoperative common peroneal nerve dysfunction, the patient should be treated immediately with local dressing decompression, knee flexion, and utilization of an ankle-foot orthosis. Nerve conduction studies and imaging are needed to further evaluate the extent of the injury. Spontaneous nerve recovery is generally expected in most cases and patient reassurance is imperative. Surgical intervention, sometimes combined with tendon transfers, may be indicated in cases of actual nerve fiber discontinuity, for better functional outcomes.

CLINICS CARE POINTS

- The common peroneal and geniculate sensory nerves are at risk with knee arthroplasty.
- The incidence of nerve injury after TKA is generally believed to be in the range of 0.12% to 0.4%.
- This common peroneal nerve, contains both the anterior tibial and peroneal nerves, which provide dorsiflexion and eversion power to the foot, and sensation to the lower lateral leg and dorsum of the foot.
- The nerve lies approximately 1.5 cm from the posterolateral tibial plateau and is interposed with the lateral gastrocnemius muscle at that level. This provides relative protection of the nerve, although it is still at risk from stray surgical saw blades, and cautery.
- Patients with abnormal alignment anatomy are at the highest risk for common peroneal nerve injury.
- Nerve injury to the superficial skin sensory nerves originating from the saphenous nerve is more common. The deficit is sensory only, often times transient, and generally has no impact on outcomes.
- With any suspicion of nerve dysfunction, any dressing which might be causing local pressure should be removed, and the leg should be positioned with the hip extended and knee flexed, to achieve maximal nerve relaxation.
- Immediate treatment includes:
  - Anatomic evaluation of the nerve and surrounding anatomy by ultrasound or MRI.
  - Walking aids.
  - Ankle orthosis.
  - Electromyography and nerve conduction studies.
  - Consider the need for immediate surgical intervention for nerve repair and tendon transfers.

DISCLOSURE

The authors have nothing to disclose.

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