

Critical sites of entrapment of the posterior division of the obturator nerve: anatomical considerations

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In the current anatomic study, special attention was given to the relationship of the posterior division of the obturator nerve to surrounding structures: the obturator canal and the fibromuscular and vascular structures of the medial thigh region. These intimate relationships may, in certain conditions, constitute critical sites of entrapment of the posterior division of the obturator nerve and may present a diagnostic challenge to the manual practitioner. Knowledge of the potential sites of entrapment of the posterior division of the obturator nerve can aid in differential diagnosis of peripheral neuropathies, provide an anatomic basis for obturator nerve pathology, and guide effective patient management, including the application of modern diagnostic techniques and safe surgical procedures. (JCCA 2010; 54(1):33-42)

KEY WORDS: obturator nerve, medial thigh region, peripheral nerve compression.

Dans le cadre de l'étude anatomique en cours, une attention particulière a été portée à la relation entre la division postérieure du nerf obturateur et les structures avoisinantes : le canal obturateur et les structures fibromusculaires et vasculaires de la région interne de la cuisse. Ces relations intimes peuvent, dans certains cas, constituer des sites critiques d'encapsulation de la division postérieure du nerf obturateur, et présenter un défi considérable au praticien manuel qui tente d'établir un diagnostic. La connaissance des sites potentiels d'encapsulation de la division postérieure du nerf obturateur peut aider à émettre un diagnostic différentiel des neuropathies périphériques, procurer une base anatomique pour la pathologie du nerf obturateur, et guider la gestion efficace du patient, notamment l'application des techniques de diagnostic modernes et les procédures chirurgicales sécuritaires. (JCCA 2010; 54(1):33-42)

MOTS CLÉS : nerf obturateur, région interne de la cuisse, compression du nerf périphérique.

Introduction

It has been stated that chronic pain in the distribution of the obturator nerve is a difficult diagnostic challenge.¹⁻⁴ This pain may be explained by the many potential causes and numerous anatomical structures in the groin area that may be susceptible to injury or disease. These pathologies include adductor muscle strain, tendonitis, bursitis, stress fractures, osteitis pubis, hernia, conjoint tendon strains,

inguinal ligament enthesopathy, compression due to prolonged lithotomy position, and entrapment of the peripheral nerves.⁵⁻¹²

Compression of the obturator nerve has been described as one cause of groin and adductor region pain, especially in athletes.^{1,2,6,7,13}

In all obturator nerve pathology, a sound knowledge of anatomy is the foundation of understanding clinical symp-

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toms and forming an accurate diagnosis. Such knowledge aids not only in greater understanding of clinical symptoms but also in application of modern diagnostic and management techniques such as ultrasound guided nerve block, ultrasound guided biopsy, and magnetic resonance imaging (MRI).^{14–22} For example, based on MRI findings, obturator neuropathy, caused by acetabular labral cyst²¹ and tumor situated in the obturator foramen,²² was diagnosed even though the nerve was not visualized. The location of the labral cyst was consistent with the region of the obturator nerve on the lateral wall of the lesser pelvis. Lower limb peripheral nerve blocks are an increasingly common method for providing anesthesia and analgesia of the lower limbs. That is why, in recent years, more and more studies have examined sonographic imaging of the obturator nerve and its divisions by scanning along the expected course of the nerve.^{14–16,18–20} However, high anatomic variability in the obturator nerve's divisions¹⁵ in conjunction with the complicated anatomy of the surrounding area makes ultrasound guided obturator nerve block one of the most technically challenging regional anesthesia techniques.¹⁴

There is considerable information concerning the intrapelvic course of the obturator nerve,^{5,7,8,23} but details concerning the obturator and adductor regions of the thigh are sparse. Reports from numerous obturator nerve decompressions have remarked upon variability in the anatomy of the nerve, vasculature, and the myofascial tissue, particularly with reference to the anterior division of the obturator nerve.^{6,16,17,18} However, variability in the posterior division of the nerve has not been well documented.^{6,15,24,25}

Therefore, the purpose of this paper is to describe the morphological variations of the posterior division of the obturator nerve in relation to the obturator canal, and vascular and myofascial structures of the medial thigh region. The findings of this report provide an anatomic basis for obturator nerve pathology, and may assist diagnosis and effective patient management.

Materials and methods

Fifty six lower limbs from twenty eight (20 males and 8 females) cadavers with an age range of 50–82 years (mean = 66 years) were dissected. The cadavers were preserved with a mixture of formaldehyde and ethanol by embalming within 3–7 days of death, and were stored in

vacuum bags at 4°C for 1–2 years. An identical dissection sequence was used in all specimens studied.

All skin and superficial fascia were removed over the anteromedial thigh to expose the fascia lata. The sartorius muscle was detached from its proximal attachment, and the femoral triangle was dissected free to reveal the femoral vessels and their branches, the pectineus, and the adductor longus muscles. The adductor longus muscle was divided transversely 1–2 cm below its origin. Its distal part was turned toward the femur. The anterior division of the obturator nerve, nerves to adductor longus and gracilis muscles, were located.

The pectineus muscle was divided transversely 1 cm below its origin and turned toward the femur. Branches of the obturator nerve and vessels were identified within the fascial layer. The obturator externus muscle was defined. The adductor brevis muscle was divided close to its origin, and turned laterally, protecting the anterior branch of the obturator nerve. Then, the posterior division of the obturator nerve was identified and traced.

The fascia from the obturator externus and adductor magnus muscles was removed without damaging the branches of the obturator nerve. The obturator externus muscle was carefully removed from its origin and the contents of the obturator canal were dissected out. Then, the obturator nerve divisions and their branches were freed and their distributions were traced. Branches of the obturator vessels and of the deep femoral artery of thigh were dissected out. The relationships between the branches of the nerve and vascular branches were documented. Schematic diagrams were drawn and photographs were taken.

Results

Anatomy of the obturator region

In our anatomical descriptions we used the internationally accepted terminology for human gross or topographical anatomy.* According to this terminology, right and left hip bones (pelvic bones, coxal bones) are the bones of the pelvic girdle.

In mature individuals, the pelvic girdle is formed by three bones: right and left hip bones and sacrum. Each hip bone develops from the fusion of three bones, the ilium,

* Terminologia anatomica: international anatomical terminology. Federative Committee of Anatomical Terminology. Stuttgart, New York: Thieme, 1998:292.

ischium, and pubis. In infants and children, the hip bone consists of three separate bones that are united by cartilage at the acetabulum.

The obturator foramen is a large opening in the hip bone. It is bounded by the margin formed by the following structures: i) superiorly – the obturator surface of the pubic body and the obturator groove, the deeply grooved base of the superior pubic ramus; ii) inferiorly – the ischial and pubic inferior rami; iii) anteriorly – the superior and inferior pubic rami; iv) posteriorly – the inferior ischial ramus. A thin fibrous sheet, the obturator membrane, is attached to the margin of the obturator foramen. The obturator internus and obturator externus muscles are connected with the obturator membrane.

The obturator internus muscle arises from: i) the pelvic surface of the margin of the obturator foramen, ii) the internal surface of the hip bone below and posterior to the pelvic brim, iii) the internal surface of the obturator membrane, the tendinous arch that completes the obturator canal, and iv) the obturator fascia. The fibers converge towards the lesser sciatic foramen and, after receiving the attachments of the gemelli, are inserted into the medial surface of the greater trochanter.

The obturator externus muscle is the deepest muscle of the superomedial part of the thigh. It arises from: i) the margins of the obturator foramen, ii) pubic and ischial rami, and iii) the external surface of the obturator membrane, the tendinous aponeurotic arch which completes the obturator canal. The muscle passes inferior to the acetabulum to attach to the trochanteric fossa.

The superior free edges of the obturator internus muscle and its fascia, the obturator membrane (between the anterior and posterior obturator tubercles), and the obturator externus muscle and its fascia collectively form the musculotendinous aponeurotic arch which converts the obturator groove into an obturator canal. The direction of the canal is i) from superior to inferior, ii) from lateral to medial, and iii) from posterior to anterior. The superior wall of the obturator canal is formed by the floor of the obturator groove. The inferior wall is formed by the rigid edge of the musculotendinous aponeurotic arch.

The contents of the obturator canal include: i) superomedially, nerve to obturator externus muscle, and obturator artery, ii) inferomedially, obturator vein, and iii) superolaterally, anterior and posterior divisions of the obturator nerve, which lay within the obturator groove. The

obturator canal is also invested with a variable amount of adipose tissue.

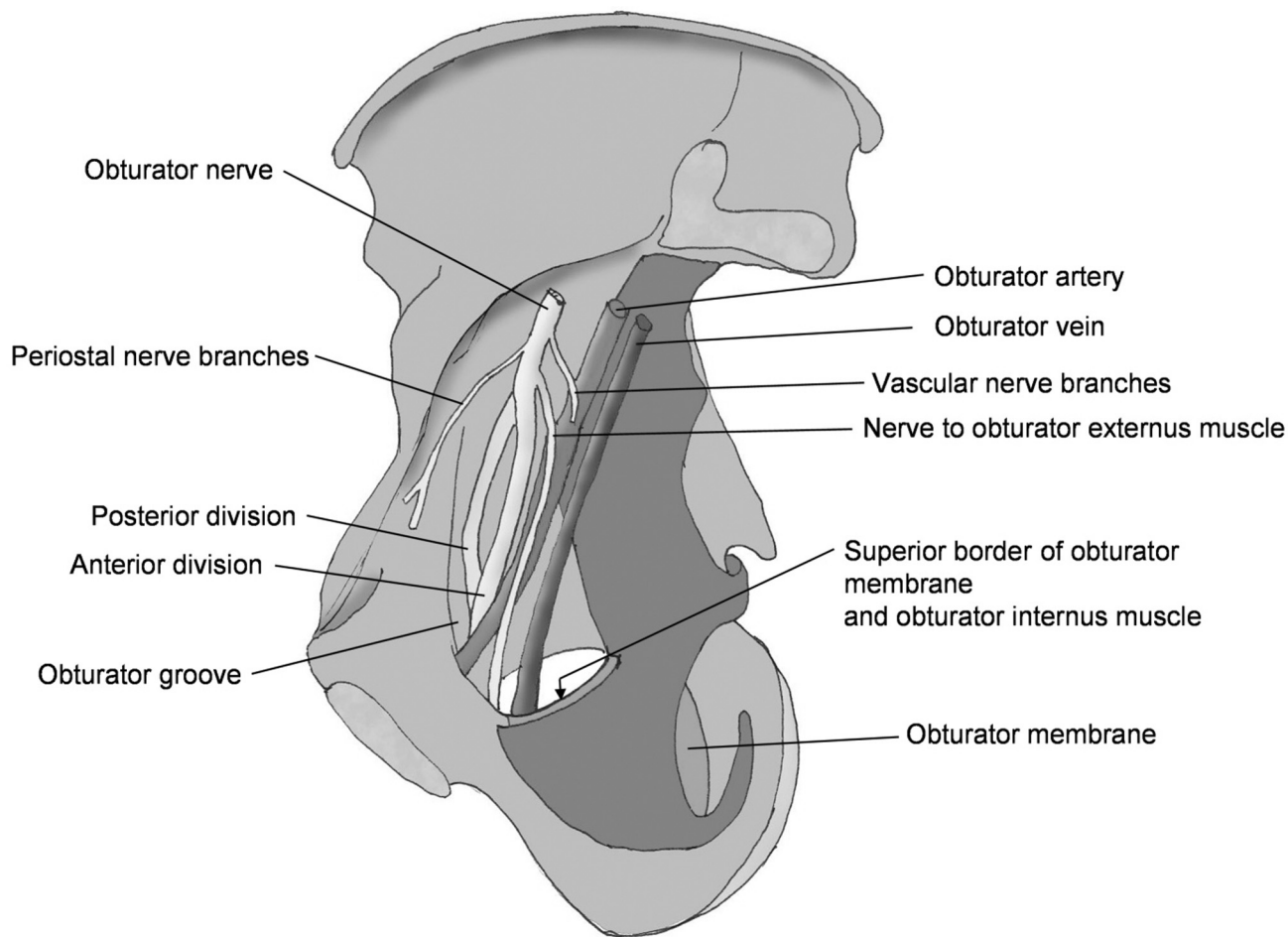
The nerve to obturator externus muscle, arising from the intrapelvic obturator nerve before it splits into divisions, crosses the obturator artery and descends between the obturator vessels. Within the obturator canal, the posterior division of the obturator nerve is bound superiorly by the anterior division of the nerve, and inferiorly by the obturator artery and the nerve to obturator externus muscle. The level of bifurcation of the obturator nerve into the anterior and posterior divisions varies, and bifurcation may occur in the pelvic cavity, or at the entrance, within or at the exit of the obturator canal, and is the object of a separate investigation.

Medial thigh region: myofascial pattern

The adductor muscles of the medial compartment of the thigh are arranged in three layers: i) the superficial layer consisting of pectineus and adductor longus muscles, ii) the middle layer represented by the adductor brevis muscle, and iii) the deep layer formed by the obturator externus and adductor magnus muscles. Each muscular layer is separated by a very definite fascial plane, consisting of fibroelastic connective tissue with variable amounts of adipose tissue condensation around the nerves and vessels. The muscular branches of the obturator nerve and the medial circumflex femoral and obturator vessels ramify within and perforate these intermuscular fascial layers in order to supply the surrounding muscles.

The obturator nerve is formed within the psoas major muscle by the anterior divisions of the anterior primary rami of L2–L4 spinal nerves. The obturator nerve emerges from the medial border of psoas major and passes into the lesser pelvis, being situated inferior to the pelvic brim. In the current anatomic study, it was found that in most cases, prior to entering the obturator canal, the obturator nerve gave off branches to the obturator artery, perios-teal nerve branches and the nerve to obturator externus muscle, and then divided into the anterior and posterior divisions. Within the obturator canal, the divisions of the obturator nerve follow the direction of the canal, passing against the canal's superolateral aspect (Figure 1). Exiting the canal, the two divisions of the obturator nerve ran against the musculotendinous aponeurotic arch; in particular, the posterior division of the nerve was in immediate contact with the arch.

Figure 1 *Obturator canal content.*



In 32 lower limbs, the posterior and anterior divisions of the obturator nerve emerged into the thigh anterior to the obturator externus muscle and its fascia, accompanied by the branches of the obturator artery and vein (Figure 2). The anterior division, from its emergence to its final branching in the thigh, and connections with the saphenous and anterior femoral cutaneous nerves, is the object of a separate investigation (manuscript in preparation).

In 22 lower limbs, the posterior division of the obturator nerve, after exiting the canal, descended posterior to the proximal quarter of the obturator externus muscle and its fascia. Then, the posterior division emerged from the substance of obturator externus, perforating it and descending anterior to its distal part (Figure 3).

The nerve branches of the posterior division of the obturator nerve were accompanied by the branches of the obturator vessels. Only in two lower limbs did the posterior division emerge from the inferior border of the obturator externus muscle, descending entirely posterior to it. Once the posterior division of the obturator nerve entered the thigh, it descended deep to the pectineus and the adductor brevis, within the fascial layer overlying the obturator externus and the proximal part of the adductor magnus muscles. From the midpoint of adductor magnus, the posterior division descended within the substance of the anterior part of this muscle towards the adductor hiatus and terminated within the posterior aspect of the fibrous capsule of the knee joint. On its way, the poster-



Figure 2 The posterior and anterior divisions of the obturator nerve emerged into the thigh anterior to the obturator externus and adductor magnus muscles:

- 1 – obturator externus muscle
- 2 – adductor magnus muscle
- 3 – posterior division of obturator nerve
- 4 – anterior division of obturator nerve

rior division sent nerve branches to the obturator externus, the adductor brevis, and the anterior part of the adductor magnus muscles.

The posterior division of the obturator nerve was intimately applied to the vessels at two sites. In the first instance, this occurred at the obturator foramen on emergence into the thigh, where the posterior division is framed by the branches of the obturator artery and vein, and is crossed by the anastomosing vein between the anterior and posterior branches of the obturator vein. The second instance was anterior to the proximal part of the adductor magnus muscle, where the posterior division is crossed by the ar-



Figure 3 The posterior division of the obturator nerve after exiting the obturator canal, descended posterior to the proximal part of the obturator externus muscle. Then, the posterior division emerged from the substance of obturator externus, perforating it and descending anterior to its distal part:

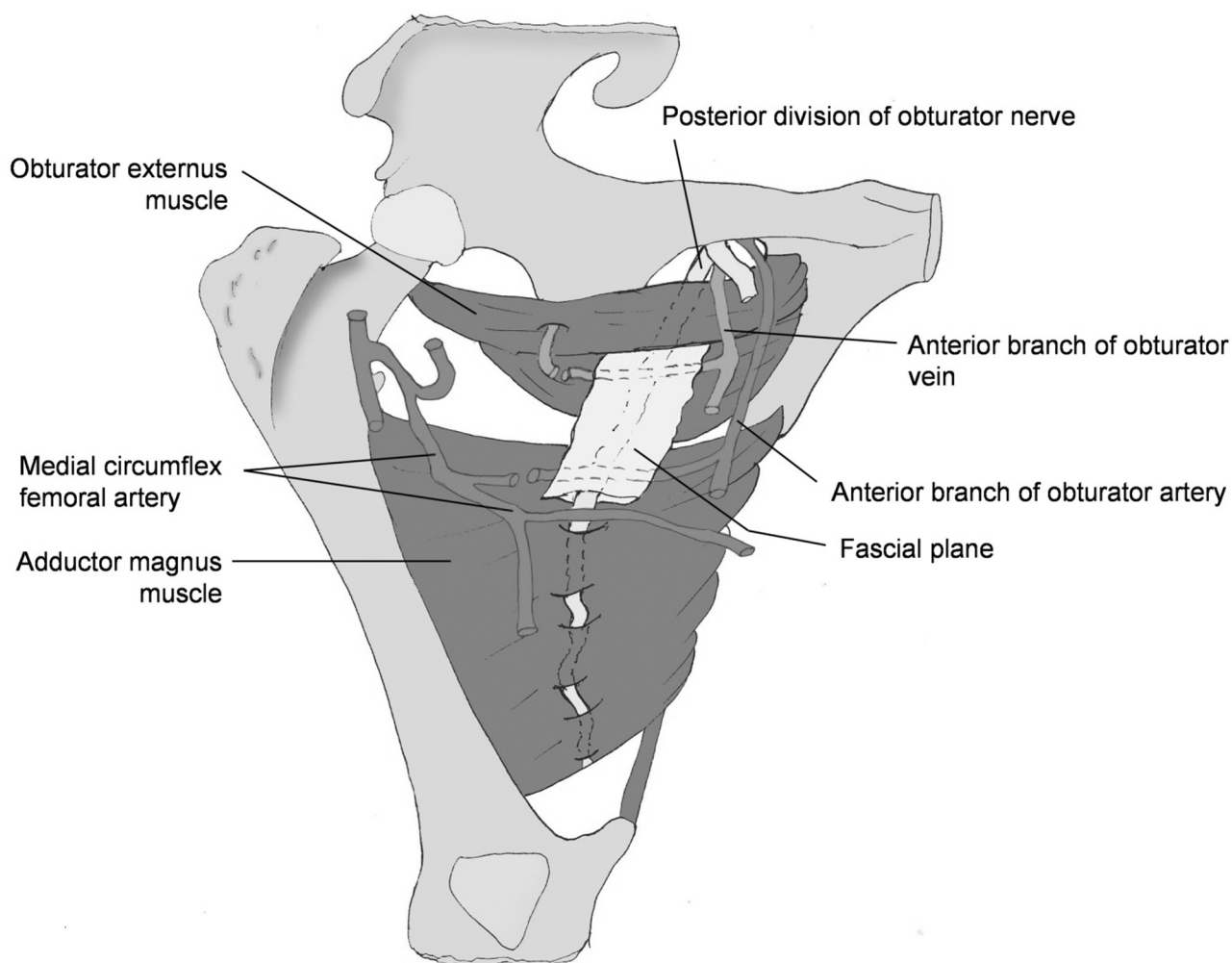
- 1 – obturator canal
- 2 – obturator externus muscle
- 3 – adductor magnus muscle
- 4 – deep fascia
- 5 – posterior division of obturator nerve

terial anastomosis between the muscular branches of the medial circumflex femoral artery and the anterior branch of the obturator artery (Figure 4).

Discussion

Detailed knowledge of the anatomy of the medial thigh region and the morphological variants of the obturator nerve is essential to understanding, diagnosing, and effectively treating patients with chronic groin and lower limb pain. Several reports have remarked upon the “growing appreciation of the importance”²⁰ of a detailed understanding of the anatomy of the obturator nerve in order to localize this nerve and its branches, and thus facilitate, for example, ultrasound guided obturator nerve block,^{14–18,20} MRI^{17,21} and ultrasound guided biopsy.²² For example, Akkaya et al. (2009), in order to develop a new approach for obturator nerve block in patients, first described, in

Figure 4 The posterior division of the obturator nerve descends within the fascial plane overlying the obturator externus and the proximal part of the adductor magnus muscles. The vascular branches of the obturator and medial circumflex femoral vessels cross the posterior division of the obturator nerve.



cadavers, the anatomical location of the common obturator nerve and its anterior division. A triangular region bordered by the superior pubic ramus, posterior margin of the pectineus muscle and anterior aspect of the external obturator muscle containing the obturator vessels and nerve was defined and later used clinically to perform obturator nerve block with ultrasound guidance.¹⁴

There are several reports of the “low visibility rate” of the posterior division of the obturator nerve, possibly as a result of its variability, small size and deep location in the obturator region.^{15,16,19} Our description of the variable

course and the critical sites of entrapment of the posterior division of the obturator nerve would aid in identification of the nerve’s ultrasound appearance, and therefore facilitate localization of this nerve for successful regional block.

Intrapelvic and obturator courses of the obturator nerve

Although an academic description²⁴ of the pelvic course of the obturator nerve and its passage through the obturator canal into the medial thigh has been published, nei-

ther morphological variation of the origin, the passage of the posterior division, nor the most susceptible sites of its compression were previously described in detail. Information regarding the sites of the obturator nerve bifurcation into anterior and posterior divisions is sparse, inconsistent and controversial.

Several studies have been published that describe various sites at which the obturator nerve branches into anterior and posterior divisions : a) near the obturator foramen,^{6,25} b) within the obturator canal,^{26,27} c) at the exit from the obturator canal,²⁸ and d) at the proximal border of the adductor brevis muscle.²⁹ In a recently published study on anatomic variations of the obturator nerve in the inguinal region,¹⁶ the branching points of the obturator nerve into the anterior and posterior divisions were reported as: intrapelvic – 23.22%; within the obturator canal – 51.78%; in the thigh – 25%.

Bradshaw illustrates the passage of the obturator nerve through the fibro-osseous tunnel, the roof of which is formed by the obturator groove of the pubic bone, and the floor of which consists of the internal and external obturator muscles and their covering fascias.² Within this tunnel, the nerve divides into two main branches, as well as a branch to the external obturator muscle. At the distal end of the tunnel, the nerve passes through the “obturator foramen” to enter the thigh.

In our study we describe the passage of the obturator nerve via the obturator canal, not the “obturator foramen,”² since the obturator groove is converted to a canal by the superior margins of the obturator membrane and the obturator muscles. We also conclude that the point of the obturator nerve bifurcation is variable: intrapelvic, at the entrance of the obturator canal, or within or at the exit of the obturator canal, and is the object of a separate investigation. Clinically, in the case of bifurcation prior to the obturator canal, it is possible that either the anterior or posterior obturator divisions might then be individually involved by pathological processes; otherwise the entire obturator nerve would be affected. Contrary to the opinion that “no pelvic structures are supplied by the obturator nerve,”²⁶ we found that in most cases the intrapelvic obturator nerve gives off a nerve branch to the obturator externus muscle (named the nerve to obturator externus muscle), as well as periosteal and perivascular nerve branches. As a result, the contents of the obturator canal include anterior and posterior obturator nerve divisions directly related

to the pubic groove, and the nerve to obturator externus muscle situated between the obturator vessels.

The presence of the obturator vessels alongside the obturator nerve divisions within the obturator canal may increase the risk of injury to these structures, for example during anesthetic procedures.¹⁶ Detailed knowledge of regional anatomy is required when exploring new techniques. Thus the use and popularity of a new technique, tension-free vaginal tape, “has led to significant vascular and bowel injuries that may have been avoided with improved familiarity” with obturator region anatomy.³⁰

At the level of the obturator canal/foramen, a lesion (e.g., obturator hernia) of the posterior division of the obturator nerve could also entrap the obturator artery or its branches. Since the femoral head is supplied by an acetabular branch (artery to head of femur, in ligament) of the obturator artery,²⁶ avascular necrosis of the head of the femur could be a comorbidity of entrapment of the posterior division of the obturator nerve.

Extrapelvic course of the obturator nerve

The literature concerning the further course of the posterior division of the obturator nerve in relation to the obturator externus muscle is controversial; in most cases it focuses on the anterior division of the obturator nerve. Some anatomy atlases and studies illustrate the anterior and posterior divisions of the obturator nerve leaving the pelvis via the obturator canal, above the superior border of the obturator externus muscle, and descending anterior to it.^{6,31–33}

Others demonstrate the anterior division descending superficial to the obturator externus muscle, and the posterior division traversing the midpoint of the same muscle and running downward, behind the adductor brevis and in front of the adductor magnus muscles.^{2,24,25,26,28,32,34} Bardeen illustrates the superior fascicles of the obturator externus muscle separated from the main belly by the “deep branch” of the obturator nerve.²⁹ Harvey and Bell, investigating obturator neuropathy, provide a detailed description of the course and variation only for the anterior obturator division⁶. It was reported that in one lower limb the anterior division of the obturator nerve was accompanied by the posterior division of the same nerve through the superior portion of the obturator externus muscle. In four other lower limbs, the anterior and posterior divisions of the obturator nerve emerged into the thigh above

the obturator externus, and then the posterior division passed back through the substance of this muscle to reach its deep surface. It is also reported that on entering the medial compartment of the thigh, the posterior division descends posterior to the obturator externus muscle.²⁷

Given the importance of the relationship between the posterior division and the obturator externus muscle as one of the possible causes of posterior division neuropathy, we identified the following classes of variations: i) the posterior division of the obturator nerve passes over the musculotendinous aponeurotic arch, anterior to the obturator externus muscle (32 out of 56), ii) the posterior division of the obturator nerve emerges from the proximal quarter of the substance of the obturator externus muscle, perforates it and descends anterior to its distal part (22 cases out of 56), iii) the posterior division descends entirely posterior to the obturator externus muscle, emerging from its inferior border (2 cases out of 56).

Medial thigh course of the obturator nerve

In recent years, more and more studies have examined sonographic imaging of the obturator nerve's divisions in the proximal medial thigh region.^{18,19} In all cases, the anterior division was easily visualized by ultrasound. However, the posterior division of the obturator nerve exhibited lower visibility since the nerve was situated within the thick fascial plane.¹⁹ It was noted that the fascia overlying the short adductor muscle is separate from the intermuscular fascial septa which is not described in any anatomy textbooks as a distinct layer.²

It is reported that the posterior division in the proximal medial thigh pierces and supplies the obturator externus muscle. Then it passes anterior to the adductor magnus muscle, dividing into branches to adductor magnus and occasionally the adductor brevis. Its terminal articular branch, traversing the adductor hiatus, enters the popliteal fossa to supply the articular capsule, cruciate ligaments, and synovial membrane of the knee joint.^{2,24,25}

In our study, we described the passage of the posterior division of the obturator nerve in the medial thigh region within the distinct fascial layer overlying the obturator externus and the proximal part of the adductor magnus muscles. This suggests that during ultrasound-guided posterior division obturator nerve block, the local anesthetic should be injected into the intermuscular fascial plane of the proximal one third of the medial thigh region.

Muscular nerve branches of the posterior division of the obturator nerve perforate the fascial layer in order to supply the obturator externus, adductor brevis, and anterior part of the proximal adductor magnus muscles, and may be susceptible to entrapment at the points of perforation. This hypothesis is supported by several reports that anatomic relationships between the anterior division of the obturator nerve and its accompanying fascia appear sufficient to result in entrapment syndrome.^{1,2,35}

Obturator neuropathy is a form of focal nerve entrapment not only by the fascia but also by vascular structures.^{1,2,23} In our study, we have described the possible sites of entrapment of the posterior division by the branches of the obturator and medial circumflex femoral vessels as they cross the posterior division of the obturator nerve at the obturator foramen and anterior to the proximal part of the adductor magnus muscle.

Since the posterior division of the obturator nerve terminates within the fibrous capsule of the knee joint, pathologies from the hip (e.g., slipped capital femoral epiphysis) may refer pain to the knee³⁶. Clinicians should be aware of this unique relationship and include hip pathology on the differential diagnosis of the painful knee. The precise mechanisms and the sites of entrapment resulting in obturator neuropathy are unclear. Several studies have provided evidence of the problems related to the anatomic placement of this nerve. The nerve may be compressed within the true pelvis from pelvic fractures, by pelvic hematomas secondary to trauma, and by intrapelvic tumors.^{37,38} Local inflammatory or infectious processes in the adjacent pubic bones may spread laterally to involve the region of the obturator foramen causing "obturator tunnel syndrome".¹⁰

The entrance to the obturator foramen has been proposed as the site of obturator nerve entrapment where both divisions were damaged.³⁹ Clinical, electrophysiological, and surgical findings suggest that the entrapment may occur at the level of the obturator foramen and proximal thigh rather than in the obturator tunnel.² Other diagnostic possibilities include obturator hernias which have been associated with obturator nerve entrapment.^{7,13,38,40,40,41}

Conclusion

Considering the anatomical passage of the posterior division of the obturator nerve, and taking into consideration accompanying fascial and vascular structures, we

conclude that the course of the posterior division of the obturator nerve places it at risk of compression at the following sites:

- i) within the obturator canal, by the vascular bundle of the obturator vessels or for other reasons described in the literature (complications of gynecological or orthopaedic surgery, inflammatory changes in the adjacent pubic bone in osteitis pubis, obturator hernia);
- ii) in the fibromuscular canal formed by the anterior surface of the obturator membrane and the posterior surface of the obturator externus muscle;
- iii) in the muscular tunnel where the posterior division perforates the obturator externus muscle;
- iv) within the distinct fascial plane situated deep to the pectineus and adductor brevis muscles, and superficial to the obturator externus and the proximal one-third of the adductor magnus muscles.

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