

**Surgical anatomy of the pudendal nerve and its branches in
South Africans**

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RUNNING HEAD: Surgical Anatomy of the Pudendal nerve

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ABSTRACT:

Dissection of the pudendal nerve and its branches in 71 cadavers revealed anatomic variations not previously described. Knowledge of this variation is necessary to prevent nerve injury resulting in sexual or sensory dysfunction. Because descriptions vary, this study re-evaluated the anatomy of the PN as implicated in perineal procedures in South Africans. The course of the PN from the gluteal region into the perineum was dissected in an adult sample of both sexes and of African and European ancestry. Distances between PN and branches to applicable landmarks were measured. Basic descriptive statistics and comparisons were carried out between groups. In 5/13 African females the inferior rectal nerve (IRN) entered the gluteal region separately and in 12/13 cases it passed medial to the ischial spine with the PN. The dorsal nerve of the clitoris or penis (DNC/DNP) was closer to the bony frame in those of European ancestry. The IRN branches were more superficial in females, but deeper in males of European ancestry. In African females, a PN block and Richter stitch should be placed more medial. Outside-in transobturator tape procedures might endanger the DNC/DNP in obese individuals. In females of European ancestry the IRN branches are compromised during ischioanal abscess drainage. In males of European ancestry, the dorsal penile nerve block might be less effective. Predictions should be verified clinically.

Keywords: Pudendal nerve; inferior rectal nerve; transobturator tape; pudendal nerve block

INTRODUCTION

Knowledge of the anatomy of the pudendal nerve (PN) – more specifically, its course, branches and variations – is of great importance in performing perineal surgery. Entrapment of the pudendal nerve or branches during perineal surgery could result in sexual dysfunction.¹⁻⁴ Findings in the literature researched are inconsistent and do not provide detailed descriptions of the anatomy of the PN in its entirety, including possible variations that could be encountered during procedures.⁵⁻¹¹ Some of the discrepancies reported could be attributed to limited sample sizes, limited exposure or differences in terminologies or populations used.^{5,7, 12-15} For these reasons the sample number and exposure areas were expanded in this study and attention was given to differences among population groups.

The aim of this study was to re-evaluate the PN, its branches and their relationships, as it is implicated in various perineal procedures. This re-evaluation will enable the clinician to perform these procedures with more safety, precision and confidence. For purposes of this study, the nerve and its variations were assessed in South African populations.

Perineal procedures considered in this study, involving the PN and branches, included: Richter's procedure (transvaginal sacrospinous colpopexy) for the treatment of vaginal vault prolapse. During the Richter's procedure, the pudendal nerve (PN), sciatic nerve and inferior gluteal vessels are at risk as the anterior or posterior vaginal wall is suspended to the sacrospinous ligament.^{1,2,5,16-20} During this procedure a

stitch is placed through the anterior or posterior vaginal wall and into the sacrospinous ligament. PN and dorsal penile nerve block; ischioanal abscess and fistula drainage and several urinary incontinence mesh tapes procedures in which a mesh is placed under the mid-urethra for the treatment of stress urinary incontinence in males and females.^{21,22}

MATERIALS AND METHODS

A total of 71 adult cadavers, comprising 42 males and 29 females of both European and African ancestry were obtained from hospitals in the Northern Gauteng region. The cadavers have been embalmed with a formalin solution prior to dissection. The cadavers were dissected in the dissection halls of the University of Pretoria and the University of Limpopo (Medunsa campus). Two approaches were used to dissect the course of the PN and its branches from its exit from the pelvis to its terminal branches in the perineum: gluteal from posterior and perineal from anterior.

Figure 1 and 2 indicates all measurements taken between bony landmarks and the PN or its various branches.

For the gluteal approach a superior oblique incision was made, starting at the posterior superior iliac spine (PSIS), terminating at the greater trochanter (GT). A medial incision was made connecting the PSIS to the tip of the coccyx, extending circularly around the anus and terminating at the penile root (bulb of corpus spongiosum). In females, the circular incision extended along the external border of the labia majora. The

medial incision terminated at the pubic symphysis. The underlying gluteus maximus muscle and sacrotuberous ligament were detached from their origins and reflected laterally. The underlying pudendal neurovascular bundle, ischial spine and sacrospinous ligament was exposed. The PN and its branches were dissected from their entry into the gluteal region to their terminal branches in the ischioanal fossa. The distance was measured from the ischial spine to the PN (figure 1a), as implicated in the Richter's procedure and pudendal nerve block. The distance between the superior and inferior borders of the sacrospinous ligament was measured (figure 1 b, c) as implicated in the Richter's procedure. The distance from the anal verge to the anal branches of the IRN were measured as is implicated in ischioanal abscess and fistula drainage.

Figure 1

For the perineal approach, a curved incision was made from the superior border of the pubic symphysis, towards the ischial tuberosity. The DNC/DNP was dissected. The following distances were measured in females and males, as it is implicated in urinary incontinence mesh tape procedures. Figure 2 indicates the measurements taken between identified bony landmarks and the DNC in females. Similar measurements were taken in males. The distance between the most inferior point of the pubic symphysis to the DNC (figure 2g) were measured. The shortest distance from the junction of the body of the pubis and the inferior pubic ramus, to the DNC (figure 2h). The shortest distance from the inferior pubic ramus to the DNC (figure 2i). The

distance from the midline, at the level of the inferior pubic ramus, to the DNC (figure 2j). In males, the distance between the bulb and the perineal nerve branches was measured. All measurements and findings were integrated and considered in an assessment of their implications for these procedures.

Figure 2.

RESULTS

Description of the course and branches of the pudendal nerve

The IRN entered the gluteal region separately without branching from the PN in 8/27 males and 5/13 females of African ancestry as opposed to 0/15 males and 1/16 females of European ancestry (Table 2, Figure 3a).

Table 1 represents the basic descriptive statistics for all the distances between the PN and its branches to the identified landmarks. Table 2 and Figure 3, the course and various branching patterns (indicated with corresponding letters) of the PN and IRN in the gluteal region are reflected.

Table 1.

Table 2.

Figure 3.

The PN (before or after branching from the IRN branch) coursed medially to the internal pudendal vessels and descended posterior to the

sacrospinous ligament. In 5/15 males and 10/16 females of European ancestry, the PN more often passed posterior to the ischial spine (Figure 1b) compared to the low incidence of 0/27 males and 1/13 females of African ancestry. The PN was found medial to the ischial spine (Figure 1c) in all males and 12/13 females of African ancestry as compared to 10/15 males and 6/16 females of European ancestry.

In individuals of European ancestry, the IRN branched from the PN at the superior border of the sacrospinous ligament in 11/15 males and 11/16 females compared to 15/27 males and 7/13 females of African ancestry. This variation meant that the IRN and PN crossed the ligament as two separate structures (Figure 1d). In the remaining cases, the IRN branched from the PN at the inferior border of the sacrospinous ligament, in this way crossing the ligament as one structure (Figure 1e).

The IRN passed posterior to the ischial spine with the PN in 10/16 females of European ancestry (Figure 1f). The IRN was found medial to the ischial spine in all males and 12/13 females of African ancestry (Figure 1g). It was noted that the PN and IRN were found further from the ischial spine and closer to the midline in individuals from African ancestry compared to individuals from European ancestry (Table 1b,c,f,g).

The DNC/P were found closer related to the bony frame of the pubis in females than in males. On average, the DNC were found 0.56 mm and 0.15 mm from the pubic symphysis in females of African ancestry and European ancestry respectively. The distance between the junction of

the body of the pubis and the inferior pubic ramus were significantly less in females than in males, and in those of African ancestry than European ancestry.

The terminal sphincteric branches of the IRN were found to be more superficial in females, especially in individuals of European ancestry. The minimum distance between the external anal skin and the most superficial sphincteric branch in females ranged between 3.25 and 6.45 mm, while in males, it ranged between 9.05 and 10.5 mm.

Variations noted in the branching pattern of the PN included the fusion of the PN and IRN after they crossed over the ischial spine; within 15 mm, an accessory IRN branched from the PN. An accessory IRN was also found in one female of African ancestry. Accessory branches also originated from the perineal nerve. In one male of African ancestry, an IRN branched from the PN to fuse with the separate IRN at the inferior border of the sacrospinous ligament.

DISCUSSION

The variations in the course of the PN and branches and the distances measured from bony landmarks have relevance for various perineal procedures. With regard to the Richter's procedure it is important to note that in females of African ancestry. Table 1 indicates that the sacrospinous ligament is significantly shorter in females of African ancestry and the PN and/or IRN are found more medial in 93.21% of cases compared to 37.5% in females of European ancestry. The placed

structures might be in danger as these nerves encroach into the area available for stitch placement. It is therefore recommended that the stitch be placed further away than 20 mm from the ischial spine in this population group, to ensure that it will avoid PN and/or IRN entrapment, which could lead to sexual dysfunction. This recommendation is in line with the proposal of Sagsoz et al.²³ and Pirro et al.¹³ that the stitch should be placed in the medial portion of the ligament, closer to the sacrum and as superficial as possible to avoid damage to the PN and its branches.

As the trocar needles used in the outside-in transobturator tape procedure have a standardized curve, the trocar may exit closer to the inferior pubic ramus and the related DNC/DNP than intended in individuals who have a higher body mass index or greater skeletal dimensions. This might lead to the entrapment of the DNC/DNP which could lead to sexual dysfunction. The DNC was found 3.79 ± 0.61 mm from the junction between the pubic body and the inferior pubic ramus in females of European ancestry and 3.92 ± 0.76 mm from the junction in females of African ancestry. The DNC/DNP was significantly closer to the junction in those of European ancestry compared to those of African ancestry. Conversely by scraping the inferior pubic ramus border while trying to exit in the genitofemoral fold during the inside-out transobturator tape procedure might cause damage to the DNC as reported by Delmas²⁴ and Delorme et al.²⁵ In males, dissections within 1 cm from the lateral border of the bulb of the penis should be avoided

during transobturator procedures in order to preserve ascending deep perineal branches.

The accurate location of the PN and its branches is important in the positioning of the needle for a PN block in order for the PN to be totally anesthetized. In 92.31% of females of African ancestry, the PN and the IRN were found medial to the ischial spine, therefore further away, compared to only 37.5% of cases in the females of European ancestry. To ensure that both terminal branches are anesthetized in females of African ancestry, the anesthetic should be injected more medial and proximal to the ischial spine before the PN crosses over the sacrospinous ligament.

The branches of the IRN were 12.9 ± 5.8 mm from the surface in females of European ancestry, which was significantly more superficial compared to all other groups and therefore could be more at risk during ischioanal abscess and fistula drainage. The branches were found deeper in more obese cadavers, commonly seen in males of European ancestry, compared to leaner cadavers.

Excess fat noted in obese cadavers increased the distance between the most inferior point of the pubic symphysis and the DNP in males. This increased distance might have an influence on the effectiveness of the anesthetic during a dorsal penile nerve block as the anesthetics might be injected further from the DNP than intended.

The PN and its branches might also be endangered during other pelvic surgeries, especially for the treatment of rectal cancers, not investigated in this study. These procedures include pelvic exenteration, radical

cystoprostatectomy and low anterior resection for lower rectal cancer (total mesorectal excision).²⁷⁻³¹

In conclusion, although this study was limited to South Africans, these results are intended to stimulate a greater awareness of the possible variations of the PN and its branches as implicated in the various clinical procedures in a greater setting. The before-mentioned predicted implications of the variations in the PN and branches amongst the populations and sexes in South Africans, however, should be verified in the clinical setting and future studies verifying the predictions and recommendations made are envisaged.

ETHICAL CONSIDERATIONS

In terms of cadaver material, the project is covered by the National Health Act No. 61 of 2003.²⁶ In addition, this research forms part of the MSc (Protocol no: S56/2012) titled: 'The Anatomy of the Pudendal nerve and its Branches and the clinical implication thereof' for which ethics approval from the Research Committee of the Faculty of Health Sciences of the University of Pretoria was obtained.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Table 1: Basic descriptive statistics for distances measured in mm from the pudendal nerve and its branches to identified landmarks

Parameter	Males of African ancestry (n=27)	Males of European ancestry (n=15)	Females of African ancestry (n=13)	Females of European ancestry (n=16)
a. Ischial spine to PN ^{1a}	3.43 <i>2.31</i> (0-7.40)	1.53 <i>0*</i> (0-7.40)	4.58 <i>2.37</i> (0-8.40)	1.71 <i>0*</i> (0-5.90)
Ischial spine to IRN ^{2a}	8.58 <i>4.73</i> (2.30-18.05)	1.94 <i>1.6*</i> (0-8.60)	8.72 <i>4.14</i> (3.05-14.45)	5.17 <i>4.65</i> (0-12.66)
b. Distance between the superior attachments of the sacrospinous ligament ^{a,b}	37.11 <i>4.80</i> (29.35-48.55)	39.69 <i>5.64</i> (31.45-54.70)	46.21 <i>5.03</i> (38.80-57.93)	49.69 <i>3.62</i> (43.45-57.20)
c. Distance between the inferior attachments of the sacrospinous ligament ^{a,b}	46.07 <i>5.18</i> (33.49-56.60)	46.69 <i>4.53</i> (40.70-57.80)	52.78 <i>3.90</i> (46.85-59.85)	57.85 <i>4.83</i> (48.97-65.30)
d. External anal skin to IRN ^{a,b} (minimum value)	16.6 <i>3.83</i> (9.05-24.00)	17.89 <i>3.41</i> (10.50-23.00)	14.54 <i>5.04</i> (6.45-20.90)	12.9 <i>5.82</i> (3.25-24.10)
e. External anal skin to IRN ^b (intermediate value)	20.69 <i>3.48</i> (15.85-28.90)	20.93 <i>2.73</i> (15.90-25.10)	17.13 <i>4.57</i> (7.55-22.45)	17.10 <i>5.91</i> (8.50-25.50)
f. External anal skin to IRN (maximum value)	22.13 <i>3.07</i> (16.55-26.40)	24.45 <i>2.51</i> (20.80-27.80)	19.79 <i>5.94</i> (10.50-26.70)	22.09 <i>4.48</i> (13.24-25.60)
g. Most inferior point of the pubic symphysis to DNP/C ^b	1.15 <i>0.90</i> (0-3.40)	1.55 <i>1.28</i> (0-4.10)	0.56 <i>0*</i> (0-3.45)	0.15 <i>0*</i> (0-2.38)
h. Junction between body of pubis and inferior pubic ramus to DNP/C ^{a,b,c}	5.1 <i>0.66</i> (4.03-6.24)	4.22 <i>0.68</i> (2.89-5.75)	3.92 <i>0.76</i> (2.96-5.86)	3.79 <i>0.61</i> (2.80-5.42)
i. Inferior pubic ramus to DNP/C	2.23 <i>1.46</i> (0-4.87)	2.12 <i>0.78</i> (1.05-3.90)	1.96 <i>1.05</i> (0.50-4.75)	2.21 <i>0.84</i> (1.30-4.05)
j. DNP/C to midline @ inferior border of pubic symphysis ^c	10.41 <i>2.09</i> (7.26-14.46)	11.50 <i>2.16</i> (5.2-14.8)	11.22 <i>1.18</i> (9.2-12.75)	10.9 <i>1.18</i> (8.3-12.75)
k. Bulb of the penis to perineal nerve branch (minimum value)	4.47 <i>2.50</i> (0-8.25)	6.28 <i>2.38</i> (0-8.70)	-	-
l. Bulb of the penis to perineal nerve branch (maximum value)	9.90 <i>2.19</i> (5.95-15.48)	8.88 <i>3.95</i> (2.53-19.60)	-	-

The sample size is indicated by n values. The mean (mm) values are indicated in **bold**. The standard deviation is indicated in *italics*, the range is shown within the round (brackets). The * indicates that intrapopulation variation exceeded possible interpopulation variation, median values were given in these cases

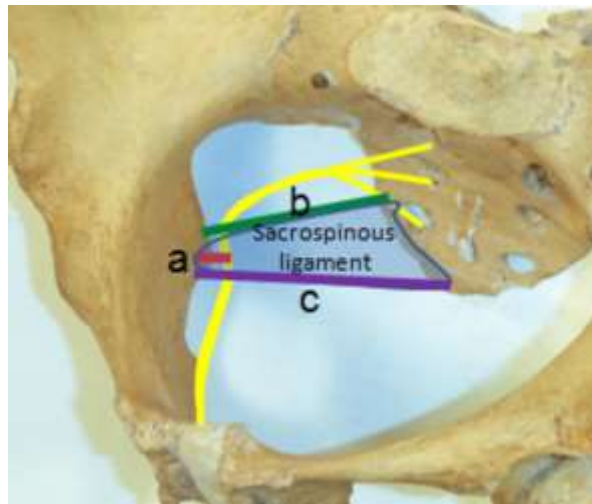
^aIndicates a significant difference in the mean values between population groups, ^bIndicates a significant difference in the mean values between sex groups, ^cIndicates an interaction between population and sex groups

Table 2. The proportion of individuals with defined course and branching patterns of the PN and IRN in the gluteal region by ancestry and sex

Course and branches	Males	of	Males	of	Females	of	Females	of
	African ancestry n=27		European ancestry n= 15		African ancestry n=13		European ancestry n=16	
a. Separate exit of IRN from pelvis (Fig. 3)	29.63% 8/27		0% 0/15		38.46% 5/13		6.25% 1/16	
b. PN passed posterior to the ischial spine	22.22% 6/27		66.67% 10/15		7.69% 1/13		62.5% 10/16	
c. PN passed medial to the ischial spine	77.78% 21/27		33.33% 5/15		92.31% 12/13		37.5% 6/16	
d. IRN originated at superior border of sacrospinous ligament	55.56% 15/27		73.33% 11/15		53.85% 7/13		68.75% 11/16	
e. IRN originated at inferior border of sacrospinous ligament	14.81% 4/27		26.67% 4/15		7.69% 1/13		25% 4/16	
f. IRN and PN passed posterior to the ischial spine	0 0/27		33.33% 5/15		7.69% 1/13		62.5% 10/16	
g. IRN passed medial to the ischial spine	100% 27/27		66.67% 10/15		92.31% 12/13		37.5% 6/16	

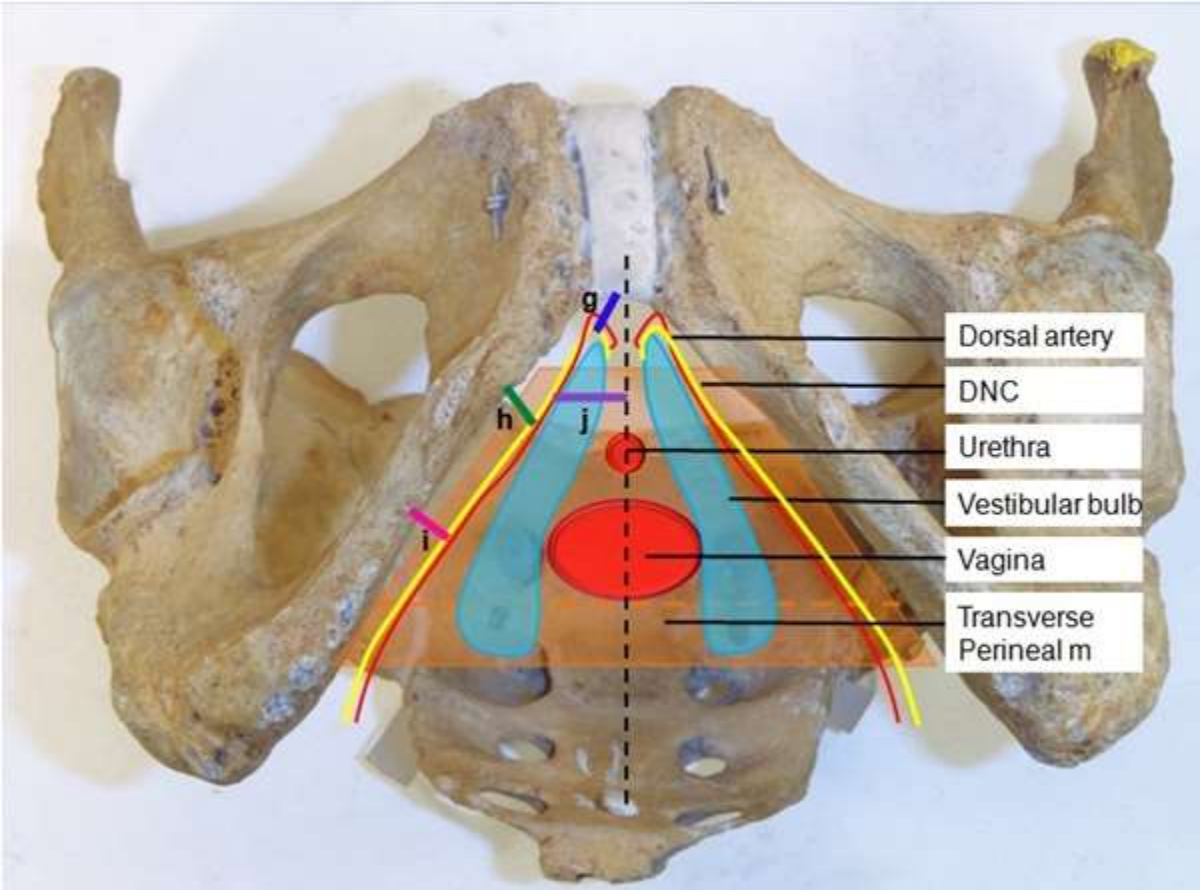
LEGENDS

Figure 1. Pudendal nerve relations



a, Ischial spine to PN; b, Distance between superior attachments of sacrospinous ligament; c, Distance between inferior attachments of sacrospinous ligament

Figure 2. Anteroinferior view of a female pelvis indicating measurements taken between landmarks and DNC.



g, Most inferior point of the pubic symphysis to the DNC; h, Junction of the body of pubis and the inferior pubic ramus to the DNC; i, Inferior pubic ramus to DNC; j, DNC to the midline (measurement taken at inferior border of pubic symphysis)

Figure 3.

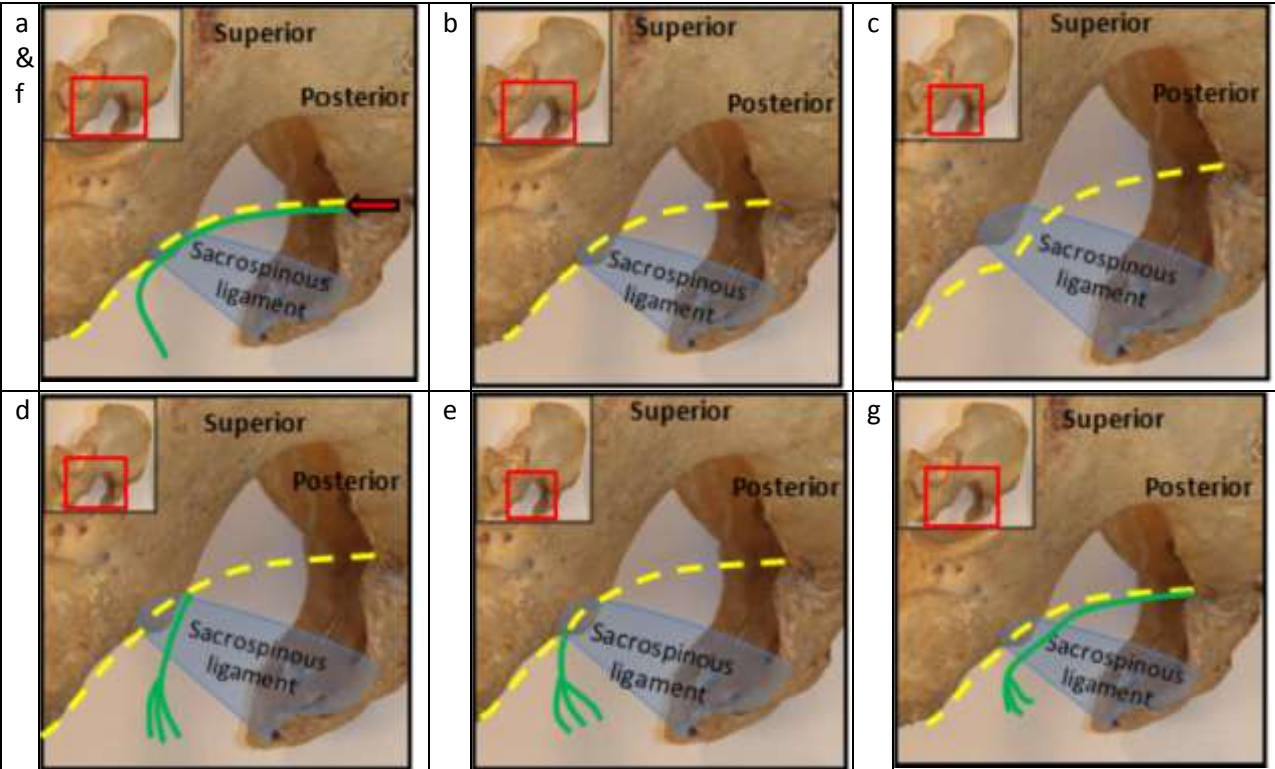


Figure 3. Diagrams depicting the course and branching pattern of the pudendal nerve (PN), indicated with a continuous line, and inferior rectal nerve (IRN), indicated with a dashed line, in the gluteal region as set out in Table 2. - - - -: Course of the PN _____: