

Anomalous formation and branching pattern of the sciatic and pudendal nerves

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SUMMARY

Multiple nerve variations were observed in the right gluteal region of a 62 year old female which includes origin, course and branching pattern of the sciatic and pudendal nerves. The sciatic nerve was formed by the L4, L5, S1 and S2 in the pelvis, whereas the pudendal nerve was contributed by the S3, S4 and S5. The pudendal was divided into medial and lateral divisions in the gluteal region. The lateral division had joined the sciatic nerve. High division of the pudendal nerve was observed and all its branches originated from the medial division of the pudendal nerve. The inferior rectal nerve passed through the sacrospinous ligament and formed a loop around the ischial spine. The dorsal nerve of the clitoris passed between the sacrospinous and sacrotuberous ligaments. Since iatrogenic injuries to these nerves may occur during surgery, a thorough knowledge of the variation anatomy of the sciatic and pudendal nerves can help to reduce post-operative complications. Moreover, variation anatomy knowledge might guide the radiologist, surgeons and other health professionals to diagnose and treat various neuralgia related to the perineum and gluteal region.

Key words: Sciatic nerve – Pudendal Nerve – Inferior Rectal nerve – Nerve loop – Dorsal nerve of clitoris – Pudendal nerve proper – Sacrotuberous ligament – Sacrospinous ligament

INTRODUCTION

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Sciatic nerve (SN): The nerve is formed by the ventral rami of the L4, L5, S1, S2, S3 and S4 (partly) roots. It leaves the pelvis through greater sciatic foramen (GSF) inferior to the piriformis muscle to reach the gluteal region (GR). In the GR it descends dorsal to the obturator internus, gemelli and quadratus femoris muscles to reach the back of the thigh. It divides into tibial and common peroneal nerves at the superior angle of the popliteal fossa (Standing, 2009; Moore et al., 2010). The nerve is prone to get injury due to its thickness and long course. Therefore, various iatrogenic injuries to the nerve might cause sciatica and also neurological deficit (Yuen et al., 1999; Brooks et al., 2011; Shewale et al., 2013). Therefore, knowledge of variation anatomy of the SN is essential to avoid iatrogenic injury to the nerve. There are various studies on the SN (Okraszewska et al., 2002; Gonzalez et al., 2008; Guvencer et al., 2009; Smoll, 2010; Brooks et al., 2011; Deopujari et al., 2012; Shewale et al., 2013; Natsis et al., 2014) but, until the present date and to the best of our knowledge, there are no reports about the formation of SN by the contribution of the pudendal nerve.

Pudendal nerve (PN): It is formed by the S2-S4 ventral rami. Matejčík (2012) mentioned the “prefix” when the nerve was contributed by the (S1 & S2) and “postfix” by the S3 & S4 roots. The formation of the nerve takes place in the pelvis along the superior border of the sacrotuberous ligament (STL), and passes through the GSF inferior to the piriformis muscle to reach the GR (Decker, 1999; Standing, 2009). It passes downwards and medially over the base of the ischial spine (IS) to enter the pelvis through the lesser sciatic foramen (LSF) to reach the pudendal (Alcock’s) canal. The nerve

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gives three branches at the posterior end of the Alcock's canal (AC), namely the inferior rectal (IRN), perineal and dorsal nerve of the penis or clitoris (Decker, 1999; Standing, 2009). The PN provides both sensory and motor fibers to the perineum (Shafik et al., 1995; Schraffordt et al., 2004).

Iatrogenic injuries may occur to the PN and might manifest as sensory or motor deficit. The nerve may get injury during pudendal block, vaginal birth, anterior colporrhaphies and anal sphincteroplasties, sacrospinous ligament (SSL) fixation, (Snook et al., 1990; Lien et al., 2005; Roshanravan et al., 2007). Injury to motor fibers might cause delayed urethral or anal sphincter functions that might lead to fecal or urinary incontinence in late life (Benson and McClellan, 1993; Mahakkanukrauh et al., 2005). Injury to the sensory fibers may occur in midurethral sling procedure and vaginal reconstruction, which might cause neurological symptoms such as hyperalgesia, allodynia, paresthesia along the area of innervations, and also cause crippling forms of genital pain (Duckett and Jain, 2005; Vervest et al., 2006; Hazewinkel et al., 2009; Fisher and Lotze, 2011; López and Contreras, 2014). Therefore, thorough knowledge of PN anatomy is mandatory for the radiologist and surgeon to diagnose and treat the PN entrapment syndrome, and also other causes of pudendal neuralgia (Filler, 2009).

In the present case, we report the high division pattern of the PN and variation of the course of its branches. Most significant was the contribution of the PN to the sciatic nerve.

The present case report gains immense significance to diagnose and treat the neuralgia in relation to gluteal and perineal regions, and also to avoid the complications in surgical procedure in both regions. There are various studies on the sciatic and pudendal nerves, but the present case is not documented in the literatures.

CASE REPORT

During routine class room dissection for the undergraduate medical student the following variations were observed in the right GR of a 62-year-old female:

Sciatic nerve: The SN was formed by the L5, S1 and S2 in the pelvis (Fig. 1). The distance between the main trunk and midpoint of the medial border of the second sacral foramen was measured 35 mm. It had followed the normal course to enter the GR (Fig. 2). Most important finding was contribution from the PN as the lateral division of it had joined the medial border of the SN (Fig. 2). The distance from the midpoint of the greater sciatic notch (GSN) and junction of the lateral division of PN was measured 39 mm (Fig. 3). The main trunk of the SN was descending downwards dorsal to the obturator internus and gemilli muscles (Fig. 3). There was a higher division of the nerve, as it di-

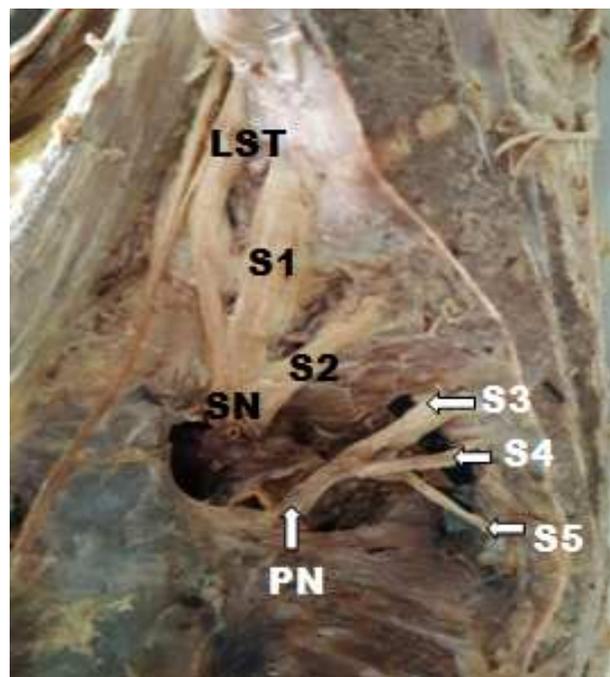


Fig. 1. Intrapelvic SN & PN formation: Right side sagittal view. Lumbosacral trunk (LST); S1-S5 nerve roots; Sciatic nerve (SN); Pudendal nerve (PN).

vides into tibial and common perineal branches at the superior border of the quadratus femoris muscle.

Pudendal Nerve: Origin: The nerve was formed by the ventral division of the S3, S4, and S5 roots (Fig. 1) at the superior border of the ischococcygeous muscle at its origin. Course: The main trunk was passing through the GSF inferior to the piriformis to reach the GR (Fig. 2). It was divided into medial and lateral divisions at a distance of 39 mm from the midpoint of the GSN (Fig. 3). The

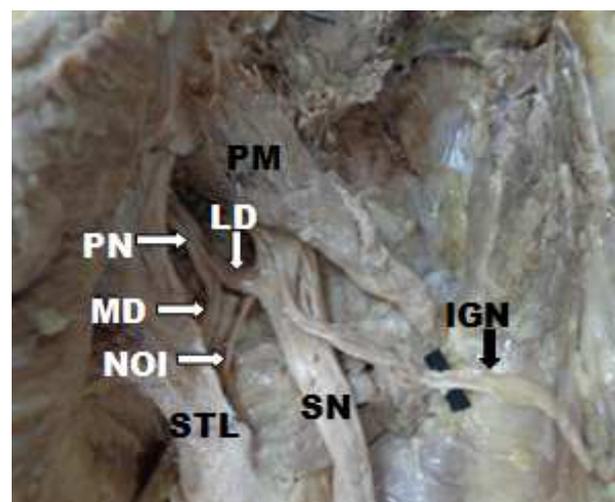


Fig. 2. Right gluteal region: Dorsal view. Piriformis muscle (PM); Pudendal nerve (PN); Lateral division of the pudendal nerve (LD); Medial division of the pudendal nerve (MD); Nerve to obturator internus and gemellus superior (NOI); Sciatic nerve (SN); Sacrotuberous ligament (STL); Inferior gluteal nerve (IGN).

lateral division had joined the SN (Fig. 3) and medial division (PN proper) was passing dorsal to the ischial spine. The PN proper enter the pelvis through the LSF to reach the Alcock's canal. Observations regarding the branches are as follow:

1. The inferior rectal nerve (IRN) was originated in the pelvis from the main trunk from its dorsal surface (Fig. 3), and came out through the GSF to reach the GR. It passed through SSL and joined the PN proper to form a loop dorsal to the IS (Fig. 3). Immediately after formation of the loop, it was separated from the PN proper and passes medial to it. In the AC, IRN was situated medial to the PN proper. It left the canal through the anterior part to reach the ischio-anal fossa to supply the external anal sphincter, lower part of the anal canal and skin around it.
2. Dorsal nerve of the clitoris (DNC) was originated from the medial side of the PN trunk adjacent to the GSN, and passed downwards medial to the main trunk of the PN (Fig. 3). It was superficial to the SSL and deep to the STL (Fig. 3). It entered the AC along with the PN proper, and passed medial to the ischio-pubic ramus to supply the clitoris.
3. Perineal nerve: the PN proper was continued as the perineal nerve (Fig. 3), and divided into the medial and lateral branches in the anterior part of the AC. There was no variation observed about its area of distribution.

DISCUSSION

Sciatic nerve: Standingr (2009) has mentioned the root value of the SN is lumbosacral trunk (L4 &

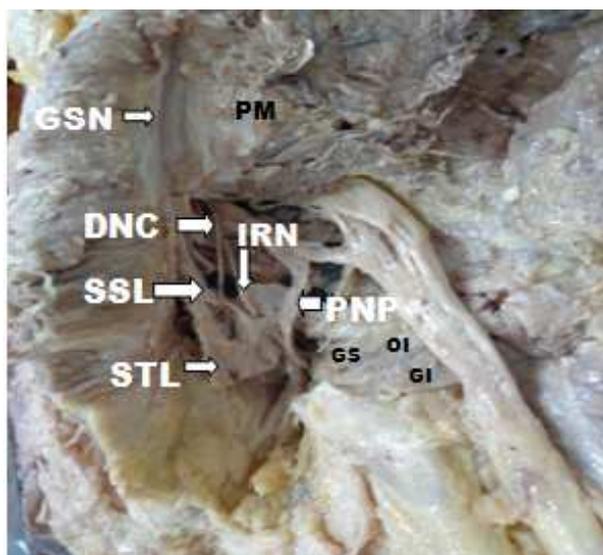


Fig. 3. Right gluteal region: Piriformis muscle (PM) removed. Dorsal nerve to clitoris (DNC); Inferior rectal nerve (IRN); Pudendal nerve proper (PNP); Sacrospinous ligament (SSL); Sacrotuberous ligament (STL); Gemellus superior (GS); Gemellus Inferior (GI); Obturator internus (OI); Great Sciatic notch (GSN).

L5), S2, S3 and S4 (partly) in the pelvis, but in the present case the nerve formation was by the L4, L5, S1 and S2 only in the pelvis. Whereas in the present case the lateral division of the PN had joined the main trunk of the SN in the GR, and the distance was measured 39 mm from the midpoint of the GSN, which might be an important landmark for radiologists and surgeons to properly diagnose the anomaly nerve and to avoid intra-operative complications. Perhaps, the lateral division of PN was carrying the S3 and S4 (partly) fibers, because those neurons that are destined to supply a particular muscle are grouped in the specific nucleus of the spinal cord and target cells for the S3 & S4 (partly) being specific for the lower limb bud (Ferguson, 1983). The nerve was divided at the superior border of the quadratus femoris muscle, which was a higher division because normally it divides at the upper angle of the popliteal fossa (Standingr, 2009; Moore et al., 2010).

Pudendal Nerve: In the present case the nerve was formed by the ventral division of the S3, S4, & S5 roots, a case that is not documented in the literature. In this case the nerve might be termed as "post-fixed" (Matejčík, 2012). The nerve divides into medial and lateral divisions in the gluteal region, which is type-II extrapelvic PN as per the Pirro et al. (2009) classification. The type II PN may complicate sphincter reconstruction procedures, and thus the surgeon needs to have vivid knowledge about the variation anatomy of PN, especially in regards to peripheral nerve reconstruction (Pirro et al., 2009). The lateral division had joined the SN at its medial border in the gluteal region. Perhaps, the lateral division of the PN was carrying the S3 & S4 (partly) for the sciatic nerve. The medial division gave three branches and in this case all the branches observed higher in origin which is not described in the literatures. The IRN had a course through SSL which agrees with Matejčík's findings (2012), but in the present case the nerve had joined the PN proper at the dorsal surface of the base of IS to form a loop, and this constitutes a unique finding. Our study result suggests that surgeons need to keep in mind this kind of anatomical variation during SSL fixation procedures to avoid the complications (Roshanravan et al., 2007). Moreover, the variation course of the IRN might be the cause of ano-rectal symptoms (Maldonado et al., 2015). The dorsal nerve of the clitoris had course between the sacrospinous and STL. When the nerve passes through both laminae of those ligaments, it might get entrapped and may manifest as neuropathic pain symptoms like crippling forms of genital pain (Hibner et al., 2010). Therefore, a thorough knowledge of variation anatomy is essential for the surgeons and radiologists for the proper diagnosis and treatment of pudendal neuralgia (Neill and Swash, 1982; Snook et al., 1990; Lien et al., 2005; Filler, 2009; López and Contreras, 2014). Moreover, variation anatomy of

the PN is very significant to avoid the iatrogenic injuries (eg. pudendal block, vaginal birth, anterior colporrhaphies and anal sphincteroplasties, SSL fixation), intraoperative and post-operative complications (Benson and McClellan, 1993; Mahakkanukrauh et al., 2005; Duckett and Jain, 2005; Vervest et al., 2006; Hazewinkel et al., 2009; Fisher and Lotze, 2011; López and Contreras, 2014; Maldonado et al., 2015).

Conclusion: Knowledge of the variation anatomy of the branching pattern of the sacral plexus is essential for the radiologists, surgeons, nurses and other health professionals to appropriately diagnose and treat sciatic neuropathy, pudendal neuralgia, or vague pain in the perineum.

REFERENCES

- BENSON JT, MCCLELLAN E (1993) The effect of vaginal dissection on the pudendal nerve. *Obstet Gynecol*, 82: 387-389.
- DECKER GAG (editor) (1999) *Lee McGregor's Synopsis of Surgical Anatomy*. 12th ed. Indian edition. K.M. Varghese Company, pp 72-74.
- DEOPUJARI R, SATPATHI DK, MANGALAGIRI AS (2012) Clinical importance of anatomical variants of sciatic nerve in relation to the piriformis muscle. *NJCA*, 1(4): 160-164.
- DUCKETT JRA, JAIN S (2005) Groin pain after a tension-free vaginal tape or similar suburethral sling: management strategies. *BJU Int*, 95: 95-97.
- FERGUSON BA (1983) Development of motor innervation of the chick following dorsal-ventral limb bud rotations. *J Neurosci*, 3(9): 1760-1772.
- FILLER AG (2009) Diagnosis and treatment of pudendal nerve entrapment syndrome subtypes: imaging, injections, and minimal access surgery. *Neurosurg Focus*, 26: E9.
- FISHER HW, LOTZE PM (2011) Nerve injury locations during retropubic sling procedures. *Int Urogynecol J Pelvic Floor Dysfunct*, 22: 439-441.
- GONZALEZ P, PEPPER M, SULLIVAN W, AKUTHOTA V (2008) Confirmation of needle placement within the piriformis of a cadaveric specimen using anatomic landmarks and fluoroscopic guidance. *Pain Physician*, 11: 327-331.
- GUVENCER M, IYEM C, AKYER P, TETIK S, NADERI S (2009) Variations in the high division of the sciatic nerve and relationship between the sciatic nerve and the piriformis. *Turk Neurosurg*, 19: 139-144.
- HAZEWINKEL MH, HINOUL P, ROOVERS JP (2009) Persistent groin pain following a trans-obturator sling procedure for stress urinary incontinence: a diagnostic and therapeutic challenge. *Int Urogynecol J*, 20: 363-365.
- HIBNER M, DESAI N, ROBERTSON LJ, NOUR M (2010) Pudendal neuralgia. *J Minim Invasive Gynecol*, 17: 148-153.
- LIEN KC, MORGAN DM, DELANCEY OLJ, MILLER AAJ (2005) Pudendal nerve stretch during vaginal birth: a 3D computer simulation. *Am J Obstet Gynecol*, 192(5): 1669-1676.
- LÓPEZ FRP, CONTRERAS FH (2014) Management of pudendal neuralgia. *Climacteric*, 17: 1-3.
- MAHAKKANUKRAUH P, SURIN P, VAIDHAYAKARN P (2005) Anatomical study of the pudendal nerve adjacent to the sacrospinous ligament. *Clin Anat*, 18: 200-205.
- MALDONADO P, CHIN K, GARCIA AA, CORTON MM (2015). Anatomic variations of pudendal nerve within pelvis and pudendal canal: clinical applications. *Am J Obstet Gynecol*, doi: 10.1016/j.ajog.2015.06.009.
- MATEJČÍK V (2012) Surgical location and anatomical variations of pudendal nerve. *Anz J Surg*, 82(12): 935-938.
- MOORE KL, DALLEY AF, AGUR AMR (2010) *Clinically Oriented Anatomy*. 6th ed. South Asian edition, New Delhi, Wolters Kluwer / Lippincott Williams & Wilkins, pp 357-358.
- NATSIS K, TOTLIS T, KONSTANTINIDIS GA, PARASKEVAS G, PIAGKOU M, KOEBKE J (2014) Anatomical variations between the sciatic nerve and the piriformis muscle: a contribution to surgical anatomy in piriformis syndrome. *Surg Radiol Anat*, 36(3): 273-280.
- NEILL ME, SWASH M (1982) Chronic perianal pain: An unsolved problem. *J R Soc Med*, 75: 96-101.
- OKRASZEWSKA E, MIGDALSKI L, JEDRZEJEWSKI KS, BOLANOWSKI W (2002) Sciatic nerve variations in some studies on the Polish population and its statistical significance. *Folia Morphol*, 61: 277-282.
- PIRRO N, SIELEZNE VI, CORROLLER LT, OUAISSI M, SASTRE B, CHAMPSAUR P (2009) Surgical anatomy of the extrapelvic part of the pudendal nerve and its applications for clinical practice. *Surg Radiol Anat*, 31: 769-773.
- ROSHANRAVAN SM, WIESLANDER CK, SCHAFFERJ I, CORTON MM (2007) Neurovascular anatomy of the sacrospinous ligament region in female cadavers: Implications in sacrospinous ligament fixation. *Am J Obstet Gynecol*, 197(6): 660.e1-660.e6.
- SCHRAFFORDT SE, TJANDRA JJ, EIZENBERG N, DWYER PL (2004) Anatomy of the pudendal nerve and its terminal branches: A cadaver study. *Anz J Surg*, 74: 23-26.
- SHAFIK A, EL-SHERIF M, YOUSSEF A, OLFAT ES (1995) Surgical anatomy of the pudendal nerve and its clinical implications. *Clin Anat*, 8: 110-115.
- SHEWALE AD, KARAMBELKAR RR, UMARJI BN (2013) Study of variations in the divisions, course and termination of the sciatic nerve. *JKIMSU*, 2(1): 62-68.
- SMOLL NR (2010) Variations of the piriformis and sciatic nerve with clinical consequence: a review. *Clin Anat*, 23: 8-17.
- SNELL RS (2010) *Clinical Anatomy by Region*. 8th ed. South Asian edition, New Delhi, Wolters Kluwer / Lippincott Williams & Wilkins, pp 325-327.
- SNOOKS SJ, SWASH M, MATHERS SE, HENRY MM (1990) Effect of vaginal delivery on the pelvic floor: a 5 year follow up. *Br J Surg*, 77: 1358-1360.

STANDRING S (editor) (2009) *Gray's Anatomy: The Anatomical Basis of Clinical practice*. 40th ed. China. Churchill Livingstone/Elsevier, pp 1091-1098 & 1384.

VERVEST HAM, BONGERS MY, VAN DER WURFF AAM (2006) Nerve injury: an exceptional cause of pain after TVT. *Int Urogynecol J*, 17: 665-667.

YUEN EC, SO YT (1999) Sciatic neuropathy. *Neurol Clin*, 17: 617-631.