Narrative Review
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Obturator Nerve Variations: A Narrative Review*

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Abstract
The aim is to understand the clinical significance of these variations in surgeries and diseases. To conduct this review, we used the PubMed database, considering factors such as the availability of full texts, the language and relevance to the topic, in order to acquire comprehensive and detailed findings. After applying our exclusion criteria, we narrowed the findings down to 11 useful results. Throughout our study, we observed significant variations concerning the obturator nerve. The nerve displays diverse paths and trajectories, leading to deviations from the commonly accepted anatomical description. Additionally, we identified variations in the division point of the obturator nerve and the resulting innervation patterns that it provides for muscles, joints, and skin. More precisely, we discovered differences regarding the path, the source and the level of composition. Moreover, the muscles innervated by the obturator nerve's anterior branch and posterior branch may vary. Furthermore, variations were observed in the innervation of both the skin and joints. **Conclusion.** Our research demonstrates that the obturator nerve is susceptible to many forms of variations. Accurate knowledge of these variations is crucial for minimizing iatrogenic complications and ensuring patient care.

Key Words: Lumbar Plexus Variations ▪ Peripheral Nerve Variations ▪ Lower Limb Innervation.

Introduction

The obturator nerve (ON) originates from the lumbar plexus located in the lower limb. It originates from the anterior division of the L2, L3, and L4 spinal nerves, and runs medially to the major psoas muscle (1-4). Eventually, the ON reaches the obturator canal, where it typically splits into an anterior and a posterior branch. The anterior branch travels behind the pectineus and adductor longus muscles, and in front of the adductor brevis muscle (1, 2). As well as providing sensation to the skin of the medial thigh and innervation to the hip joint, the obturator nerve also innervates several muscles, including the adductor longus, the gracilis the adductor magnus, and occasionally the adductor brevis and the pectineus muscle (1-3). Nevertheless, numerous variations of this nerve have been observed by the scientific community. This review aims to provide a structured summary and full description of the reported variations of the obturator nerve (ON) documented in the international literature. Our research highlights the considerable variability in the branching pattern of the ON.

In conclusion, our primary objective is to present a comprehensive understanding of the variations of the ON based on previous research and case reports.

Materials and Methods

The literature search was conducted using the PubMed database to identify original articles, case reports, and anatomical reviews related to variations of the obturator nerve. For this purpose, we

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conducted a search by using the terms "obturator nerve AND variations" in October 2023. To ensure consistency, we only considered articles written in English. Furthermore, we excluded articles whose full-text versions could not be located, and articles that did not demonstrate any obturator nerve variations. Articles were selected on the basis of their relevance to the topic, and we did not apply any publication date restrictions, as historical references might provide essential insights (5). It is important to note that we purposely avoided using other databases in order to reduce systematic errors.

We specifically selected PubMed because all the articles are peer-reviewed. A total of 57 articles were initially identified through the database search. After eliminating one duplicate, 56 articles were screened. The articles were pursued for retrieval, however, two were not accessible. The remaining 54 articles were assessed for eligibility on the basis of specific inclusion criteria related to anatomical variations of the obturator nerve (5). Among these, 43 articles were excluded: 38 were unrelated to the topic (since they did not supply any details regarding the obturator nerve or its variations), three were in a foreign language, and two did not present any relevant anatomical variations. Ultimately, 11 studies fulfilled the criteria and were included in this narrative review (Figure 1). These studies provided valuable data on the anatomical variations of the obturator nerve, contributing to the understanding of its clinical significance.

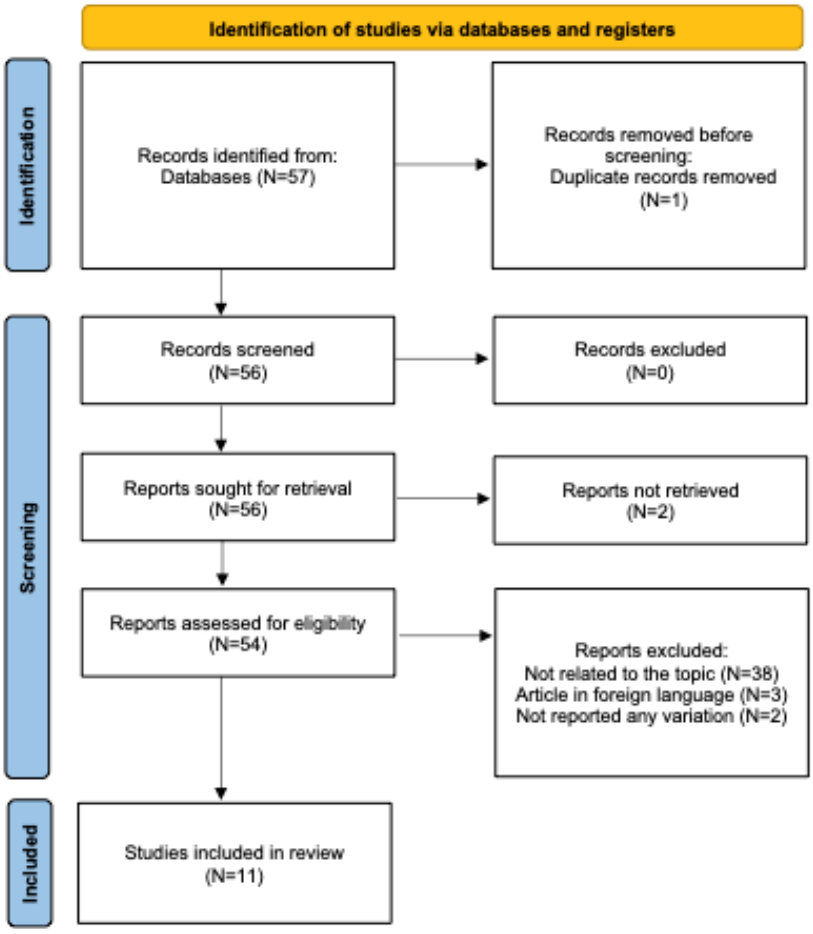

Figure 1. Flowchart describing the narrative review selection progress.

Results

The literature reviewed highlights significant anatomical variations in the obturator nerve (ON). These variations are categorized into four primary aspects: origination and morphology, division point, muscular innervation, and articular and sensory contributions.

The obturator nerve typically originates from the anterior divisions of the L2, L3, and L4 spinal nerves in most cases (4, 6). However, rare variations were identified, including origins from L3-L4, L3-L5, and in exceptionally rare cases, L1-L3 (4, 6-8). The level of emergence of the ON also displayed variability, with the majority occurring at the L5-S1 vertebral level (4). Other reported levels include S1, L5, S2 and L4-L5 (4).

In some cases, the ON travels through the obturator muscle, modifying its fibrous texture, while in other cases it is positioned either anteriorly or posteriorly in relation to the muscle (9). Moreover, the obturator nerve diverges into

anterior and posterior branches, with the branching point showing variability. This may occur as follows: inside the pelvis, prior to the obturator foramen (observed in 2%-22% of cases); within the obturator canal (noted in 23%-93% across various studies); outside the obturator canal, in the medial thigh (exemplified in 5%-64% of cases) (1, 2, 9). The division point's proximity to the superior pubic ramus, approximately ±20 mm, has clinical implications for the success of anesthesia injections administered near the obturator canal (1). Furthermore, variations concerning muscular innervation patterns of the obturator nerve are also reported.

The anterior branch primarily innervates the adductor longus, adductor brevis, and gracilis muscles. In most cases, this is the observed pattern, however, a two-branch pattern involving the adductor longus and gracilis muscles is also noted occasionally. A less common variation includes a four-branch pattern that innervates the adductor longus, adductor brevis, gracilis, and pectineus muscles (2).

Concurrent innervation of the adductor brevis by both anterior and posterior branches was also observed. The posterior branch innervates the adductor magnus and external obturator muscles. Its branching patterns varied between one, two, three or four branches (2). Rare cases reported supernumerary branches innervating anomalous muscles between the adductor brevis and adductor minimus or supplying the iliacus muscle (6, 8).

The obturator nerve's contribution to articular branches for the hip joint also displayed variability: in 61.28% of cases, a single articular branch was observed, typically originating from the common ON (61.98%), the anterior branch (19.23%), or the posterior branch (3.84%) (2). Two articular branches were observed in 20.32% of cases, with variations in their origin, while three branches were identified in 17.85% (2).

Differences in the number of articular branches (ranging from 1 to 7) and their patterns of distribution were identified, with significant implications for clinical application (2). Sensory variations included rare connections between the ON and the ilioinguinal nerve, with branches supplying the anterior scrotal skin in certain cases (3, 10). This detailed review underscores the considerable anatomical variability of the obturator nerve, emphasizing its clinical implications in surgeries and anesthetic interventions.

Discussion

Accurate documentation of anatomical variations, particularly concerning the obturator nerve, is crucial. These variations hold substantial significance in clinical practice, especially regarding surgical and anesthetic interventions. Henry et al. (2024) emphasize that systematic reviews present a systematic method for aggregating data from various studies, which guarantees the availability of high-quality evidence for clinical guidance (11). By adhering to the stringent methodologies indicated for systematic reviews, this narrative review expands on prior research to offer an in-depth insight into the variations of the obturator nerve and their importance in clinical contexts.

For educational purposes and in order to facilitate understanding, the variations will be presented as alterations relevant to the origin and morphology of the ON, variations relevant to the division point of the ON, variations relevant to muscle innervation by the obturator nerve, and finally, as variations relevant to the articular and sensory innervation by the ON.

Variations Related to the Origin and the Morphology of the Obturator Nerve

In studies using cadavers, researchers have observed many different variations in the course and formation of the obturator nerve. Specifically, studies have found variations in the course of the ON in relation to the obturator muscle. The common obturator nerve, before dividing into anterior and posterior branches, can either pass through the internal obturator muscle or above it. When it passes through the muscle, it loses its fibrous texture. This variation is almost equally distributed among the dissected samples (50% each; N=16) (9).

Additionally, there may be variations in the course of the posterior branch of the obturator nerve. According to Sim et al., in 61% (N=18) of dissected samples, the posterior branch of the obturator nerve runs anteriorly to the external obturator muscle. In some instances, the posterior branch passes through a fleshy section of the muscle with a distinct fiber separation in 22% (N=18) of cases, while in 17% (N=18), the fiber separation is unclear. In only one case, the posterior branch of the obturator nerve was separated from the muscle by fatty tissue (9).

In addition, there are variations in the origin of the obturator nerve. In most cases (around 97%, N=60 in one study, 89%, N=73 in a second study and 80%, N=181 in a third study), the obturator nerve consists of the ventral branches of the L2, L3, and L4 ventral rami. Occasionally, the obturator nerve may originate from the ventral branches of L3 and L4 ventral rami (about 3%, N=60 in one study, 5.5%, N=73 in a second study and 20%, N=181 in a third study) (4, 6, 12). In rare instances (approximately 5.5%, N=4), the obturator nerve may also derive from the ventral rami of L3, L4, and L5 (6). It is worth mentioning that, in statistical analysis, this variation seems to be unrelated to sex (12). In a single case recorded, the obturator nerve seems to derive from L1 and L2 ventral branches. These ventral branches were united and then divided into many branches, where the first of them was the obturator nerve (7). In another single case report, it is shown that the obturator nerve is formed by a combination of the L1, L2 and L3 ventral rami (8).

Furthermore, differing levels of composition variations were noted. Typically, the ON emerges at the level of the L5-S1 vertebra (60%; N=60). The ON may emerge on the level of the S1 vertebra (22%; N=60), L5 vertebra (15%; N=60), S2 vertebra (2%; N=60) or L4-L5 (2%; N=60) (4).

Variations Related to the Division Point of the Obturator Nerve

The common obturator nerve is divided into an anterior and a posterior branch. The point at which the nerve divides may occur within the pelvis, or after it passes through the obturator canal. Previous studies have not reached a consensus on the most common location of the division point. Anagnostopoulou et al. conducted cadaveric research and found that in the majority of dissections (51.78%; N=168), the division occurred after the nerve passed through the obturator canal, in the medial thigh. The division was also frequently observed within the obturator canal (23.33%; N=168) or within the pelvis, prior to the obturator foramen (21%; N=168) (2).

Iwanaga et al. found that in most cases (64.3%; N=14), the division point is observed after the obturator foramen. They also observed the significant persistence of the bifurcation point before the obturator foramen (21.4%; N=14) and within the obturator canal (14.3%; N=14) (1). In contrast, Purdhon et al. discovered that the bifurcation occurred within the obturator canal in 89% of cases (N=18) and after the obturator foramen in 11% of cases (N=18) while Zithulele et al. observed that in 2% of cadaveric dissections, the bifurcation occurred within the pelvis, 93% within the obturator canal, and 5% after exiting the canal (9, 12). However, they also demonstrated that these variations are statistically unrelated to sex (12). Additionally, it was noted that the point where the obturator nerve divides is situated approximately ±20mm from the upper or lower limit of the superior pubic ramus (1).

Variations Related to Muscle Innervation by the Obturator Nerve

Mainly, the obturator nerve provides innervation to the adductor longus, gracilis, and adductor magnus muscles. However, many studies have presented, among others, variations that relate to the muscular branches of the obturator nerve.

The first and most frequent finding is that the anterior branch of the obturator nerve appears to provide innervation, through three muscular branches, to the adductor longus, adductor brevis, and the gracilis muscle (66.6%; N=168) (2). It may also provide two branches only for the adductor

longus and gracilis muscle (28.57%; N=168) or four branches for the adductor longus, adductor brevis, gracilis and pectineus muscle (4.76%; N=168) (2). One study reports pectineus muscle innervation by the anterior branch of the obturator nerve as a rare finding, observed in only one case (12). The pectineus muscle receives its branch from the anterior branch of the obturator nerve, which descends diagonally and ends at the posterior aspect of the pectineus. It is quite common for the pectineus muscle to enclose two sources of nerve supply, both from the femoral nerve and the branch of the obturator nerve (10%, N=10) (3).

Thus, extra caution is necessary when it comes to denervating the pectineus muscle. Within the muscle, the branch of the obturator nerve that supplies the pectineus muscle is divided into two to four smaller branches, which are only found in the middle third of the muscle, and extend laterally (13). At times, there may be an anastomosis between the branches of the femoral nerve and their corresponding counterparts from the obturator nerve branches (13). It is also important to note that the branches from the femoral nerve are generally smaller in size than those from the obturator nerve. Statistical analysis reveals that there is no significant relationship between this variation and sex ($P<0.05$) (13). Additionally, it has been noted that in some cases (27.4%, N=73) the adductor brevis muscle receives innervation from both the anterior and the posterior branches of the obturator nerve (6).

Moreover, the innervation of muscles by the posterior branch of the obturator nerve also appears to vary. From the posterior branch of the obturator nerve, one branch may arise for the adductor magnus muscle (13.69%; N=168), two branches for the adductor magnus and adductor brevis muscles (60.11%; N=168), three branches for the external obturator, adductor magnus and adductor brevis muscles (19.04%; N=168) or four branches for the adductor magnus, adductor brevis, adductor longus and external obturator muscle (7.14; N=168) (2). Other research shows that in approximately 10% of cases, the posterior branch of the obturator nerve aids the anterior branch in innervating the adductor brevis (12). A single case presentation also includes a report of a small branch from the obturator nerve innervating the iliacus muscle (8).

Additionally, there have been reports of the presence of extra twigs and branches originating from the obturator nerve. These supernumerary branches are responsible for innervating the anomalous muscle, if it exists. This anomalous muscle is located between the adductor brevis and adductor minimus muscles, arising from the inferior ramus of the pubis and following a downward and lateral course, resulting in the pectineal line (23.3%, N=73). The supernumerary branch originates from the posterior branch of the obturator nerve, and supplies the anomalous muscle from its posterior aspect (6). Additional innervation of the adductor minimus by a supernumerary twig was also observed. This twig arises from the posterior branch of the obturator nerve, and it may be distributed to the anterior (24.7; N=73) or the posterior aspect (11%; N=73) of the muscle (6).

Variations Related to the Articular and Skin Innervation by the Obturator Nerve

Numerous studies have indicated that the articular branches of the obturator nerve are susceptible to variations. Firstly, the number of branches of the obturator nerve for the hip joint may vary. Typically, the obturator nerve gives rise to only one articular branch (61.28%; N=168). This branch can originate from either the common obturator nerve (61.98%; N=104) (Figure 2, 1A), the anterior branch of the obturator nerve (19.23%; N=104) (Figure 2, 1B), or the posterior branch of the obturator nerve (3.84%; N=104) (Figure 2, 3C).

In some cases, the obturator nerve may provide two articular branches for the hip joint (20.32%; N=168). In these instances, both branches can arise from the common obturator nerve (45.05%; N=34) (Figure 2, 2A), both from the posterior branch of the obturator nerve (41.17%; N=34) (Figure 2, 2B), or one from the common obturator nerve and the other from the posterior branch of the obturator nerve (22.76%; N=34) (Figure

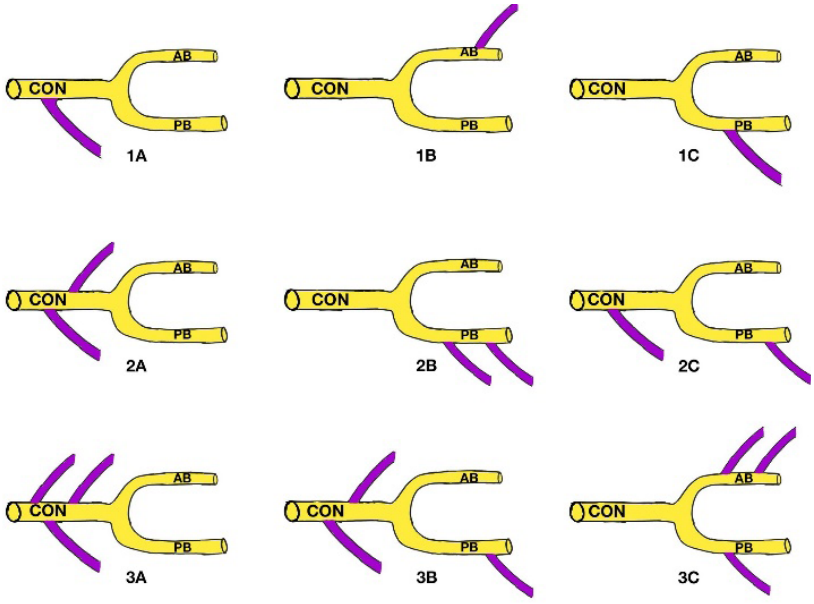

Figure 2. Illustration of variations related to the origin of the hip joint articular branch deriving from the obturator nerve.

2, 2C). In certain cases, the hip joint may receive three articular branches from the obturator nerve (17.85%, N=168). These three branches may be derived in different ways: all three branches deriving from the common obturator nerve (53.34%, N=30) (Figure 2, 3A); two branches deriving from the common obturator nerve and one from the posterior branch of the obturator nerve (26.66%, N=30) (Figure 2, 3B); or two branches deriving from the anterior division of the obturator nerve and one from the posterior (20%, N=30) (Figure 2, 3C) (2).

The violet-colored branch relates to the hip joint articular branch.1A: The hip joint articular branch deriving from the common obturator nerve (CON), 1B: The hip joint articular branch deriving from the anterior branch (AB) of the obturator nerve, 1C: The hip joint articular branch deriving from the posterior branch (PB) of the obturator nerve, 2A: Both hip joint articular branches deriving from the CON, 2B: Both hip joint articular branches deriving from the PB of the obturator nerve, 2C: One hip joint articular branch deriving from the CON and the other from the PB of the obturator nerve, 3A: All three hip joint articular branches deriving from the CON, 3B: Two of three hip joint articular branches deriving from the CON and the third from the PB of the obturator nerve, 3C: Two of three hip joint articular branches of the obturator nerve deriving from the AB of the obturator nerve, and the third from the PB of the obturator nerve.

In addition, it has been reported that the hip joint's articular branches originating from the obturator nerve can range from two to seven in number, with their bands starting between 9-19 mm and ending between 7-38 mm in width (10). In one reported case, it was observed that a branch originated from the anterior branch of the obturator nerve and ran in a superomedial direction in the thigh. Subsequently, it merged with the ilioinguinal nerve in front of the medial crus of the superficial inguinal ring. During this course, it produced another branch that descended along the anterior aspect of the spermatic cord. This branch divided into multiple cutaneous branches responsible for supplying the anterior scrotal skin. Such variations in nerve anatomy have significant implications in clinical practice, especially during local anesthesia procedures. Failure to recognize these variations may lead to excruciating pain for the patient (3).

Conclusions

In our review, we established that the obturator nerve is highly susceptible to variations. This finding underscores the importance of research and studies that identify and discuss morphological variations in vascular, nerve, and muscular structures, particularly in the context of surgical procedures. Recognizing these variations prior to surgery is imperative for surgeons, anesthesiologists, and plastic surgeons in order to provide

optimal care to patients and minimize iatrogenic complications.

What Is Already Known on This Topic:

Many variations concerning the obturator nerve are noted throughout the literature. Research has highlighted a range of differences in the anatomy and innervation patterns of the obturator nerve. More specifically, the obturator nerve is prone to variations regarding its morphology and origin. Furthermore, the muscles and skin regions innervated by the obturator nerve may vary. Last but not least, several studies have identified variations in the articular innervation provided by the obturator nerve.

What This Study Adds:

This study provides a comprehensive overview of the anatomical variations of the obturator nerve, synthesizing findings from the existing literature. It highlights deviations in the nerve's origin, division point, and innervation patterns. By categorizing these variations, the study offers valuable insights that can help clinicians anticipate challenges during interventions involving the obturator nerve. Furthermore, this review underscores the importance of precise anatomical knowledge in minimizing iatrogenic complications and optimizing patient care, making it a crucial resource for surgeons, anesthesiologists, and medical educators.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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