



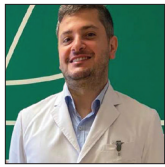
Review Article

Anatomical variations of ilioinguinal nerve: A systematic review of the literature

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ABSTRACT

Background: Several anatomical variations of the ilioinguinal nerve branches have been recorded in older studies. Knowledge of these variations is useful for the improvement of peripheral nerve blocks and avoidance of iatrogenic nerve injuries during abdominal surgeries. The purpose of this study is to perform a systematic review of the literature about the anatomical topography and variations of the ilioinguinal nerve.

Methods: An extensive search in PubMed, Scopus, and Web of Science electronic databases was conducted by the first author in November 2021, with the use of the PRISMA guidelines. Anatomical or cadaveric studies about the origin, the course, and the distribution of the ilioinguinal nerve were included in this review. Thirty-one cadaveric studies were included for qualitative analysis.

Results: Several anatomical variations of the ilioinguinal nerve were depicted including its general properties, its origin, its branching patterns, its course, its relation to anatomical landmarks, and its termination. Among them, the absence of ilioinguinal nerve ranged from 0% to 35%, its origin from L1 ranged from 65% to 100%, and its isolated emergence from psoas major ranged from 47% to 94.5%. Numerous anatomical variations of the ilioinguinal nerve exist, not commonly cited in classic anatomical textbooks. The branches of the ilioinguinal nerve may be damaged during spinal anesthesia and surgical procedures in the lower abdominal region.

Conclusion: Therefore, a better understanding of the regional anatomy and its variations is of vital importance for the prevention of ilioinguinal nerve injuries.

Keywords: Anatomical variations, Iliohypogastric nerve, Ilioinguinal nerve, Lumbar plexus

INTRODUCTION

The ilioinguinal nerve is the 2nd nerve of the lumbar plexus. It derives from the anterior branch of the 1st lumbar nerve (L1), usually after the administration of an anastomotic branch to the anterior branch of the 2nd lumbar nerve (L2), and occasionally with the contribution of the 12th thoracic nerve (T12). In parallel and below the iliohypogastric nerve, the ilioinguinal nerve emerges from the lateral border of the psoas muscle, anterior to quadratus lumborum muscle, behind the renal fossa, into the kidney fat, behind the lower pole of the kidney.^[24,10]

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Between the middle and anterior third of the iliac crest, the ilioinguinal nerve perforates the aponeurosis of the transverse abdominal muscle and runs anterior, almost tangential to the iliac crest, between the two oblique abdominal muscles.^[23] The ilioinguinal nerve usually runs through the inguinal canal and, at various distances from the white line, it penetrates the aponeurosis of the external oblique abdominal muscle and becomes subcutaneous, divided at its skin branches. The ilioinguinal nerve supplies muscular branches to the local abdominal muscles and cutaneous branches to the skin of the medial aspect of the upper thigh, the skin of the root of the penis, and the adjacent area of the scrotum in men (anterior scrotal branch) or the skin of the mons pubis and the labia majora, in the woman (anterior labial branch).^[11]

In surgeries around the groin area, the ilioinguinal nerve blockade provides effective perioperative pain control^[13] and often sufficient anesthesia for outpatient treatment of hernia in adults.^[47] Furthermore, postoperative iatrogenic entrapment syndromes of the ilioinguinal nerve are not unusual^[7] and may cause neuralgias around the sensory innervations areas of the nerve. The variations at the spinal origin, connections, course, and distribution of the branches of the ilioinguinal nerve may be responsible for chronic spontaneous neuropathies, difficulties in diagnosing ilioinguinal nerve syndrome^[1], and failures and complications regarding its blockades in groin hernia operations.^[44] Given that the ilioinguinal nerve cannot be directly visualized transperitoneal, detailed knowledge of the anatomical variations of the ilioinguinal is of vital importance. The purpose of this study is to perform a systematic review of the literature about the anatomical topography and variations of the ilioinguinal nerve.

METHODS

An extensive search in PubMed, Scopus, and Web of Science electronic databases was conducted by the first author in November 2021, with the use of the PRISMA guidelines.^[9] The keyword “ilioinguinal nerve” was used. Moreover, the reference lists of the included papers were scanned for additional studies.

Anatomical or cadaveric studies about the origin, the course, and the distribution of the ilioinguinal nerve were included in this review. Exclusion criteria were (a) study protocols, case reports, systematic reviews, meta-analyses, (b) studies in non-English language or without available full text, and (c) non-human studies.

RESULTS

The initial search revealed 2344 studies [Figure 1]. After the removal of duplicates, 1164 studies were evaluated. After the screening of titles and abstracts, 1092 were omitted, leaving 72 studies for full-text evaluation. Among them, 46 studies

were excluded for specific reasons. Moreover, five studies were added after reviewing the references list of included studies. At last, 31 studies were left for analysis in the present review.^[1,10-39]

General properties

As shown in Table 1, the reported absence of the ilioinguinal nerve in cadaveric studies is variable and ranges from 0% to 35%. Four studies have reported the existence of a double ilioinguinal nerve with a 1–3.3% frequency.^[28,29,4,33] Two studies have reported the mean width of the ilioinguinal nerve. Klaasen *et al.* calculated the mean diameter of the ilioinguinal nerve at 2.2 mm (1.3–3.1 mm).^[19] Similarly, according to Izci *et al.*, the calculated mean width was 1.2 mm (1.0–1.3 mm). The mean length of the ilioinguinal nerve has been measured at 188 mm (185–190 mm).^[27]

Origin

The origin of the ilioinguinal nerve has shown great variability. It is known that the iliohypogastric nerve is mainly derived from L1, with the occasional contribution from L2 to T12.^[27] As shown in Table 2, the ilioinguinal nerve rises from L1 with reported rates of 65–100%, followed by L1–L2, with reported rates of 0–22.5%, and T12–L1 with reported rates of 0–14%. In rare cases, the ilioinguinal nerve may derive from L2 and L3 roots. According to a cadaveric study by Ji and Hur, the mean thicknesses of L1 and L2 constituting the ilioinguinal nerve were 0.6 and 0.4 mm, respectively.^[18] It has been reported that the ilioinguinal nerve communicates with the adjacent nerves of the lumbar plexus through accessory nerve branches.^[19]

Table 1: Reported frequency of absence of the ilioinguinal nerve.

Study (Year)	n	Rate of absence of ilioinguinal nerve (%)
Moreno-Egea (2021) ^[25]	100	0
Paul and Shastri (2019) ^[33]	60	3.3
Gogi (2019) ^[15]	40	10
Anandhi <i>et al.</i> (2018) ^[4]	50	6.6
Arora <i>et al.</i> (2016) ^[6]	60	14.97
Nontasaen <i>et al.</i> (2016) ^[30]	131	0
Geh <i>et al.</i> (2015) ^[14]	43	0
Reinhold <i>et al.</i> (2015) ^[37]	60	6.6–10
Gandhi <i>et al.</i> (2013) ^[12]	60	0
Klaasen <i>et al.</i> (2011) ^[19]	200	0
Ndiaye <i>et al.</i> (2010) ^[29]	100	7
Anloague and Huijbregts (2009) ^[5]	38	0
Ndiaye <i>et al.</i> (2007) ^[28]	100	7
Wijsmuller <i>et al.</i> (2006) ^[46]	18	22.22
Tubbs <i>et al.</i> (2005) ^[42]	22	2.5
Akita <i>et al.</i> (1999) ^[1]	54	5.6
Salama <i>et al.</i> (1983) ^[39]	25	12
Moosman and Oelrich (1977) ^[27]	424	35

n: Number of ilioinguinal nerves studied

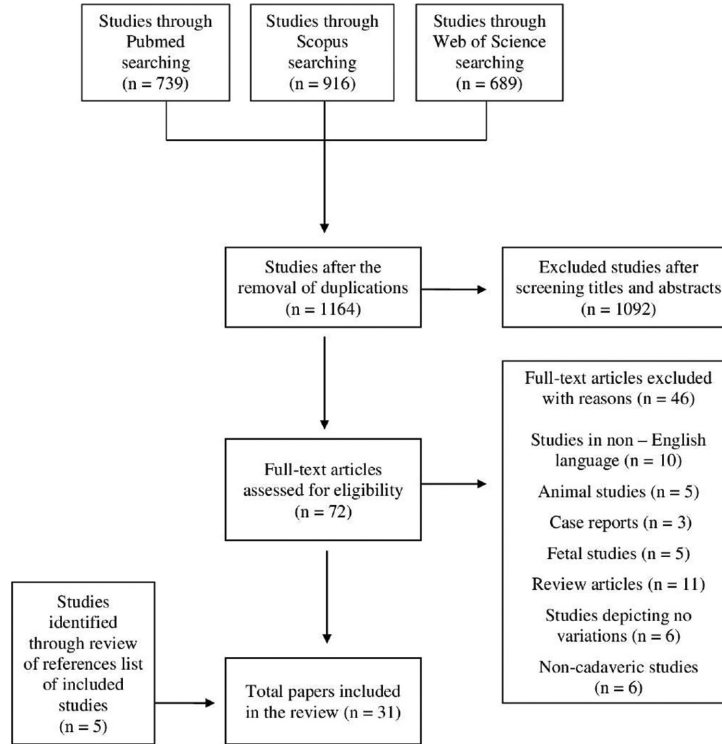


Figure 1: Flowchart of the selected studies.

Table 2: Variability of the origin of the ilioinguinal nerve.

Study (Year)	n	T12-L1 (%)	L1 (%)	L1-L2 (%)	L2 (%)	L2-L3 (%)
Ji and Hur (2021) ^[37]	30	0	90.9	9.1	0	0
Paul and Shastri (2019) ^[33]	60	0	100	0	0	0
Gogi (2019) ^[15]	40	0	67.5	22.5	0%	0
Anandhi et al. (2018) ^[4]	50	8	80	8	2	0
Arora et al. (2016) ^[6]	60	8.33	73.3	1.66	1.66	0
Nontasaen et al. (2016) ^[30]	131	3.8	90.1	3.8	0.8	1.5
Klaasen et al. (2011) ^[19]	200	14	65	11	0	10

n: Number of ilioinguinal nerves studied

Table 3: Variability of the branching pattern of iliohypogastric and ilioinguinal nerves.

Study (Year)	n	Type I (single trunk of the 2 nerves) (%)	Type II (two separate branches) (%)
Moreno-Egea (2021) ^[25]	100	22	78
Reinpold et al. (2015) ^[37]	60	18	82
Geh et al. (2015) ^[14]	43	53	47
Gandhi et al. (2013) ^[12]	60	11.7	88.3
Klaasen et al. (2011) ^[19]	200	20	80
Ndiaye et al. (2010) ^[29]	100	14	86
Rahn et al. (2010) ^[36]	36	50	50
Anloague and Huijbregts (2009) ^[5]	38	5.8	94.2
Pescaud et al. (2006) ^[34]	40	7.5	92.5
Tubbs et al. (2005) ^[42]	22	25	75
Mandelkow and Loeweneck (1988) ^[22]	42	30	70
Papadopoulos and Katritsis (1981) ^[32]	348	46.83	53.17

n: Number of ilioinguinal nerves studied

Branching patterns

The ilioinguinal nerve may emerge from the outer border of the psoas muscle, either united with a common trunk with the iliohypogastric nerve (Type I) or, most commonly, as a separate nerve (Type II). As shown in Table 3, the classic pattern or Type II in cadavers ranges from 47% to 94.5%.

In the case of a Type I branching pattern, the division of the iliohypogastric and the ilioinguinal nerve may be located behind the kidney or between the internal oblique muscle and the transverse abdominal muscle.^[22] According to Geh *et al.*, in Type I cases, the single trunk of the two nerves had a mean distance of 2.7 ± 1.5 cm from the psoas-diaphragm junction.^[14] In the study by Klaasen *et al.*, the mean distance of the two nerves before the union was 2.6 cm (1–5.5 cm).^[19] Ghandi *et al.* observed that the common trunk of these nerves had a mean length of 6 cm within the belly of the psoas muscle before the separation to the iliohypogastric and ilioinguinal nerves.^[12]

In the case of the Type II branching pattern, according to Moreno-Egea, the ilioinguinal nerve emerges from the lateral border of the psoas at a mean distance of 2.5 ± 0.8 cm (range 1.3–4.2 cm), from the iliohypogastric nerve.^[25] In the study by Geh *et al.*, the mean distance of the ilioinguinal nerve to the psoas-diaphragm junction was 4.7 ± 2.4 cm.^[14] Measured from the midline, the ilioinguinal nerve rises from the lateral border of the psoas muscle at a mean distance of 6.5 cm (range 5.5–8.5 cm).^[42]

Retroperitoneal course

Almost always, the ilioinguinal nerve courses on the anterior surface of the quadratus lumborum muscle, which

is the position with the minimum anatomic variability. According to Gandhi *et al.*, the ilioinguinal nerve was 1.5 cm apart all along its course across the quadratus lumborum muscle.^[12] The ilioinguinal nerve enters the abdominal wall either superiorly or inferiorly from the iliac crest and lateral from the anterior superior iliac spine.^[37]

Likewise, to the iliohypogastric nerve, the topographic variability of the ilioinguinal nerve increases from dorsally to ventrally. The relation of the nerve with the posterior superior iliac spine is quite variable. According to Reinold *et al.*, in half of the cases, the nerve runs up to 5.0 cm laterally, and the nerve runs up to 1.6 cm medially with respect to the posterior superior iliac spine. Moreover, in about half of cases, the nerve runs up to 5.5 cm cranially, and in half of the cases, the nerve runs up to 4.0 cm caudally to the posterior superior iliac spine. In one case, the ilioinguinal nerve was divided into two branches 5.0 cm laterally from the posterior superior iliac spine. The mean distance of the ilioinguinal nerve to the posterior superior iliac spine is 7.7 ± 1.0 cm cranially.^[28] According to Moreno-Egea, the ilioinguinal nerve pierced the transverse abdominal muscle at an average of 1.2 cm cranial and medial with the posterior superior iliac spine. In 6% of cases, the ilioinguinal nerve had a caudal course below the iliac crest.^[20]

Relation to anterior superior iliac spine

As its course through the abdominal wall is rather oblique, the ilioinguinal nerve lies only 5–6 mm deep to the fascia of the transverse abdominal muscle.^[38] The ilioinguinal nerve exits retroperitoneal space and enters the abdominal wall by penetrating the aponeurosis of the transverse abdominal muscle following a highly variable course. Table 4 shows the reported mean distances from the penetration of transverse abdominal muscle to the anterior superior iliac spine. The ilioinguinal nerve is always superior to the supracristal plane, with a mean distance of 5 cm.^[12,42] Peschaud *et al.* observe that,

Table 4: Mean distance from penetration of the abdominal wall to the anterior superior iliac spine.

Study (Year)	n	Mean distance from IIN penetration of TAM to ASIS (cm)±SD
Reinbold <i>et al.</i> (2015) ^[37]	56	5.0 ± 2.9 (range 0.5–13.0) dorsally
Klaasen <i>et al.</i> (2011) ^[19]	200	2.8 ± 1.1 cm (range, 1.1–5.2 cm) medial 4 ± 1.2 cm (range, 1.2–4.8 cm) inferior
Ndiaye <i>et al.</i> (2010) ^[29]	94	3.33 ± 2 cm
Whiteside <i>et al.</i> (2003) ^[45]	16	3.1 ± 1.5 cm (range, 0.9–6.3 cm) medial 3.7 ± 1.5 cm (range, –0.5–5.9 cm) inferior

n: Number of ilioinguinal nerves studied. IIN: Ilioinguinal nerve, TAM: Transverse abdominal muscle, ASIS: Anterior superior iliac spine, SD: Standard deviation

Table 5: Mean distance from emergence of internal oblique muscle to the anterior superior iliac spine.

Study (Year)	n	Mean distance from IIN emergence of IOM to ASIS (cm)±SD
Rahn <i>et al.</i> (2010) ^[36]	36	2.5 (range 1.1–5.1) medially 2.4 (range 0–5.3) inferior
Pescaud <i>et al.</i> (2006) ^[34]	40	2.8 ± 1.2 (range 2.5–3.2) medially
Avsar <i>et al.</i> (2002) ^[7]	24	4.84 (3–6.4) (right) 3.37 (2–5) (left)
Mandelkow and Loeweneck (1988) ^[22]	42	3.08 ± 1.18 medially

n: Number of ilioinguinal nerves studied. IIN: Ilioinguinal nerve, IOM: Internal oblique muscle, ASIS: Anterior superior iliac spine, SD: Standard deviation

between the transverse abdominal and the external oblique muscle, the ilioinguinal nerve follows a common course with the iliohypogastric nerve at a mean distance 7.2 ± 3 cm (range 5.6–9 cm). This course was always 2 cm below the anterior superior iliac spine.^[34] According to Rosenberger *et al.*, in half of the specimen, the ilioinguinal nerve appeared on the iliac fascia at 2–4 cm lateral and caudal to the anterior superior iliac spine.^[38] Table 5 shows the reported mean distances from the emergence of the ilioinguinal nerve in the internal oblique muscle to the anterior superior iliac spine.

Relation to inguinal canal

An early study by Moosman and Oelrich in 1977 observed that in 35% of cases, the ilioinguinal nerve followed an aberrant course through the inguinal canal covered by the spermatic cord or the round ligament of the uterus.^[27] In 1983, Salama *et al.* mentioned that in 81.8% of cases, the ilioinguinal nerve emerged in the lateral third of the inguinal ligament in the insertion of the internal oblique muscle.^[39] Other older studies have measured the mean distance of the ilioinguinal nerve from the middle of the inguinal ligament to 0.64 cm. In 23% of cases, this distance was <2 cm.^[32] More recently, Ndiaye *et al.*, observed that the ilioinguinal nerve emerged from the internal oblique muscle at a mean distance of 1 ± 0.8 cm from the inguinal ligament. This distance was <2 cm in 34% of cases. In half of the cases, the course of the ilioinguinal nerve was parallel to the inguinal ligament. In 28.72% of the cases, the ilioinguinal nerve was initially parallel to the inguinal ligament and then gradually approached it before reaching the outer orifice of the inguinal canal.^[28] In a later study, Ndiaye *et al.* observed that the ilioinguinal nerve appeared posterior to the inguinal ligament in 18% of cases, forming a common trunk with the iliohypogastric nerve in 14% of cases and appearing as a single trunk in half of the cases.^[29]

According to Mandelkow and Loeweneck, in the majority of cases (72%), after a short course in the inguinal canal, the ilioinguinal nerve runs medially to the spermatic cord at the superficial inguinal ring. At 10% of the specimen, it passes lateral to the spermatic cord or the round ligament. In the rest of the cases (18%), the ilioinguinal nerve perforates the deep fascia of the external oblique muscle 1–2 cm above the superficial inguinal ring.^[22] Wisjmueller *et al.* showed that in 43% of the cases, the ilioinguinal nerve perforated the internal oblique muscle just laterally from the deep inguinal ring.^[46] When present, the ilioinguinal nerve coursed ventrally and parallel to the spermatic cord, posterior to the deep fascia of the external oblique muscle, exiting the inguinal canal by passing through the superficial inguinal ring ventrally from the spermatic cord.^[46] Ndiaye *et al.* noted that in 99% of cases, the ilioinguinal nerve always crossed the anterior surface of the internal oblique muscle.^[28] In 71.3% of specimens, the ilioinguinal nerve was entirely covered by the aponeurosis

of the external oblique muscle. In the 28.7% of specimens, the ilioinguinal nerve initially ran below the aponeurosis and then pierced the aponeurosis of the external oblique muscle through an orifice at a mean distance of 2 cm from the superficial inguinal ring, as described by Salama *et al.*,^[39] before reaching the spermatic cord or the round ligament.^[28] Rahn *et al.* observed that the ilioinguinal nerve emerged from the superficial inguinal ring in 100% of cases.^[36]

According to Ndiaye *et al.*, in 78.7% of cases, the ilioinguinal nerve travels anterior to the spermatic cord toward the superficial inguinal ring. In 2.12% of cases, the ilioinguinal nerve perforated prematurely the fascia without any connection to the spermatic cord.^[28] However, the classically described anatomy is evident in only 60% of specimens.^[27] Mandelkow and Loeweneck found that in 72% of the cases, the ilioinguinal nerve passed medially to the spermatic cord.^[22] The ilioinguinal nerve may also course through or posterior to the cremaster muscle. Occasionally, the fibers of the ilioinguinal nerve are too thin to be detected.^[27]

Termination

The ilioinguinal nerve is known to supply the sensory innervation of the pubic symphysis, the anterior surface of the scrotum in men, the labia majora in women, and the superomedial area of the thigh. According to Akita *et al.*, the incidence of this pattern of the sensory distribution of the ilioinguinal nerve was 90.7%. In 13% of these cases, the genitofemoral nerve contributed to the sensory innervation of these four regions.^[1] These findings were in accordance with the observations of the study by Mandelkow and Loeweneck, which also found an 18% contribution of the genitofemoral nerve in the innervation of the anterior scrotum and the superomedial thigh.^[22] On the other hand, Rab *et al.* confirmed the classic sensory innervations only in 28.1% of cases, while the rate of the involvement of the genitofemoral nerve was 7.8%.^[35] Ndiaye *et al.* noticed the classic type of sensory distribution to the four areas only in the low percentage of 2.12%.^[29]

Two studies by Ndiaye *et al.* have evaluated the terminal distribution of the ilioinguinal nerve.^[28,29] In 50% of the cases, the ilioinguinal nerves appeared in the form of a unique trunk, with scrotal (85.1%), pubic (8.5%), or femoral (6.4%) termination. In the other half of the specimen, the ilioinguinal nerve was separated prematurely in the inguinal region into collateral and terminal branches distributed to the scrotal, pubic, or femoral areas. At last, 16 modes of division of the ilioinguinal nerve were recorded. In the majority of cases, these terminal branches began on average 1.5 cm above the superficial inguinal ring. In 31.6% of cases, the terminal and collateral branches perforated the aponeurosis of the external oblique muscle. In 5.4% of cases, an anastomosis with the branches of the iliohypogastric nerve was found.^[28,29] Conversely, Salama *et al.* found a high

terminal division in the inguinal canal in 88% of the cases. According to this study, the separation into two branches is the rule, with an upper pubic branch in 95% of cases and a lower branch distributed to the femoral or scrotal regions.^[39] In the study by Moosman and Oelrich, the terminal branches never begin in the inguinal canal but inside or below the superficial orifice.^[27]

The genital branches of the ilioinguinal and the iliohypogastric nerve may be either distinct or fused to constitute a common trunk. In 60% of cases, the distal portions of the iliohypogastric and the ilioinguinal nerve are united to a single genital branch.^[1,27,39] Genital branches of iliohypogastric and ilioinguinal nerves were absent in 12% of cases. When present, these genital branches terminate at the deep surface of the fascia of the external oblique muscle.^[39] Sometimes, the anterior branch of the iliohypogastric nerve is replaced by the ilioinguinal nerve just before its exit from the superficial inguinal ring.^[32]

The mean distance of the termination of the ilioinguinal nerve from the midline has been measured in three studies. According to Klaasen *et al.*, this mean distance is 3 ± 0.5 cm (range, 2.2–5.3 cm) lateral.^[19] In the study by Rahn *et al.*, this distance was 5.9 cm (range 4.0 – 8.3 cm), at 2 cm above the pubic symphysis.^[36] Whiteside *et al.*, measured this distance at 2.7 ± 0.9 cm (range, 1.4–4.4 cm) lateral. Moreover, they found that the ilioinguinal nerve terminated at a mean distance of 1.7 ± 0.9 cm (range, 0.9–3.8 cm) superior to the pubic symphysis.^[45] A cadaveric study by Cardenas-Towers *et al.* showed that it is safe to harvest a rectus abdominis fascia graft at 5.4 cm above the pubic symphysis without injuring the ilioinguinal nerve.^[8]

DISCUSSION

The anatomical variations of the ilioinguinal nerve are plentiful in the literature. To the best of our knowledge, this is the first systematic review attempting to record all the anatomical variations of the ilioinguinal nerve in relation to its properties, its origin, its branching patterns, its course, its relation to anatomical landmarks, and its termination.

The knowledge of the anatomical variations of the ilioinguinal nerve is significant in lower abdomen operations, regional anesthesia, and nerve entrapment syndromes. The branches of the ilioinguinal nerve are closely related to surgical approaches in the lower abdomen below the superior anterior iliac spine and may be damaged at skin incisions or trauma suturing, causing nerve entrapment.^[3,9,22] The rate of ilioinguinal nerve injury during Pfannenstiel incisions is up to 3.2%, and the incidence of ilioinguinal nerve entrapment syndrome after laparoscopic hernia repairs is up to 1.1%.^[20,40] Injury to the ilioinguinal nerve can result in the absence of cremasteric reflex or lancinating and burning pain in the anterior scrotum or labia

majora. The proposed mechanisms of ilioinguinal neuropathy are direct trauma or the formation of painful neuromas.^[36]

It has been reported that the frequency of failure of ilioinguinal nerve blockades is 10–25%.^[43] Regardless of the applied technique for regional anesthesia, the origin of fibers comprising the ilioinguinal nerve and the anatomical route are of vital importance for the proper administration of local anesthetic. Needle malposition at the administration of the blockade may result in postoperative nerve injuries and the formation of painful neuromas.^[12] Therefore, the optimal knowledge of the regional anatomy and the nerve anatomical variations is essential for the prevention of iatrogenic nerve injuries.

In the present review, the reported incidence of complete absence of ilioinguinal nerve is up to 35%. In case of complete absence of the ilioinguinal nerve, the genital branch of the genitofemoral nerve may compensate for the sensory innervations. This variation should be suspected when the nerve is not found under the aponeurosis of the external oblique muscle, and special attention is required during the approach of the cremaster muscles and the dissection of the herniated sac.

Most commonly, the ilioinguinal nerve derives from the L1 root with or without the contribution of L2 and T12. However, in literature, sensory fibers composing the ilioinguinal nerve encompass a region of the spinal cord extending from T12 to L3. The nerve may emerge from the psoas major, united with the iliohypogastric nerve, but most commonly (47–94%), it arises separately as a single nerve. The two nerves may initially rise separately and communicate at the iliac crest. All these complicated origins, interconnections, and anastomoses of the branches of the ilioinguinal nerve may result in sensory overlap or provoke chronic spontaneous neuropathies and failures and complications regarding their blockades.^[19,49] This complexity of the branching patterns may modify the clinical expression of the lesions of the ilioinguinal nerve by enlarging the neuralgic area and influencing the selectivity of the nerve blockade.^[19]

The retroperitoneal course of the ilioinguinal nerve also contains certain variations. Studies reporting its relation to the posterior superior iliac spine have shown contradictory results.^[25,37] The ilioinguinal nerve runs either caudally or cranially to the posterior superior iliac spine. As variability increases from the spinal cord to the terminal distribution, the most reliable area to detect the ilioinguinal nerve is on the anterior surface of the quadratus lumborum. The nerve enters the abdominal wall above or below the iliac crest and lateral from the anterior superior iliac spine and always superior to the supracristal plane.^[12,42]

The ilioinguinal nerve may travel variably through the inguinal canal, with a variable relation to the spermatic cord or the round ligament, either as a single trunk or united with branches of the iliohypogastric nerve.^[1,27,39] As the ilioinguinal nerve rarely passes more than 2 cm from the midpoint of the inguinal

ligament, the fascia of the external oblique muscle should be incised at least 2 cm from the inguinal ligament.^[28,32] As the rate of perforation of the fascia of the external oblique muscle by the ilioinguinal nerve is increased, there is a high risk of iatrogenic injury. For the protection of the nerve, special care should be taken at the incision of the aponeurosis of the external oblique muscle and the superficial orifice of the inguinal canal. During the dissection of the hernial sac, Mandelkow and Loeweneck proposed moving the ilioinguinal nerve away from the spermatic cord for its protection.^[22] At the hernia repair and the closure of the fascia of the external oblique muscle, attention must be paid to ensure that sutures do not catch the nerve.^[22,41] To protect the nerve from injury, Moosman and Oelrich suggested the incision of the fascia of the external oblique muscle from the upper edge of the superficial orifice of the inguinal canal, in the direction of the muscle fibers and laterally to expose the ilioinguinal nerve along with the spermatic cord in men and the round ligament in women.^[38] Potential damage of the nerve at this level may trigger a partial neuralgia in the area of the sensory distribution.^[2]

The variability of the course of the ilioinguinal nerve continues at its terminal branches. These may present as a single trunk or may divide prematurely in the inguinal area into collateral and terminal branches distributed in the scrotal, pubic, or femoral regions. As the terminal branches of the ilioinguinal nerve usually begin below the inguinal canal, they are at risk of injury during the dissection of the spermatic cord. Taking this diversity into consideration, Ndiaye *et al.* suggested the performance of an ilioinguinal block with the use of superficial and easily palpable landmarks at 1 cm of the inguinal ligament and 3.3 cm of the anterior superior iliac spine.^[29] To avoid damage to the ilioinguinal nerve, Rahn *et al.* suggested the placement of trocars in the infraumbilical area of the anterior abdominal wall, more than 6 cm from the midline, at the level of the anterior superior iliac spine, and more than 5 cm superior to the pubic symphysis.^[36] In case of the monoterritorial termination of the ilioinguinal nerve, the sensory innervations of the ilioinguinal nerve may be reduced, modifying the region of the neuralgia of the ilioinguinal nerve, resulting in partial ilioinguinal nerve syndrome and incomplete anesthesia during the ilioinguinal nerve block.^[29]

CONCLUSION

The results of the present review revealed numerous anatomical variations of the ilioinguinal nerve in number, path, and method of termination, not commonly cited in classic anatomical textbooks. These atypical locations of the ilioinguinal nerve may predispose to a higher rate of injury, resulting in postoperative pain. The knowledge of these variations may prevent damage during repairs of groin hernias and the postoperative complication of inguinodynia. Moreover, it may help in understanding the etiology and the surgical aspects

of neuropathies of the groin. The branches of the ilioinguinal nerve may be damaged during spinal anesthesia and the anatomic variability of the nerve may cause failures of the blockade of the nerve. Further studies delineating ilioinguinal nerve topography variation may increase the success of nerve blockades in abdominal surgical procedures and decrease the possibility of ilioinguinal nerve injuries.

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We state that Manolakos Konstantinos and Manolakos Othon have seen and can confirm the authenticity of the raw data.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

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Use of artificial intelligence (AI)-assisted technology for manuscript preparation

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