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Anatomical Relationship of the Sciatic Nerve and its Protection During Posterior Approach for Primary and Revision Hip Arthroplasty

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Abstract

The sciatic nerve is an important anatomical structure to consider in the context of hip arthroplasty, in both primary and revision cases. Due to its proximity to surgical field in question, it is vulnerable to injury. This can have wide and far-reaching implications to the patients undergoing hip surgery. In this paper we discuss the anatomy of the sciatic nerve its variations, and adjustments which can be made to the conventional posterior approach to the hip in order to protect the sciatic nerve from injury or damage.

Introduction

The sciatic nerve courses closely to the posterior hip and can be injured directly or indirectly during standard posterior approaches in both primary and revision scenarios. Nerve injury in the context of hip surgery is a debilitating post-operative complication, as it can result in numbness, weakness or significant pain. These things are a significant cause for concern for the arthroplasty surgeon. This paper aims to review the anatomy, course and variation of the sciatic nerve as well as its relationship to the hip joint during surgical exposure in arthroplasty. We will also describe simple steps that can be taken in the adjustment of the posterior approach and exposure of the hip joint, from the point of view of the pelvic surgeon who performs complex arthroplasty and reconstructive surgery. Focus will be on the Kocher-Langenbach approach to the hip joint. The senior author advocates exposure of the posterior wall of the acetabulum with direct visualization and protection of the sciatic nerve during every posterior approach to the hip. Using this approach, we have experienced no recorded nerve injury thus far.

Incidence of injury

The incidence of Sciatic Nerve (SN) (tibial or peroneal division) and/or femoral palsy after Total Hip Replacement (THR) ranges from 1-3%. Incidence of nerve palsy after primary THR is 1-2%, after revision THR 3-4% and up to 5-6% in THR for congenitally dislocated hips. Females are at higher risk. Retractor placement is one of the leading causes of intraoperative nerve injury [1-6]. Regardless of mechanism, the peroneal division of the sciatic nerve is more vulnerable to traumatic damage and its potential for recovery is restricted compared to the tibial division [2,3,7]. Lateral localization of the peroneal division may predispose to injury in THR surgery, however its vulnerability may be also due to other reasons other than its anatomical proximity [2].

Injury Risk Factors in THR

These include limb lengthening, and direct injury. However, risk factors contributing to injury is unclear or unknown in up to 60% of cases [5,6].

Prognosis

- Related to the degree in which the nerve was initially damaged.
- Mild injury consisting of transient conduction block may recover in days to weeks.
- Severe injury with axonal damage may not recover at all or may be incomplete after 1-2 years.

Sciatic Nerve Function, Anatomy and Variations

Sciatic Nerve Function

The sciatic nerve is the largest peripheral nerve in the body. It originates from the lumbosacral plexus (nerve roots L2 - S3). Its tibial division provides motor innervation to the muscles in the posterior compartment of the thigh (semimembranosus, semitendinosus, long head of biceps femoris, hamstring portion of adductor magnus) the posterior compartment of the calf (gastrocnemius, soleus, plantaris, tibialis posterior), and some of the muscles of the foot (flexor hallucis longus, flexor digitorum longus). Its peroneal division provides motor innervation to other muscles of the foot (abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, foot lumbricals and interossei, quadratus plantae, flexor digiti minimi, adductor hallucis, abductor digiti minimi). The peroneal division (articular branch) also provides sensory innervation to the knee joint.

The sciatic nerve provides cutaneous innervation to the lower leg, via its terminal branches (tibial nerve, common fibular nerve [superficial and deep branches] and sural nerve). Following its exit from the sciatic notch, it usually runs anterior (or deep from the point of view of the arthroplasty surgeon, in the posterior approach) to the piriformis muscle, and posterior (or superficial, from the point of view of the arthroplasty surgeon) to the short external rotators of the hip (superior and inferior gemelli, obturator internus). It then enters the posterior compartment of thigh by passing deep to the long head of biceps femoris. Classically the sciatic nerve has been described as bifurcating at the apex of the popliteal fossa into tibial and common peroneal nerves; however, as we shall go on to discuss, there is significant variation described in the course and level of this division.

Variations in Nerve Anatomy

- As the sciatic nerve has significant anatomical variation in its course, topography and level of division, the unpredictability of this leads to inadvertent damage intra-operatively.
- This has been described previously [8].
- High level division is a relatively frequent finding, dividing into its terminal branches at any level on the pelvis and thigh.

Level of Division of the Sciatic Nerve

Many authors have given different classifications for the level of division and course of sciatic nerve in relation to piriformis muscle. The degree and prevalence of anatomic variation has remained relatively constant in cadaveric and Magnetic Resonance Imaging studies with around 90-93% of cases following typical type 1 pattern with anatomic variation in up to 10%. Some rare unclassified variations may still be encountered during surgical intervention in this region. Beaton and Anson classified the relationship of the SN to the piriformis and its subdivisions to the muscle [9]. Four main types were observed with Type 5 and 6 were considered hypothetical variations (Figure 1).

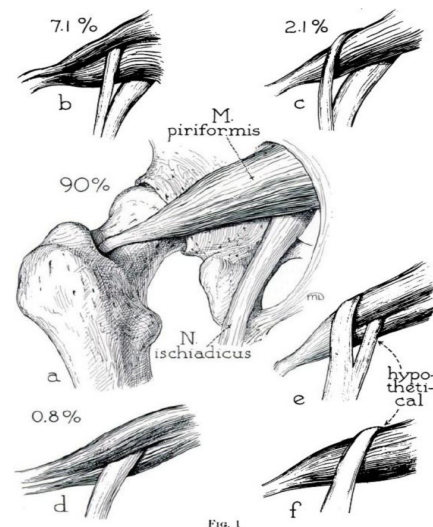


Figure 1: Nerve course and variation reproduced from Beatons original 1939 paper.

Type 1: Undivided nerve below undivided muscle - 90%

Type 2: Division of nerve between and below undivided muscle - 7.1%

Type 3: Division above and below undivided muscle - 2.1%

Type 4: Undivided nerve between heads - 0.8%

Type 5: Division between and above heads.

Type 6: Undivided nerve above undivided muscle.

Suggested Hints and Tips for Posterior Approach to the Hip

Indications

Primary, complex and revision THR, acetabulum and posterior wall and column open reduction & internal fixation. The Kocher-Langenbach approach is the more extensile version of the Southern or Moore posterior approach using the intermuscular plane of gluteus maximus through a muscle splitting approach.

Advantages of Posterior Approach in Hip Arthroplasty

- Provides excellent exposure to 360 degrees of the internal surface of the acetabulum as well as the posterior wall, lateral aspect of the posterior column, indirect access to the true pelvis and anterior aspect of the posterior column and proximal femur.
- Allows for accurate sciatic nerve identification, assessment and protection throughout procedure.

Incision

Laterally based posteriorly curved incision, centered over the Greater Trochanter (GT) with the proximal end of the incision curved posteriorly just below the iliac crest, lateral to the Posterior Superior Iliac Spine (PSIS) and the distal extent of the wound in line with the lateral aspect the femoral shaft.

Authors' Top Tip

- Mini- incision shows no long term benefits to hip function.
- Mark incision prior to commencement. Mark center of greater trochanter, place hip in maximum flexion, extend mark in a smooth line 6cm proximal towards the PSIS and 6cm distal to the mark in line with femur. Extension of hip will now provide appropriately posterior curved incision line.

Superficial Dissection

Tensor Fascia Lata (TFL) is split in line with the wound and gluteus maximus, innervated by the inferior gluteal nerve is split. The muscle split is stopped when the first nerve branch of the inferior gluteal nerve is encountered. Nerve branches of the upper third of the muscle cross the intended interval of dissection halfway between the level of the greater trochanter and the PSIS.

Authors' Top Tip

- Release a portion of the gluteal sling (formed by the attachment of the deep fibres of the inferior part of the gluteus maximus on the lateral ridge of the linea aspera of femur also known as the 'Gluteal tuberosity' and the lateral intermuscular septum) via combination of blunt finger dissection and diathermy, keeping tendon cuff for repair at the end to avoid cosmetic dissatisfaction from buttock sagging.
- This release assists anterior retraction of muscle belly and reduces distal tethering and tension on the sciatic nerve and thereby helps protect it from compression injury during surgical procedure.

A Charnley bow retractor is placed ensuring not to capture muscle belly and only fascia within the retractor claws. Clearance of the bursa is recommended and Short External Rotators (SER) are identified, tagged and detached. The piriformis provides a

landmark leading to the greater sciatic notch, the contents of which include the piriformis, superior and inferior gluteal vessels and nerves, Sciatic and posterior femoral cutaneous nerves, internal pudendal vessels and nerves to the obturator internus and Quadratus Femoris (QF).

Authors' Top Tip

- Identify and blunt dissect, with scissors, along the superior margin of piriformis and interval between inferior gemellus and QF. Create a space between the SER bundle superior to QF and detach as close to their insertion to the GT as possible. Tag with stay suture and gently retract posteriorly, protecting the sciatic nerve.
- The capsule is then incised as an upside-down U-shape, providing a superior, transverse and inferior capsular release. This too is tagged and retracted posteriorly.
- Careful separation of the capsule away from the posterior wall of acetabulum aide's exposure without the need for self-retaining retractors or pins which may inadvertently create tension across the sciatic nerve. This should be done by positioning the hip in extension and knee in flexion with the assistant's hand on the foot to reduce sciatic nerve tension and distance as well as allow immediate warning to the diathermy wands proximity to the nerve via muscle twitching. The surgeons' finger should help retract the capsule away from the posterior wall, simultaneously providing protection to the nerve which lies posteriorly.

Such exposure methods can be extended to expose the posterior column in more complex cases associated with column disruption requiring surgical attention. QF may be released if required from its femoral attachment when identification of the lesser trochanter is desired.

Management of Suspected SN Injury

In the case of limb lengthening, the initial management is to nurse with knee flexed to relieve stretch of nerve. Early ultrasound may be helpful to rule out haematoma that may require surgical evacuation. Surgical intervention is only indicated for severe lesions without potential for recovery. Sharp transections of the SN should be treated within 72 hours to prevent retraction of the nerve [3].

Consideration of wound exploration, for example haematoma evacuation, should be undertaken when compression or constriction of the nerve is thought to be the cause. Exploration and neuro lysis is recommended over conservative treatment in patients with neuropathic pain associated with a sciatic nerve palsy post operatively [10,11]. No consensus exists for a stretched or contused nerve regarding optimal time period of observation and surgical exploration. Serial physical examination, observation and

use of ankle foot orthosis to prevent foot drop, Electro MyoGraphy (EMG) and Nerve Conduction Studies (NCS) at three months is widely accepted. Most patients show spontaneous recovery to acceptable level of function following conservative treatment [2,3,7,12]. Magnetic resonance imaging with optimized pulse sequences to reduce implant artefact may also be of diagnostic value [12]. Early involvement of physiotherapy and pain team for management is essential for radicular pain and type 2 Chronic Regional Pain Syndrome (CRPS). Such cases may also have positive response with sympathetic blocks. Prognosis for recovery of tibial division is good despite severe initial damage. Prognosis for recovery of peroneal division is dependent on severity of initial injury [4,13].

Conclusion

A complete understanding of the anatomy and associated variations if the SN is essential to the arthroplasty surgeon. Technical adjustments in surgical approach as described may help to further identify and protect the sciatic nerve during arthroplasty. Clear documentation of the appearance of the sciatic nerve, and attempts made to protect it intra-operatively, is also strongly recommended, as is early identification, assessment and early referral to a peripheral nerve injury specialist when injury is identified.

Compliance with Ethical Standards

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