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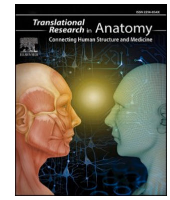

The anatomy of the obturator nerve and its branches in a South African cadaver sample

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ABSTRACT

Purpose: Several surgical and clinical procedures are performed in the area of the medial compartment of the thigh. This places the obturator nerve and its branches in potential danger of injury. This study aimed to provide a clear description of the anatomy and course of the obturator nerve and its branches. Methods: One hundred and one formalin-fixed cadavers were dissected just lateral to the lumbar vertebra to describe the origin and course of the obturator nerve, as well as its relation to other anatomical structures. The location of the obturator nerve within the obturator foramen was quantified by measuring the distance from three bony landmarks of the obturator foramen to the nerve. Findings: In 20% of cases the obturator nerve originated from L3 and L4 rather than L2 to L4 in the combined sample. The bifurcation of the nerve occurred intrapelvically in 2% of cases, within the obturator canal in 93% of cases and extrapelvically in 5% of the sample. Regarding the course in the abdomen, the L3 root joined the L4 root more distally after exiting the psoas major muscle. In all cases on the left ($n = 97$) and 99% on the right, the anterior branch innervated the muscles of the medial thigh, in one case on the right the anterior branch innervated the pectineus muscle. The posterior branch assisted the anterior branch in the innervation adductor brevis in 10% on the left and 11% on the right sides.

Conclusion: The results of this study may be used in the pre-operative preparation of surgeons that are to perform surgery in the area of the obturator foramen such as obturator nerve blocks for pain relief of adductor muscle contractions, prevention of adduction of the thigh during transurethral bladder surgery, additional analgesia after knee surgery, chronic hip pain, as well as postoperative analgesia after hamstring harvest for anterior cruciate ligament reconstruction.

1. Introduction

The obturator nerve originates from the ventral rami (anterior divisions) of the second (L2), third (L3) and fourth (L4) lumbar spinal nerves. In other words, the nerve is a mixture of the anterior branches of the spinal nerves that join to form the peripheral obturator nerve These rami fuse within the psoas major muscle, to then descend and emerge on its medial border; running on the linea terminalis.

The nerve then enters the true pelvis at the level of the sacroiliac joint, where it is accompanied by the obturator artery and vein to the obturator foramen. The neurovascular bundle passes through the obturator foramen via the obturator canal; located at the most superolateral point of the foramen bordered superiorly by the superior pubic ramus and inferiorly by the obturator membrane and the obturator externus muscle.

Once through the obturator canal, the obturator nerve bifurcates into an anterior and posterior branch, as well as a branch to the obturator externus muscle. These branches innervate the muscles of the medial compartment of the thigh and give sensory innervation to the medial thigh and the knee joint. The anterior and posterior branches are separated by the obturator externus muscle as the obturator nerve enters into the medial compartment of the thigh [1–6]. The bifurcation of the nerve has been reported to be variable in its location and have been described to either be intrapelvic, in the canal or extrapelvic (in the medial thigh)

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[6–8].

The anterior division provides sensory innervation to the distal two-thirds of the skin over the medial thigh and motor innervation to the adductor muscles. Along its course, it is commonly described to innervate the adductor longus, adductor brevis and gracilis muscles [2,4,7,9]. Variations of the motor innervation of the anterior branch have been reported, where the nerve may in addition innervate the pectineus and obturator externus muscles [2,7,10].

The posterior branch runs between the adductor brevis muscle posteriorly and the adductor magnus muscle anteriorly, commonly described giving sensory innervation to the knee joint and motor innervation to the adductor part of the adductor magnus muscle only. The nerve has been reported to assist the anterior branch in giving double innervation to the adductor brevis muscle and in some cases innervating the muscle in the absence of the anterior branch [2,6,7,9,11–13].

An accessory obturator nerve exists, arising from the ventral rami of L3-L4. This nerve is not commonly found and has been reported in 13–40% of people [2,10,14,15].

Complications related to damage to the obturator nerve and its branches intra-operatively and post-operatively have previously been reported in the literature [2,16–19].

With regard to regional anaesthesia of the obturator nerve and its branches, failed blocks or even nerve damage have been reported when an obturator nerve block for knee and hip surgery is incorrectly performed [20–22].

The obturator nerve and its branches have been reported to be variable in their branching patterns and innervation [7,8,23–25]. An extensive review of the available literature indicates that, apart from general anatomical descriptions, few studies have been published to provide a detailed description of the exact position, course, branching pattern or possible anatomical variations of the obturator nerve. Furthermore, a thorough description of the position of the obturator nerve within the obturator foramen is lacking. This is especially true for the South African population.

The aim of this study was to give detailed qualitative and quantitative descriptions of the anatomy (origin, course, branching patterns and variations) of the obturator nerve in a Southern African cadaver population.

2. Materials and methods

A total of 101, formalin-fixed, cadavers were used in the study. The sample comprised of 61 males and 40 females (68 $\pm$ 17 years). The cadavers were obtained from the Department of Anatomy, School of Medicine, Faculty of Health Sciences, ***Blinded for review***. The dissection of these cadavers falls under the auspices of the South African National Health Act 61 of 2003. Bilateral dissections were made to the posterior abdominal wall, pelvic cavity and upper medial thigh of each cadaver.

Cadavers were excluded if there was any evidence of previous surgery, pathology or if previous dissection had damaged the psoas major and the related nerves along the lumbar vertebra. The same applies to the area of the obturator foramen and the muscles thereof. There was no exclusion with regard to age, race or sex.

2.1. Abdominal dissection

As a result of the exclusion criteria, the sample size was reduced to 181 sides (90 left and 91 right sides) for dissection along the lumbar vertebra. The cadaver sample consisted of 55 males and 36 females. The investigation involved the observation of the anatomy of the obturator nerve from its origin at the lumbar vertebra, its course through the abdominal and pelvic cavities, until its termination in the medial compartment of the thigh.

The lumbar vertebrae were identified and pins were placed into their respective intervertebral discs to indicate the root values. To reveal the nerve rami, the fibres of the psoas major muscle were carefully reflected from their origins on the vertebral column using forceps. The rami were isolated using blunt dissection to ensure that they were not damaged (Fig. 1).

The rami were pinned and any variations found were noted and photographed. The relations of the rami to those of other nerves were also recorded (Fig. 2). Thereafter, the course of the obturator nerve, after its rami fused, was observed. All relations to muscles, vessels and other nerves were noted as it descended towards the true pelvis and travelled to conclude its course in the obturator canal.

The course of the nerve was then followed into the lower limb, as the obturator nerve exited the obturator canal. The obturator nerve was firstly observed as it terminated into its anterior and posterior branches, noting whether it terminated within the pelvis (intrapelvic), the obturator canal (within canal) or the thigh (extrapelvic). Within the canal was defined as a point between the obturator canal and the anterior surface of the obturator externus muscle. This defined a nerve to have bifurcated within the canal if the anterior and posterior branches originated before they emerged from the obturator externus muscle; where the posterior branch pierces the muscles. In turn, extrapelvic bifurcation would be when the anterior and posterior branches originated after the obturator externus muscle, emerging on its superior border, to then innervate the muscles of the medial thigh.

Thereafter, the course of each terminal branch to their respective areas of muscle innervation were observed. Finally, the position of the terminal branches, in relation to adductor muscles, and their course to innervate these muscles were observed and accurately described. Any variations observed were also noted.

Statistical analysis was performed by a statistician of the ***Blinded for review***. A Chi-Square test was performed against sex to determine significance of the different root values. For cells with an expected count of less than 5, a two-tailed Fisher's exact test was performed. For the bifurcation patterns of the obturator nerve at the obturator foramen, a contingency table was made to determine frequencies. Similarly, a contingency table was also made for the innervation patterns of the anterior and posterior branches of the obturator nerve in the medial compartment of the thigh.

2.2. Medial thigh dissection

Dissections were done in the medial thigh to location of the obturator nerve within the obturator foramen. Measurements were made using a mechanical dial sliding calliper (Vogel Germany) with an accuracy of 0.01 mm and only after all observations of the obturator nerve and its branches within the abdomen, pelvis and the medial compartment of the thigh were completed. The exclusion of cadavers or one side of a cadaver reduced the sample size to 186 sides; 95 left and 91 right sides. These sides were from a sample of 99 cadavers; 60 males and 39 females.

To determine the location of the obturator nerve (B) within the obturator foramen, three specific bony landmarks of the obturator foramen were used. These were the most superior (A), most medial (C) and most inferior points (D) of the obturator foramen (Fig. 3).

Prior to the commencement of dissection, the cadavers were placed in a supine position, with the hips abducted. To expose the designated landmarks, the adductor muscles of the medial thigh and surrounding muscles were reflected or removed, as necessary. The most superior point of the obturator foramen was exposed by carefully reflecting the pectineus muscle laterally from the pectineal line and the adductor longus muscle inferiorly from the superior pubic ramus.

Once landmark A was exposed, a measurement was taken between the latter and the obturator nerve (landmark B). To expose landmark C and D of the foramen, parts of the adductor brevis and adductor magnus muscles were removed from their origins. Some fibres of the muscles remained to allow stability of the obturator nerve and accurate measurements to the nerve. A part of the adductor brevis muscle was removed from the body and inferior ramus of the pubis and a part of the

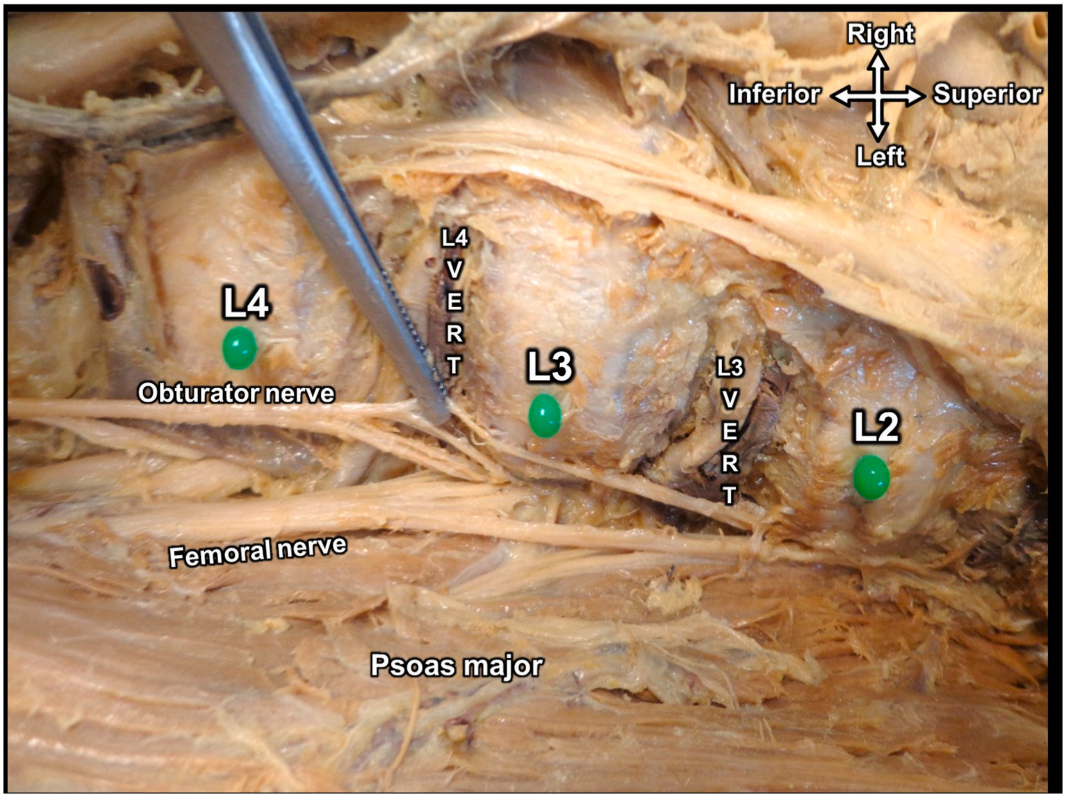

Fig. 1. Pinning of the intervertebral discs on the left *(Vert – Vertebra) [Please print in color]*.

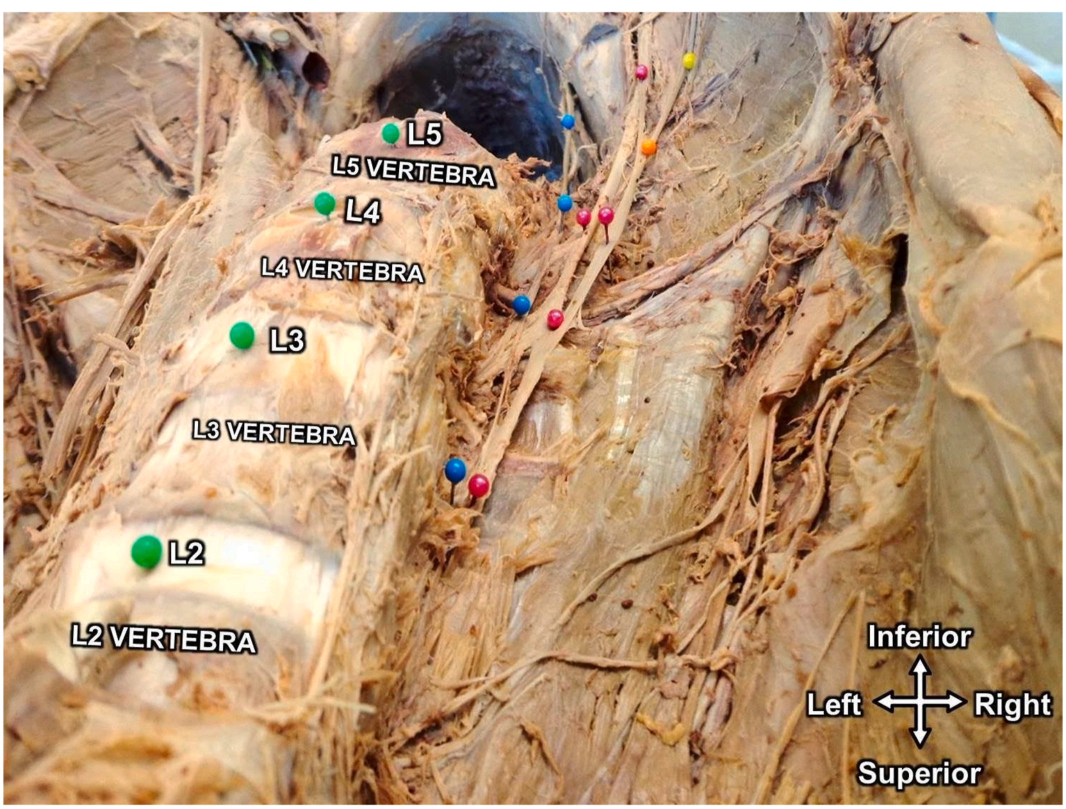

Fig. 2. Pinned intervertebral discs (green) and nerve rami of the obturator nerve (blue), femoral nerve (pink) and femoral cutaneous nerve (orange and yellow) *[Please print in color]*.

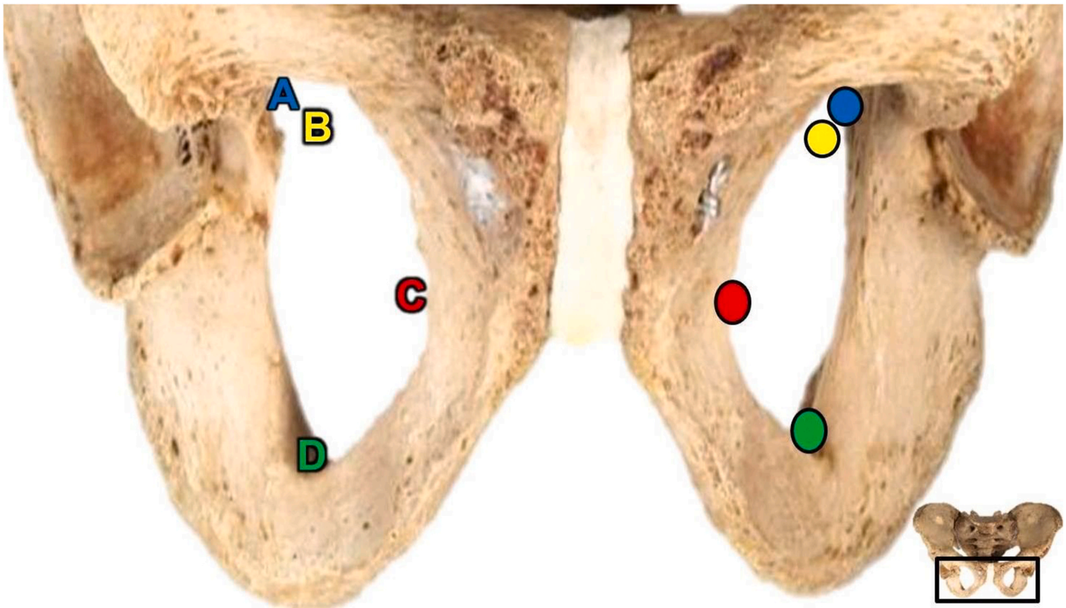

Fig. 3. Landmarks used to locate the obturator nerve within the obturator foramen. Each point is indicated by a similarly colored letter (right) and circle (left) where A is the most superior point of the obturator foramen, B is the obturator nerve, C is the most medial point of the obturator foramen and D is the most inferior point of the obturator foramen. *[Please print in color].*

adductor magnus muscle from the ischiopubic ramus. Lastly, the obturator externus muscle was reflected along the margins of the obturator foramen. The sliding calliper was pressed against landmarks C and D and measurements to landmark B were made from each point.

To evaluate the location of B within the obturator foramen, a two-tailed *t*-test was done. The measurements of the left and right sides of A-B, B–C and B-D were compared to test for any significant difference between them ($p < 0.05$). Thereafter, individual Generalised Linear Models (GLM) were performed on the measurements using sex as a defining factor to test if sex has an influence on the measurement.

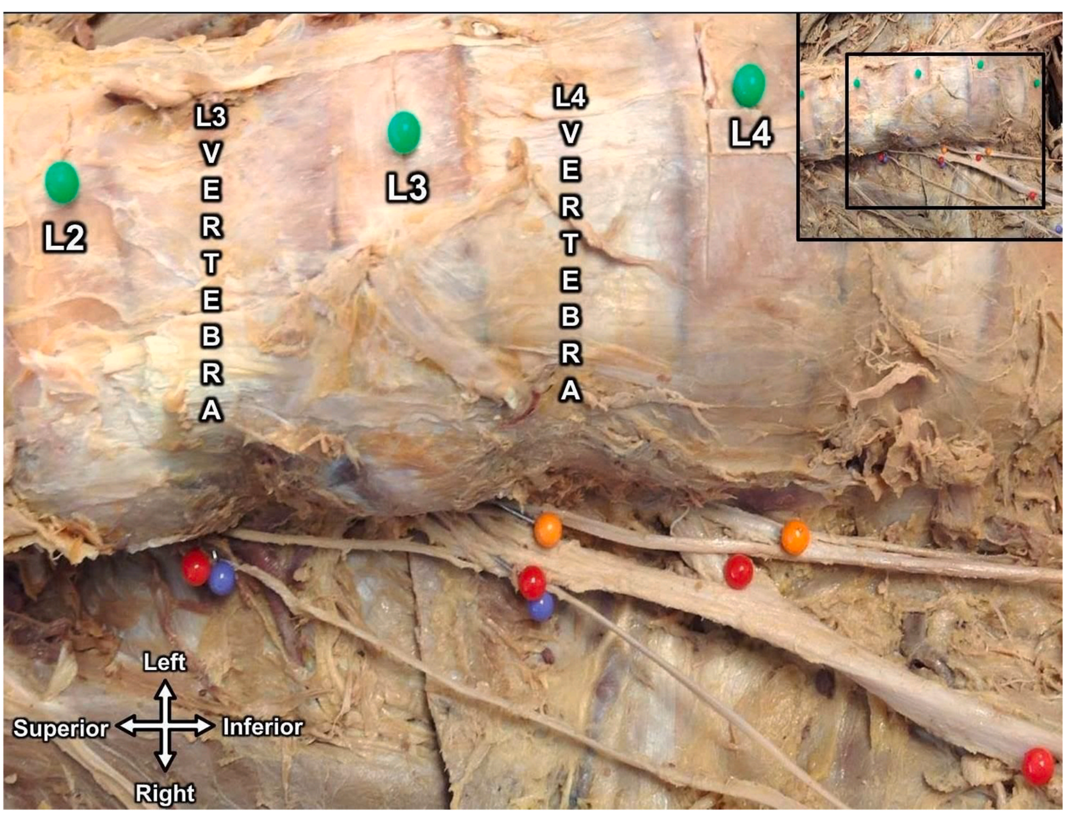

Fig. 4. Nerve roots of the nerves of the lumbar plexus from L2-L4, with an absent obturator nerve L2 contribution.
Green – Intervertebral discs. Orange – Obturator nerve roots. Red – Femoral nerve roots. Blue – Lateral femoral cutaneous nerve roots [Please print in color].

3. Results

3.1. Root values of the obturator nerve

The obturator nerve originates from the L2, L3 and L4 spinal nerves. Variations of this norm are known to be present, as seen in Fig. 4, where the L2 root is absent.

A total of 90 left sides were investigated. A Chi-square test revealed that no significant difference ($p = 0.49$) between sex and root values of the obturator. Overall, 82% ($n = 74$) of the obturator nerves observed originated from the L2-L4 nerve roots and 18% ($n = 16$) originated from only the L3 and L4 nerve roots.

Similar investigations were performed on the nerve root on the right ($n = 91$). A Chi-square test determined that sex had no statistically significant influence on the root value of the right obturator nerve ($p = 0.96$). The results show that 78% ($n = 71$) of the cases had the obturator nerve originated from the L2-L4 spinal nerve roots, while 22% ($n = 20$) originated from L3 and L4.

This allowed the sample to be combined into a sample of 181 sides. In the new combined sample, the nerve was observed to originate from L2-L4 in 80% ($n = 145$) of the cases and from L3 and L4 in 20% ($n = 36$) of the cases.

3.2. Course through the abdomen

The roots of the obturator nerve generally fused within the fibres of the psoas major muscle. Some instances were recorded where one of the roots only joined the others more distally, after exiting the medial border of the psoas major muscle. This is evident in Fig. 5, where the L3 nerve root joins the L4 root within the true pelvis. Similar fusions were seen in 2 other cases [$n = 3$ of 181 cases (1.7%)].

3.3. Bifurcation of the obturator nerve

The frequencies of the left and right bifurcation patterns were investigated in an overall sample size of 101 on the left and 100 on the right. Intrapelvic bifurcation occurred only in 3% ($n = 3$) on the left and 1% ($n = 1$) on the right. Bifurcation was observed mostly within the obturator canal, in 92% ($n = 93$) of the cases on the left and in 94% ($n = 94$) on the right. Extrapelvic bifurcation occurred in 5% of the cases on both the left and right ($n = 5$).

No significant difference was found between left and right sides in terms of sex ($p > 0.05$). The lack of significance allowed the left and right sides to be pooled into one sample size of 201 specimens. In the new sample, intrapelvic bifurcation of the nerve was observed in 2% ($n = 4$) of the cases. Bifurcation within the obturator canal was observed in 93% ($n = 187$) of the sample and extrapelvic bifurcation was observed in 5% ($n = 10$) of the sample.

3.4. Muscle innervation in the medial thigh

In all cases on the left ($n = 97$) and 99% on the right ($n = 98$), the anterior branch innervated the muscles of the medial thigh as commonly described. There was one case on the right, where the anterior branch innervated the pectineus muscle. The posterior branch of the obturator nerve innervated the adductor as commonly described in 90% ($n = 87$) on the left of the total cases ($n = 97$) and in 89% ($n = 87$) of the cases on the right ($n = 98$). The posterior branch was also observed to assist the anterior branch in the innervation adductor brevis. This was the case in 10% ($n = 10$) on the left and 11% ($n = 11$) on the right sides.

3.5. Location of the obturator nerve within the obturator foramen

To quantify the location of the obturator nerve within the obturator foramen, a two-tailed *t*-test was performed to test for significant

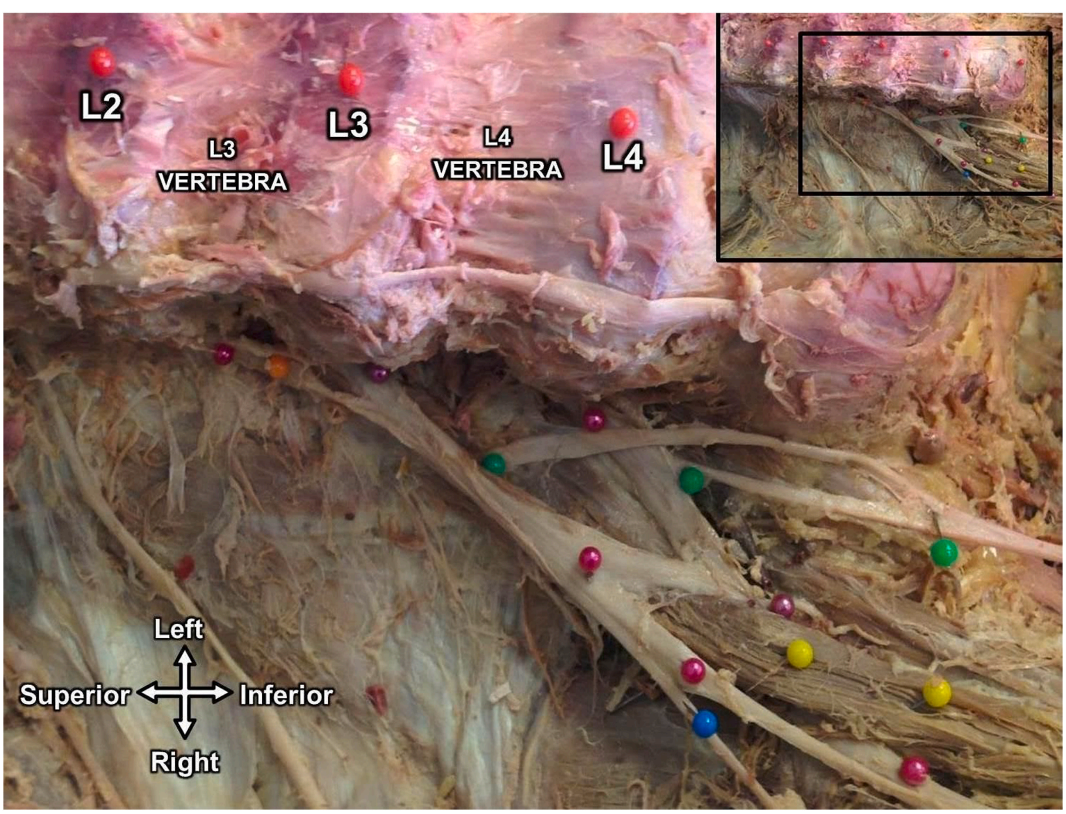

Fig. 5. The low fusion of L3 to L4 obturator nerve (green) roots also demonstrating the lack of the L2 nerve root. Pink – Femoral nerve. Blue – Lateral femoral cutaneous nerve. Orange (with arrow) – Genitofemoral nerve. Yellow – Remaining fibres of psoas major. [Please print in color].

differences between the left (n = 95) and right (n = 91) measurements. Pooled (equal variance) and Satterthwaite (unequal variance) methods were performed on the A-B measurements to analyse the probability of having either equal or unequal variance between the samples. Both the methods resulted in a p-value of 0.19, showing no significant difference between the measurements, regardless of variance. A test of equality of variance confirmed that the samples have equal variance, resulting in a p-value that is equal to 0.19.

Similar statistics were performed on the B–C measurements. A check for the variance of the sample had a p-value of 0.95 for the Pooled and Satterthwaite methods. The test of equality revealed that the sample had equal variance, with a p-value of 0.34. This indicated equal variance of the sample.

For the B-D measurements, a p-value of 0.26 was observed for both the Pooled and Satterthwaite methods. A p-value of 0.71 was seen for the test of the equality of variances for the measurements. Equal variance of the sample could then be assumed.

GLMs were made for each of the averages of the measurements of the obturator foramen landmarks to the nerve. These models were used to test whether sex had a significant influence on the measurements within the obturator foramen. A p-value of 0.34 for the influence of sex indicated that there was no significant difference with regard to the distance between the most superior point of the foramen (landmark A) and the obturator nerve (landmark B) within the obturator canal. The mean value (mean $\pm$ SD) of the A-B length averages was found to be 6.25 $\pm$ 1.76 mm.

GLM was also performed for the B–C measurement. The mean value for the B–C lengths was 31.77 $\pm$ 3.74 mm. No significant difference was found for the influence of sex on the distance between the obturator nerve (B) and the most medial point of the obturator foramen (landmark C) (p = 0.61).

The final measurement completed the overall location of the obturator nerve in the obturator foramen. The B-D measurements had a mean value of 47.48 $\pm$ 4.19 mm. There was however a significant difference found for the influence of sex on the distance of the obturator nerve (B) to the most inferior point of the obturator foramen (landmark D) ($p < 0.001$).

The observed mean values for the measurement B-D in the male and female samples are 48.85 $\pm$ 3.55 mm and 44.99 $\pm$ 3.42 mm respectively. It is important to note that the male sample mean value is larger than the female sample.

4. Discussion

Knowledge of the anatomy of the obturator nerve and its branches is important in the successful performance of clinical and surgical procedures. The results indicate that there are variations with regard to the origin, course and branching pattern of the obturator nerve. The aim of this study was to provide a clear and concise observational and quantitative analysis of these variations, which will assist in decreasing complications involving the obturator nerve in procedures performed on or around the area of the obturator nerve and its branches.

The lack of significance of sex on nerve root values of the obturator nerve implies that procedural techniques performed on the obturator nerve or structures within its surrounding area at the lumbar vertebra may be applied to both males and females.

Variations were found with regard to the absence or presence of the L2 spinal root in the formation of the obturator nerve. This is contrary to a study by Anloague et al. [26], where no variations were found in the origin of the obturator nerve at the lumbar vertebrae. In a study of 60 lumbar plexuses by Arora et al. [25], the obturator nerve originated from L2-L4 in only a third of the sample. Horwitz [23] found similar results in a sample of 228 lumbar plexuses, where it was observed that the obturator nerve mostly arose from L3 and L4, with a small percentage originating from the L2 to L4 and the twelfth thoracic lumbar nerve root (T12) to the L5 root values. An Ethiopian study found that 88.1% arises from L2, L3 and L4 and; 11.9% from L3 and L4 spinal nerves [8]. This was not observed in the present study.

The accessory obturator nerve is not commonly found in the lumbar plexus [11,26,27]. Similar to a study by Tubbs et al. [11] where no instance of an accessory nerve was found, the current study did not observe the presence of an accessory obturator nerve in the 181 sides. Several studies that have examined the presence of an accessory obturator nerve are summarised in Table 1.

4.1. Nerve roots and the psoas major muscle

The roots of the obturator nerve have been documented to fuse within the psoas major muscle, descending within the muscle and emerging on its medial border at the level of the linea terminalis [2,7,24,28]. This description of the course of the roots of the obturator nerve was observed in this study, with the roots traversing the length of the psoas major muscle until it entered the true pelvis. It entered the true pelvis posterior to the convergence of the internal and external iliac veins, at the level of the sacroiliac joint.

4.2. Obturator neurovascular bundle

Within the true pelvis, the obturator nerve lies against the lateral pelvic wall, accompanied by the obturator vessels. The neurovascular bundle runs together, from superior to inferior, as the obturator nerve, obturator artery and then the obturator vein. As they accompany each other, the neurovascular bundle enters the obturator canal of the obturator foramen. This correlates with findings by Won et al. [29]. After entering the medial compartment of the thigh, the orientation of the neurovascular bundle changes to; from medial to lateral; the obturator vein, obturator artery and then the obturator nerve. This was observed in a study by Kendir et al. [30], where 22 cadaver sides were investigated.

Knowledge of these relationships will allow for the prevention of complications such as haemorrhaging of the obturator artery during surgery [31,32]. In a study of pelvic neuropathies by Cardosi et al. [33] of 23 patients that had undergone pelvic surgery, the incidence of obturator nerve damage was 39% (n = 9). Knowledge of the relationship of the obturator nerve to other structures within the pelvis could allow the incidence rates of complications to decrease.

4.3. Bifurcation (termination) of the obturator nerve

The obturator nerve terminates into the anterior and posterior branches of the obturator nerve around the area of the obturator canal. This bifurcation of the nerve is known to vary in its location in relation to the obturator canal. In a study by Anagnostopoulou et al. [7], the authors investigated this phenomenon in 168 sides (84 cadavers). Berhanu et al. [8] found the bifurcation levels of the obturator nerve to be 23.9%, 44.8% and 31.3% to be intrapelvic, within the obturator canal and extrapelvic, respectively.

No additional literature investigating the bifurcation patterns of the obturator nerve could be found. This lack of information echoes the previous statements on the need for further research of the anatomy of the obturator nerve. The results between the two studies are very different. This might be as a result of the difference in the definition of each location of bifurcation of the obturator nerve into its anterior and

Table 1
Prevalence of the accessory obturator nerve.

Study	Country	n	Prevalence (%)
Tubbs et al. [11]	USA	22	0
Akkaya et al. [27]	Turkey	24	12.5
Anloague and Huijbregts [26]	USA	38	8.8
Current study	South Africa	181	0

posterior branches, specifically in the definition of extrapelvic and "within canal" bifurcation. Anagnostopoulou et al. [7] defined extrapelvic bifurcation as a point after the obturator canal and then define "within canal" bifurcation as located within the obturator canal. The within canal definition was difficult to adhere to, as it gave little room for clear visualisation, as the obturator membrane that forms the obturator canal is a thin fibrous layer. The current study defined the locations differently, by using the obturator externus muscle as the boundary between "within canal" and extrapelvic. The definition allows consistency in the allocation of bifurcation location; as the obturator externus muscle is always present in the area.

4.4. Anterior branch of the obturator nerve

The anterior branch has both motor and sensory fibres. It appears deep to the pectineus muscle to continue between the adductor longus and brevis muscles, innervating them. The nerve also innervates the gracilis muscle, medially, to provide sensory innervation to the medial aspect of the thigh. This description was observed in this study. These observations have been documented by other researchers as well [7,34].

4.5. Posterior branch of the obturator nerve

The posterior branch of the obturator nerve emerges through the obturator externus muscle to enter the medial compartment of the thigh, innervating the muscle [2,6]. There was variation with regard to the appearance of the posterior branch in relation to the obturator externus muscle. The nerve either pierced or appeared on the supero-lateral surface of the muscle.

After branching from the obturator nerve, the posterior branch ran between the adductor brevis and adductor magnus muscles, only innervating the latter. This was observed in the current study. It was also observed that the posterior branch assisted the anterior branch in the innervation of the adductor brevis muscle in 11% ($n = 21$) of the sample ($n = 195$). This variation was observed at a higher frequency in a study by Anagnostopoulou et al. [7], where the double innervation of the adductor brevis muscle was seen in 70% of the sample ($n = 168$).

The anatomy and variations are important to note, as blocking of the posterior branch of the obturator nerve, with a local anaesthetic solution, has been reported to assist in post-operative analgesia of patients that have undergone knee and hip surgery; in combination with other blocks [35,36].

4.6. Location of the obturator nerve within the obturator foramen

Three bony landmarks of the obturator foramen were identified as possible points that may be used to locate the obturator nerve during surgery. To the best of our knowledge, no published literature was found where these landmarks were used to locate the obturator nerve within the obturator foramen.

The present study found that these bony landmarks are viable to use during surgical procedures where a pathway through the obturator foramen is required. The most medial and most inferior points of the obturator foramen are palpable during stress urinary incontinence (SUI) surgeries. Although the most superior point may not be used in procedures, it was important to use this landmark in order to provide a complete description of the obturator nerve within the obturator foramen. If used concurrently with the quantified location of the obturator nerve within the obturator foramen reported in this study, these landmarks may aid in pre-operative planning, as well as the success of intra- and post-operative procedures or care.

The ability to palpate these landmarks intra-operatively will assist surgeons to safely guide their instruments through the foramen without damaging the obturator nerve and its branches. This is opposed to the use of the midpoint of the ischiopubic pubic ramus used during trans-obturator tape (TOT) and inside-out tension-free vaginal transobturator tape (TVT-O) procedures for the treatment of SUI in males and females. Studies suggest that this landmark will guide surgeons in inserting the needles closer to the ischiopubic ramus within the obturator foramen [37,38]. Use of the midpoint of the ischiopubic ramus is subjective, as this point is dependent on the surgeon performing the procedure.

This study aimed to provide a clear location of the obturator nerve within the area using the selected landmarks, to assist in the possibility of using them as landmarks in clinical and surgical procedures. Knowledge of the location of the obturator nerve within the obturator foramen may assist in the safe performance of surgical procedures performed in the area; such as in the treatment of SUI in males and females [39–42].

Moore et al. [5] describes the obturator foramen to be different in shape between males and females. In this anatomical textbook, the shape of the obturator foramen is described as round in males and oval in females. Not much research has been done on the shape of the obturator foramen. In a study by Ridgeway et al. [43], the shape of the obturator foramen between American women of African and European ancestries were investigated. The authors reported that there was a difference in the shape of the obturator foramen between the two population groups. The study suggested that the differences were as a result of differences in stature and not race.

In a study by Bierry et al. [44], the authors investigated the difference in the shape of the obturator foramen between 52 males and 52 females using three-dimensional computed tomography The obturator foramen was described to be oval in males and triangular in females, concluding that there is sexual dimorphism in the shape of the foramen.

The results of the current study yielded a significant difference on the influence of sex for the B-D measurement only ($p < 0.001$), the distance between the obturator nerve and the most inferior point of the obturator nerve. The authors suggest that this may be as a result of sexual dimorphism as a result of the differences found on the shape of the obturator foramen. This finding supports the use of different instruments in procedures for the treatment of SUI between males and females.

5. Conclusion

This study served to assist in the clear description of the obturator nerve from its origin at the lumbar vertebra, its course in the abdomen and pelvis, until its termination in the medial compartment of the thigh. The results show that there are noteworthy variations with regard to the course of the obturator nerve. These include the prevalence of variation of the root values of the obturator nerve in the lumbar area and the bifurcation of the obturator nerve into its terminal branches at the level of the obturator foramen. Additionally, the variations of the innervation of the anterior and posterior branches of the obturator nerve in the medial compartment of the thigh. These variations have not been widely studied, especially in a South African context.

The results reported in this study on the anatomy of the obturator nerve and its branches will help guide clinicians during pre-operative preparation and decrease the possibility of intra-operative complications. Clinicians should familiarise themselves with the prevalence of variations of the innervation patterns of the anterior and posterior branches to rule out the possibility of obturator nerve damage. Accurate knowledge of the anatomy and any possible variations that may occur is imperative for clinicians and surgeons performing procedures in the area.

To avoid damage to the obturator nerve in procedures that pass through the obturator foramen, the most medial and most inferior points of the obturator foramen are the safest points to use. These are the furthest points from the nerve. Using the area between the most medial and most inferior points is most ideal.

The described course of the obturator nerve and its branches in this study may be used in the teaching of the anatomy of the obturator nerve in medical schools.

The results should be verified in a clinical setting to validate their practical use, possibly allowing refinement of procedural guidelines for a South African population.

6. Limitations of the study

The study needs to be replicated in a clinical setting where procedures such as TOT and TVT-O are performed, as well as surgeries where obturator nerve blocks are indicated. The location of the obturator nerve and its branches should be repeated using sonographic imaging of live individuals, nor could the methods used in the present study be replicated in fresh cadaver tissue. Another limitation is that the study sample was not equally disturbed among the sexes.

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Ethical statement

The cadavers were obtained from the Department of Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, South Africa. The dissection of these cadavers falls under the auspices of the South African National Health Act 61 of 2003.

CRediT authorship contribution statement

Zithulele N. Tshabalala: was responsible for the, Visualization, of the data, Data curation, was responsible for data curation, Formal analysis, Investigation, were responsible for investigation of the study, Methodology, designed the methodology of the project, were responsible for, Project administration, The cadavers used in the study were resourced from the University of Pretoria, were responsible for resources such as citation and referencing of articles used in the study, Formal analysis, were responsible for conducting statistical software analyses, wrote the first draft of the manuscript. **René Human-Baron:** was responsible for editing and submission of the final draft, She is also the corresponding author, were co-supervisors of the project, Conceptualization, the study, Investigation, were responsible for investigation of the study, Methodology, designed the methodology of the project, were responsible for resources such as citation and referencing of articles used in the study. **Soné van der Walt:** were co-supervisors of the project, Investigation, were responsible for investigation of the study, Methodology, designed the methodology of the project. **Elizabeth M. Louw:** Formal analysis, were responsible for conducting statistical software analyses, Formal analysis, and. **Albert-Neels van Schoor:** Conceptualization, the study, Formal analysis, was responsible for, Funding acquisition, Investigation, were responsible for investigation of the study, Methodology, designed the methodology of the project, were responsible for, Project administration, The cadavers used in the study were resourced from the University of Pretoria, Formal analysis, were responsible for conducting statistical software analyses, was the main supervisor.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

The authors would like to declare that one of the co-authors, Prof A-N van Schoor is a member of the editorial board of the Journal of Translational Research in Anatomy. Given their role as Editorial Board Member/Associate Editor/Editor-in-chief, had no involvement in the peer-review of this article and has no access to information regarding its peer-review.

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