

## MORPHOLOGICAL STUDY

## Surgical treatment of nervus pudendus

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**Abstract:** An objective of our work was to clarify variations in pudendal nerve formation, as well as their possible impact on the clinical picture.

Bilateral pudendal nerve course and formation was studied on 20 adult cadavers. Anterior approach was used in 15 of them, both posterior and anterior approaches were used in five of them.

The prefixed type plexus formation was observed in eight cases (40 %). In these cases S<sub>1</sub>, S<sub>2</sub> roots contributed to the formation of the pudendal nerve. In the postfixed type particularly the S<sub>3</sub> root was dominant in two cases (66.7 %), and less the S<sub>4</sub> root in one case (23.3 %) from three cases. Mostly the S<sub>2</sub> root participated in its formation in 17 cases (85 %). The pudendal nerve branches run below the sacrospinous ligament on the level of the sacrospinous and sacrotuberous ligaments.

The changes of the nerve and the branching thereof were most evident from the anterior access below the sacrospinous ligament and in front of the sacrotuberous ligament.

The inferior rectal nerve penetrating the sacrospinous ligament was seen in one case, it has risen from the pudendal nerve before entering the pudendal canal in four cases. The dorsal nerve of the penis has risen from the S<sub>1</sub> root in two cases (10 %). We observed its branching before entering the pudendal canal in 15 cases (75 %). It has divided in the pudendal canal in other cases.

This description may be useful particularly for the pudendal nerve block and the nerve saving surgeries directed on the relevant region (Fig. 8, Ref. 24). Full Text in PDF [www.elis.sk](http://www.elis.sk).

Key words: pudendal nerve, sacral plexus, sacrospinous ligament, sacrotuberous ligament.

The pudendal nerve is one of the sacral plexus branches; originating from the anterior branches of S<sub>2</sub> to S<sub>4</sub> sacral nerves. It is the sensory and motor nerve of the perineum, innervating the external anal sphincter, urethral sphincter, perineal muscles and the skin (1–5).

The main trunk of the pudendal nerve is formed proximally to the ischial spine, and medially and caudally to the sciatic nerve. It runs between the piriformis and coccygeus, medially to the pudendal vessels. Branches for the levator ani and coccygeus leave the pudendal nerve at the inferior margin of the piriformis. It then continues into the gluteal area through the greater sciatic foramen, and enters the pudendal canal through the lesser sciatic foramen.

It runs behind the sacrospinous ligament and in front of the sacrotuberous ligament, then continues ventrocaudally into the perineal area, where it enters the pudendal canal (Alcock) formed by divided fascia of obturatorius internus. During its course it gives off inferior anal nerves and inferior rectal nerves respectively, which rise from the pudendal nerve just before entering the pudendal canal, or leave the pudendal canal and enter the

proximal part of ischiorectal fossa; then they run through the fat and innervate the external anal sphincter and the skin around the anus (4, 5). Approximately in the centre of the pudendal canal it bifurcates into two branches – the perineal nerves and the dorsal nerve of the penis/clitoris. The perineal nerves serve for sensitive skin innervation of the perineal area, and motor branches are for the perineal muscles: superficial and deep transverse perineal muscles, bulbospongiosus and ischiocavernosus. By leaving the pudendal canal, the dorsal nerve of the penis/clitoris penetrates through transverse perineal muscle and enters the body of the penis, or reaches the clitoris. It participates in the innervation of the urogenital diaphragm: deep transverse perineal muscle and external sphincter muscle of urethra.

Depending on T<sub>12</sub> root presence, we talk about a high cranial prefixed lumbosacral plexus or low caudal one. The boundary root participating in the plexuses formation is L<sub>4</sub> root, which in some cases is largely involved in lumbar plexus formation and in sacral in others. Its proportion in that or the other plexus helps to characterize the whole plexus – as cranial prefixed with a share or caudal postfixed without a share of T<sub>12</sub> (6–8). It is necessary to realise that L<sub>4</sub> root does not always play the role of boundary root; sometimes it is L<sub>5</sub> root.

The variations in the anatomy of the pudendal nerve have been previously described (3–5,9), however we have not found in the literature dealing with variations of the pudendal nerve formation depending on the type of the lumbosacral plexus any deviations of its branches, e. g. those of the dorsal nerve of the penis/clitoris.

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**Material and methods**

The study involved 20 fresh cadavers without any known abnormalities. The ethics committee approval was obtained prior to the study. The age ranged between 50 and 75 years, average age was 62. Three of the dead bodies were those of females. Lumbosacral plexuses and the pudendal nerves were dissected and visualized bilaterally from the front after the evisceration in all cases. At the approach from the front, the position of the dead body was lying face upwards – supine position. The anterior access dissection enabled us to observe the pudendal nerve formation more easily and the variations of its rising branches: the inferior rectal nerve and dorsal nerve of the penis/clitoris.

At the approach from the back, the position of the dead body was lying face downwards – prone position. The posterior access dissection (after the division of sacrotuberous ligament, Fig. 8 enabled us to observe the pudendal nerve branches within the pudendal canal, particularly the perineal nerves after their leaving the pudendal canal.

Both anterior and posterior approaches were used in five cases.

In the posterior approach, we followed Mohsenipour (10); we have used a line between the tip of the greater trochanter and posterior iliac spine for an orientation in one case (corresponding with the piriformis course). The access was made 4cm below the centre of this line, parallel to the intertrochanteric line.

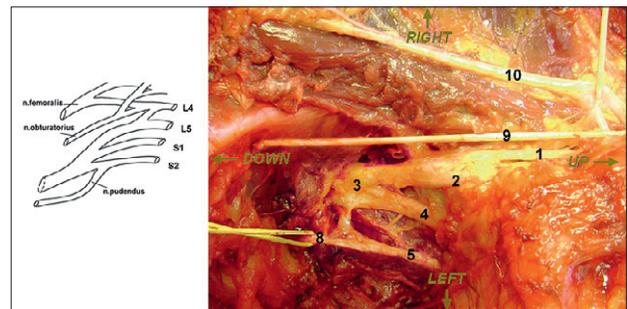
In another four cases we followed Schraffordt (3); this approach was clearer. We visualized the gluteus maximus from its origin on the sacrum, coccyx, ilium and sacrotuberous ligament, which was then separated from its attachment enabling the pudendal nerve observation. The nerve runs proximally to the greater sciatic foramen, distally into the pudendal canal. We exposed the course of the nerve.

We have observed the variations of its formation, depending on the type of the lumbosacral plexus formation.

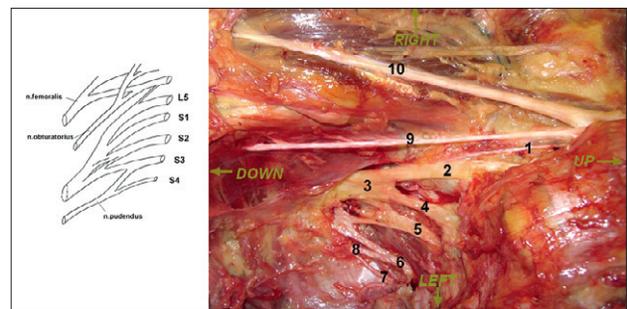
**Results**

The prefixed type plexus formation was observed in eight cases. In these cases S<sub>1</sub>, S<sub>2</sub> roots contributed to the formation of the pudendal nerve (Fig. 1). In the postfixed type particularly the S<sub>3</sub> root was dominant in two cases (66.7 %), and less the S<sub>4</sub> root in one case (23.3 %) from three cases (Fig. 2). Mostly the S<sub>2</sub> root participated in its formation in 17 cases (85 %). The pudendal nerve branches run below the sacrospinous ligament on the level of the sacrospinous and sacrotuberous ligaments.

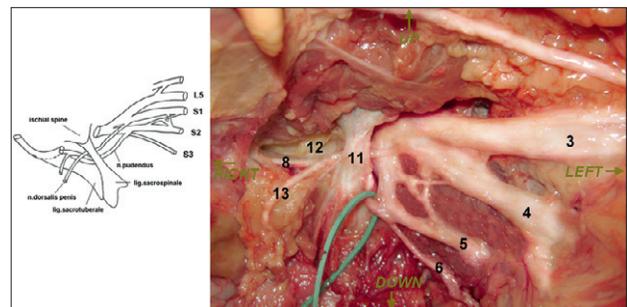
The pudendal nerve course was seen in the vicinity of the ischial spine in eight cases. In the prefixed type, it was in six cases (75 %); in the postfixed type, it was not even in one case. The changes of the nerve and the branching thereof were most evident from the anterior access below the sacrospinous ligament and in front of the sacrotuberous ligament (Figs 3, 4 and 5). This area – between the sacrotuberous and sacrospinous ligaments – is the area of its frequent compression, resulting in the development of entrapment syndromes. The narrow space between the sacrospinous and sacrotuberous ligaments – less than 5mm (6.7±1.7



**Fig. 1.** Prefixed type of the lumbosacral plexus – right side from the anterior, craniocaudal direction. The S<sub>2</sub> root dominates in formation of the pudendal nerve. Femoral nerve (10), obturator nerve (9), branch from L<sub>4</sub> root (1), L<sub>5</sub> root (2), lumbosacral trunk (3), S<sub>1</sub> root (4), S<sub>2</sub> root (5), pudendal nerve (8).



**Fig. 2.** Postfixed type of the lumbosacral plexus – right side from the anterior, craniocaudal direction. The S<sub>3</sub> root dominates in formation of the pudendal nerve. A thin branch from L<sub>4</sub> root (1) to L<sub>5</sub> root (2), lumbosacral trunk (3), S<sub>1</sub> root (4), S<sub>2</sub> root (5), S<sub>3</sub> root (6), S<sub>4</sub> root (7), pudendal nerve (8), obturator nerve (9), femoral nerve (10).



**Fig. 3.** The right side from the anterior. From right to left: lumbosacral trunk (3), S<sub>1</sub> root (4), S<sub>2</sub> root (5), S<sub>3</sub> root (6), sacrospinous ligament (11), dorsal nerve of penis (13), sacrotuberous ligament (12), pudendal nerve (8).

mm; range 4–10 mm) was seen in three cases (15 %). The ligament was seen sclerotic in five cases (62.5 %) above 70 years. The thickened pudendal nerve with evident macroscopic changes within the range of the sacrospinous ligament was seen in four cases, in which calcifications of the sacrospinous ligament were present. The evident muscle atrophy was observed in three cases. The pudendal nerve was compressed by the inferior margin of the sacrospinous ligament in eight cases (40 %). In all these cases it ran 2 to 5 mm from the attachment of the sacrospinous ligament

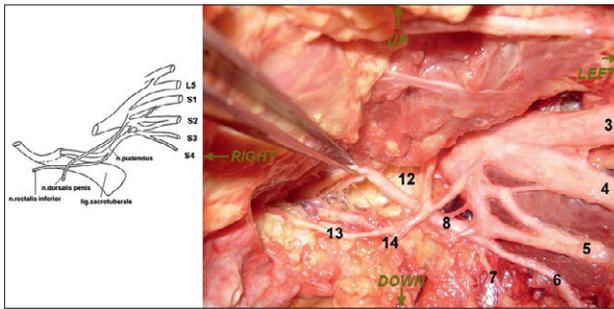


Fig. 4. The right side from the anterior. From right to left; after a division of sacrospinous ligament: lumbosacral trunk (3), S<sub>1</sub> root (4), S<sub>2</sub> root (5), S<sub>3</sub> root (6), S<sub>4</sub> root (7), the inferior rectal nerve (14), dorsal nerve of penis (13), pudendal nerve (8), sacrotuberous ligament (12).

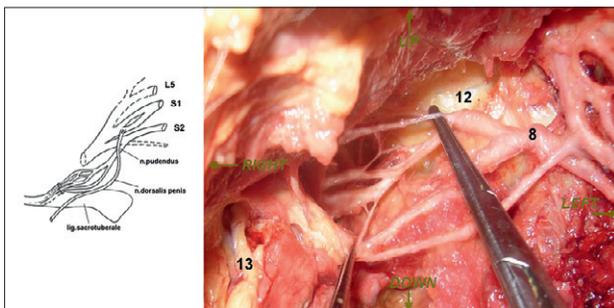


Fig. 5. The anterior view after a division of sacrospinous ligament, the right side. From right to left: pudendal nerve (8), sacrotuberous ligament (12), dorsal nerve of penis (13) leaving S<sub>1</sub> root.

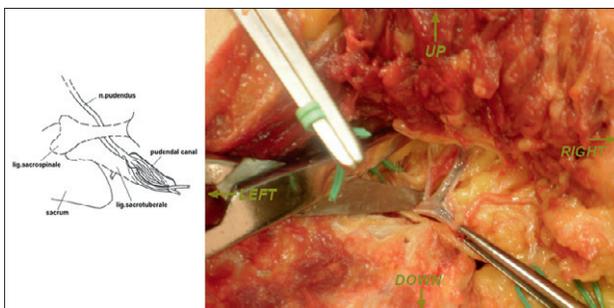


Fig. 6. The posterior view, the right side. After the opening of the pudendal canal, from left to right. Perineal nerve, dorsal nerve of penis, the inferior rectal nerve, vena and arteria pudenda.



Fig. 7. The posterior view, the right side, after opening of the pudendal canal, nerve and vessel bundle, perineal nerve.

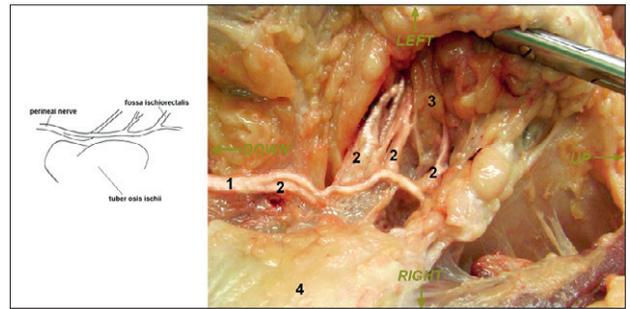


Fig. 8. The posterior view, the right side: perineal nerves – perineal nerve (1), perineal nerve branches (2), ischiorectal fossa (3), sciatic tuber (4).

to the ischial spine in most cases. The pudendal canal walls were thickened in two cases.

The inferior rectal nerve penetrating the sacrospinous ligament was seen in one case, it has risen from the pudendal nerve before entering the pudendal canal in four cases. The dorsal nerve of the penis has risen from the S<sub>1</sub> root in two cases. We observed its branching before entering the pudendal canal in 15 cases (75 %). It has divided in the pudendal canal in other cases (Figs 6, 7 and 8). For the posterior access the pudendal nerve was localized 13.1±0.72 cm (range 12–14 cm) medially to the greater trochanter, 8.1±0.72 cm (range 7–9 cm) above the ischial tuberosity, in the depth of 6.4±0.32 cm (range 6–7 cm). After identifying the pudendal nerve, the depth from the skin to the pudendal nerve was also measured according to the bony landmark.

The changes observed in the pudendal nerve dissection indicate that the most frequent potential cause of the pudendal nerve lesions is not the pudendal canal compression but the ligament conflict (5).

## Discussion

Variations in the anatomy of the pudendal nerve has been previously described (3–5, 11). However, there have been no records about forming of the pudendal nerve depending on the type of the lumbosacral plexus. We have only come across the works mentioning the participation of the individual roots of the sacral plexus at the formation of the pudendal nerve (1, 5, 12, 13). It is supposed that the deviations in lumbosacral plexus formation are caused by a deviation from the normal process of development during the fourth week of foetal development (14).

We observed the normal type of the lumbosacral plexus in nine cases and, in all of such cases the roots S<sub>2</sub> and S<sub>3</sub> participated.

In the prefixed type, the roots S<sub>1</sub> and S<sub>2</sub> predominated in all eight cases (Fig. 1). At the postfixed type, the roots S<sub>3</sub> and S<sub>4</sub> in three cases (Fig. 2). The contribution of the root S<sub>2</sub> was minimal.

The root S<sub>2</sub> participated in the forming of the pudendal nerve in 85 % of cases.

Unlike our observations, O'Bochere et al (13) state that particularly roots S<sub>2</sub> and S<sub>4</sub> participate in forming the pudendal nerve without the contribution of the roots S<sub>1</sub> and S<sub>5</sub>.

In their work, authors Nakanishi, Shafik et al (5, 12) mention

the participation in the forming of the pudendal nerve of the first and the fifth sacral roots – from 17.9 % up to 30 %. Nakanishi (12) observed the participation of the sacral root in 14.3 % and that of the fifth sacral root in 3.6 %.

Authors Mahakkanukrauh et al., Nakanishi (1, 12) observed the prevailing participation of the roots  $S_2$  and  $S_3$  at the forming of the pudendal nerve.

The dorsal nerve of the penis rose from the  $S_1$  root in two cases (10 %). O'Bichere et al (13) reported that 25 % of the dorsal nerves of the penis (or clitoridis) derived independently from  $S_2$  nerve root. The inferior rectal nerve penetrated through the sacrospinous ligament in one case (5 %). Mahakkanukrauh et al (1) and Roberts et al (15) observed a sacrospinous ligament penetration rate of 11 % to 20 % in his study of inferior rectal nerve variation. The pudendal nerve branches can sometimes penetrate through the sacrospinous or sacrotuberous ligaments (2, 15). The entrapment syndrome caused by the pudendal nerve compression was firstly described by the bicyclists in 1987 (16).

It may be pressed from the sacrospinous ligament up to the urogenital diaphragm. The pudendal nerve may be pressed within the pudendal canal resulting in the pudendal canal syndrome. The manifested symptoms include proctalgia and in addition to anal pain the motor or sensory manifestations of the pudendal neuropathy may occur (15, 17).

The pudendal nerve compression may occur in the space between sacrospinous and sacrotuberous ligaments. The narrowing of this space was observed in three cases. The narrowing of the space between sacrospinous and sacrotuberous ligament is also a result of variations in the anatomy of the two above-mentioned ligaments (11). The space between the sacrospinous and sacrotuberous ligaments is also a place of potential formation of haematoma, resulting in further nerve compression (3, 4, 18, 9).

Loukas et al (20) described the relationship between the pudendal nerve and the sacrotuberous ligament emphasizing the presence of the falciform process of sacrotuberous ligament and its relevance in the pudendal nerve entrapment syndrome. If the pudendal nerve becomes entrapped between this ligament process and the sacrospinous ligament causing perineal pain, the sacrotuberous ligament is surgically severed to relieve the pain. The variations of the pudendal nerve may be related to the intractable pain in the seated position.

The variations of  $S_1$  to  $S_5$  sacral roots are important in explaining clinical symptoms. Signs of the pudendal nerve lesion can also be observed in the case of the  $S_1$  nerve root lesions. Various grades of injury depends particularly on participation of  $S_1$  to  $S_4$  roots, in the dependency of the plexus type and the nerve rising variations.

Knowledge of the pudendal nerve variations is important for clinics (19, 21). In the prefixed type, the nerve roots receive more filaments from above-located spinal nerves. In such cases, the injuries of the nerve roots or the nerves are joined with more frequent peripheral lesion compared with those due to the same injuries in the postfixed type. In the postfixed type, the  $S_3$  root can have many filaments, normally carried in the  $S_2$  root, and the  $S_4$  contribution can be greater (22, 23).

Surgical treatment is considered, when the conservative therapy failed to be effective (5, 24).

## Conclusion

This description may be useful particularly for the pudendal nerve block and the nerve saving surgeries directed on the relevant region.

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Received January 25, 2012.

Accepted August 18, 2013.