Anatomic variations of the Sacral plexus in Thais

Supichya Chanpak, M.Sc.*
Sanjai Sangvichien, M.D., D.Sc.*
Aporn Chuncharunee, D.V.M., M.Sc.*†
Kittipun Aronphalungsunti, B.Sc.*

Abstract : **The aim of this study was to examine the variation of the sacral plexus in Thais in terms of its origin, branches, and variation in each branch. Anatomical dissections were conducted in 150 halves of formalin–embalmed cadavers. All preserved cadavers were Thais, ranging in age from 35 to 85 years old, 86 males and 64 females. The sacral plexus was markedly comprised of the fourth lumbar to fourth sacral ventral rami (L_4-S_4) in 98.67% of the plexuses (or 148 cases) except for two plexuses (1.33% of the plexuses) those were derived from the ventral rami of the fourth lumbar to fifth sacral ventral rami (L_4-S_5). The sacral plexus, lying on the posterior wall of the lesser pelvis anterior to the piriformis muscle, has nine named branches. Six of these are distributed to the buttock and lower limb, including *1) Nerve to the Quadratus Femoris and Gemellus Inferior, 2) Nerve to the Obturator Internus and Gemellus Superior, 3) Superior Gluteal, 4) Inferior Gluteal, 5) Posterior Femoral Cutaneous and 6) Sciatic.* The other branches supply structures belonging to the pelvis, including *7) Nerve to the Piriformis, 8) Pudendal and 9) Pelvic Splanchnic.* The variant of origination and formations of all branches occur on both sides. However, the anatomic variability of the plexuses was not statistically different with regard to either side or gender. The results from this study provided additional information and new insights into the sacral plexus in terms of its origins, branches, and variations of each branch that might be useful in medicine, anesthesia, surgery and physical therapy.**

Key words : sacral plexus, anatomy, variation, Thais

เรื่องย่อ : **ความหลากหลายของโครงข่ายประสาทส่วนก้นกบในคนไทย**

สุพิชญา จันทร์พรรค วท.ม.*, สรรใจ แสงวิเชียร พ.ด.*, อาภรณ์ จันท์จารุณี วท.ม.*†, กิตติพันธุ์ อรุณพลังสันติ วท.บ.*

**ภาควิชากายวิภาคศาสตร์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพมหานคร 10700.*

สารศิริราช 2547; 56: 297-307.

วัตถุประสงค์เพื่อศึกษากำเนิดและรูปแบบการเรียงตัวของแขนงโครงข่ายประสาทส่วนก้นกบ (sacral plexus) ในคนไทย การศึกษาโดยการชำแหละโครงข่ายประสาทส่วนเอว จำนวน 150 โครงข่าย จากศพอาจารย์ใหญ่ช่วงอายุ 35 ถึง 85 ปี ประกอบด้วยโครงข่ายประสาทของเพศชาย 84 โครงข่าย และเพศหญิง 64 โครงข่าย ผลการศึกษาพบว่าโครงข่ายประสาทส่วนก้นกบของคนไทย 148 โครงข่ายหรือร้อยละ 98.67 มีกำเนิดจากประสาทไขสันหลังส่วนเอวที่ 4 ถึงประสาทไขสันหลังส่วนก้นกบที่ 4 ยกเว้น 2 โครงข่าย หรือร้อยละ 1.33 มีกำเนิดจากประสาท

**Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700.*

†*Corresponding author*

ไขสันหลังส่วนเอวที่ 4 ถึงประสาทไขสันหลังส่วนก้นกบที่ 5 ตำแหน่งของโครงข่ายประสาทส่วนก้นกบอยู่ที่ผนังด้านหลังของเชิงกรานโดยอยู่หน้าต่อกล้ามเนื้อ piriformis ให้กำเนิดประสาท 9 เส้น โดยประสาท 6 เส้นไปเลี้ยงก้นและขา ได้แก่ 1) Nerve to the quadratus femoris and gemellus inferior 2) Nerve to the obturator internus and gemellus superior 3) Superior gluteal nerve 4) Inferior gluteal nerve 5) Posterior femoral cutaneous nerve 6) Sciatic nerve ส่วนอีก 3 เส้นไปเลี้ยงเชิงกรานได้แก่ 7) Nerve to the piriformis 8) Pudendal nerve 9) Pelvic splanchnic nerves

สรุปความหลากหลายของแขนงโครงข่ายประสาทส่วนก้นกบพบทั้งสองข้าง แต่ไม่มีความแตกต่างระหว่างข้างซ้าย-ขวา และเพศชาย-หญิง ผลการศึกษาครั้งนี้ได้ข้อมูลเพิ่มเติมมากขึ้น และข้อมูลใหม่ ในความหลากหลายของกำเนิดและรูปแบบการเรียงตัวของแขนงโครงข่ายประสาทส่วนก้นกบที่สามารถนำมาประยุกต์ใช้ทางด้านศัลยกรรม การรักษา การวางยาสลบ และการฟื้นฟูทางกายภาพบำบัด

INTRODUCTION

The sacral plexus is the nerve plexus which lies on the posterior wall of the lesser pelvis anterior to the piriformis muscle. According to typical textual descriptions[1-5], the plexus originates from the fourth lumbar through the fourth sacral ventral rami (L_4-S_4). There are nine named branches arising from the sacral plexus: nerve to the quadratus femoris and gemellus inferior, nerve to the obturator internus and gemellus superior, superior gluteal nerve, inferior gluteal nerve, posterior femoral cutaneous nerve, sciatic nerve, nerve to the piriformis, pudendal nerve, and pelvic splanchnic nerves. The knowledge of the precise anatomy and anomalies of the sacral plexus and its branches is essential for performing a block of the sacral plexus and its branches[6], for diagnosing the cause of pain, and treating entrapment neuropathy and nerve injuries[7-8], for surgical treatment such as pudendal canal decompression[9-10], piriformis muscle syndrome[11], operating in the perineal region[12], and for neurostimulation,[10] etc. Additionally, studies on the origin of sacral plexus and the variations of its branches, however, are not conclusive and are still controversial[13-16]

Therefore, the aim of this study was to examine the variation of the sacral plexus in Thais in terms of its origin, branches, and variations in each branch. Consequently, a comparison of described variations to those known from former studies was performed; the influences of gender and side differences were also taken into consideration.

MATERIALS AND METHODS

Anatomical dissections of the sacral plexus were conducted in 150 halves of formalin–embalmed cadavers at the Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University. All preserved cadavers were Thais, ranging in age from 35 to 85 years. There were 86 males and 64 females. The approach to dissection was to first remove the skin and subcutaneous fat of the entire abdomen and thigh. The abdomen was then opened and the visceral organs and retroperitoneal fat were removed. The psoas major muscle was carefully removed and each root of the sacral plexus was determined. After exploring the origin of the sacral plexus, its branches and the variations of each branch were identified and recorded.

RESULTS

The sacral plexus was formed by the lumbosacral trunk (L_4-L_5), the ventral rami of the first through fourth sacral nerves. All of the contributing nerves, except S_4, were divided into anterior and posterior branches. As above, it was found in 148 plexuses or 98.67% (Figure 1). However, two plexuses (1.33 %) were derived from the ventral rami of the fourth lumbar through the fifth sacral ventral rami (L_4-S_5). The sacral plexus, lying on the posterior wall of the lesser pelvis anterior to the piriformis muscle, had nine named branches. Six of these were distributed to the buttock and lower limb, including

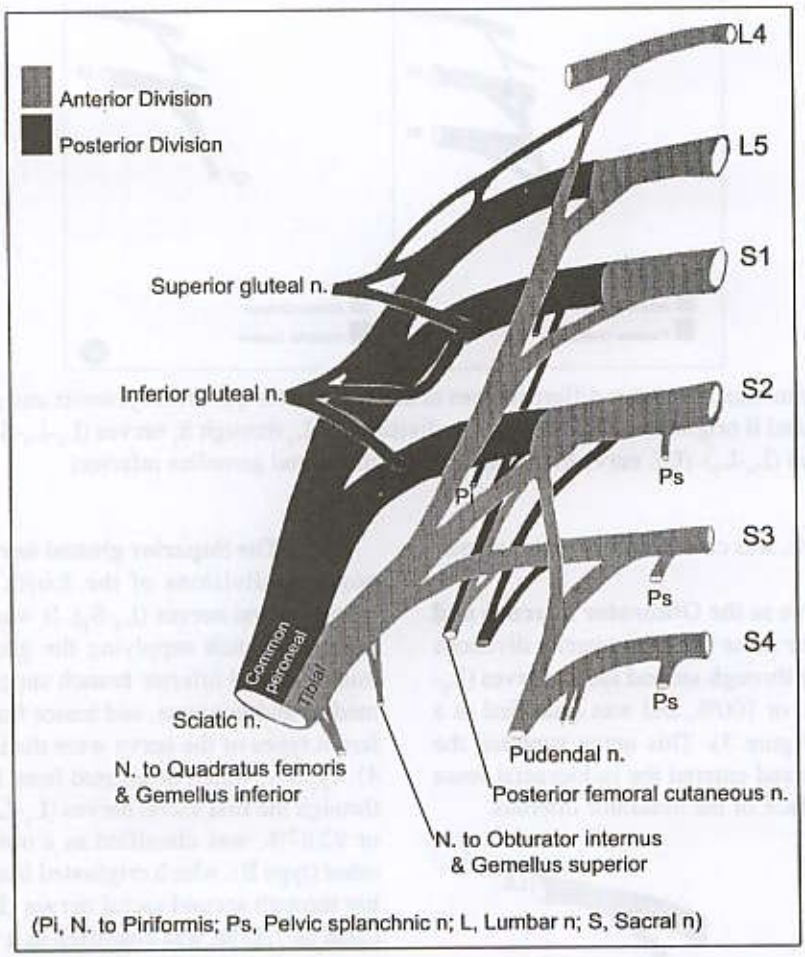

Figure 1. A diagram showing the normal pattern of origin and formation of sacral plexus and its branches. The plexus included contributions from L_4 through S_4 nerves (L_4-S_4). All of the contributing nerves, except S_4, were divided into anterior and posterior divisions.

1) nerve to the quadratus femoris and gemellus inferior, 2) nerve to the obturator internus and gemellus superior, 3) superior gluteal nerve, 4) inferior gluteal nerve, 5) posterior femoral cutaneous nerve and 6) sciatic nerve. The other branches supply structures belonging to the pelvis, including *7) Nerve to the Piriformis, 8) Pudendal nerve, and 9) Pelvic Splanchnic nerves* (Figure 1). The variant of origination and formations of all branches occurred on both sides and were described as follows:

The Nerve to the Quadratus femoris and Gemellus inferior arose from the anterior divisions of the fourth and fifth lumbar and/or first sacral nerves. It supplied the hip joint, inferior gemellus, and ended in the anterior surface of the quadratus femoris. Based on origins from the sacral plexus, two different types of nerve were distinguished (Figure 2). Type A, which originated from three roots, the fourth and fifth lumbar and first sacral nerves (L_4-L_5-S_1) in 146 cases or 97.33%, was classified as a normal pattern. The other (or type B), which originated from two roots (L_4-L_5)

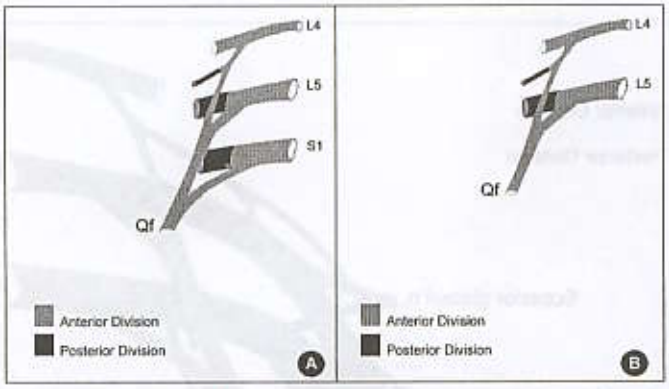

Figure 2. A diagram illustrating two different types of the *nerve to the quadratus femoris and gemellus inferior*. Type A and B originated from the anterior divisions of L_4 through S_1 nerves (L_4-L_5-S_1), and L_4 through L_5 nerves (L_4-L_5). (Qf, nerve to the quadratus femoris and gemellus inferior)

in 4 cases or 2.67%, was classified as a variation pattern.

The Nerve to the Obturator internus and Gemellus superior arose from the anterior divisions of the fifth lumbar through second sacral nerves (L_5-S_1-S_2) in all cases, or 100%, and was classified as a normal pattern (Figure 3). This nerve supplied the superior gemellus and entered the ischiorectal fossa on the medial surface of the obturator internus.

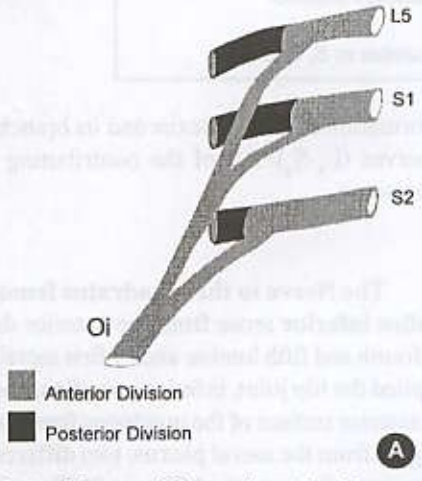

Figure 3. A diagram illustrating the Nerve to the *Obturator Internus and Gemellus Superior* originated from the anterior divisions of L_5 through S_2 nerves (L_5-S_1-S_2). (Oi, Nerve to the Obturator internus and Gemellus superior)

The Superior gluteal nerve arose from the posterior divisions of the fourth lumbar through second sacral nerves (L_4-S_2). It was divided into the superior branch supplying the gluteus medius and minimus, and inferior branch supplying the gluteus medius and minimus, and tensor fascia lata. Two different types of the nerve were distinguished (Figure 4). Type A, which originated from the fourth lumbar through the first sacral nerves (L_4-L_5-S_1) in 139 cases or 92.67%, was classified as a normal pattern. The other (type B), which originated from the fourth lumbar through second sacral nerves (L_4-L_5-S_1-S_2) in 11 cases or 7.33%, was classified as a variation pattern.

The Inferior gluteal nerve leaves the pelvis below the piriformis and passes to the gluteus maximus. It arose from the posterior divisions of the fifth lumbar through second sacral nerves (L_4-S_2). Based on its origin, two different types of the nerve were distinguished (Figure 5). Type A, which originated from the posterior divisions of the fifth lumbar through second sacral nerves (L_5-S_1-S_2) in 144 cases or 96%, was classified as a normal pattern. Type B, which originated from the posterior divisions of the fifth lumbar and first sacral nerves (L_5-S_1) in 6 cases or 4%, was classified as a variation pattern.

The Posterior femoral cutaneous nerve is distributed to the skin of the perineum and posterior surface of the thigh and leg. Four different types of the nerve were distinguished (Figure 6). Type A, which originated from the posterior divisions of the

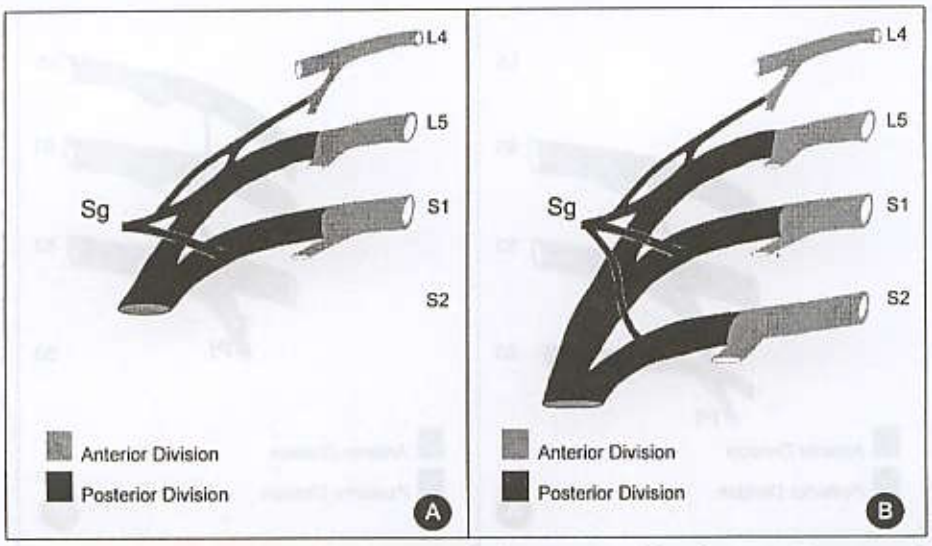

Figure 4. A diagram illustrating two different types of the *superior gluteal nerve*. Types A and B originated from the posterior divisions of L_4 through S_1 nerves (L_4-L_5-S_1), L_4 through S_2 nerves (L_4-L_5-S_1-S_2). (Sg, Superior gluteal nerve)

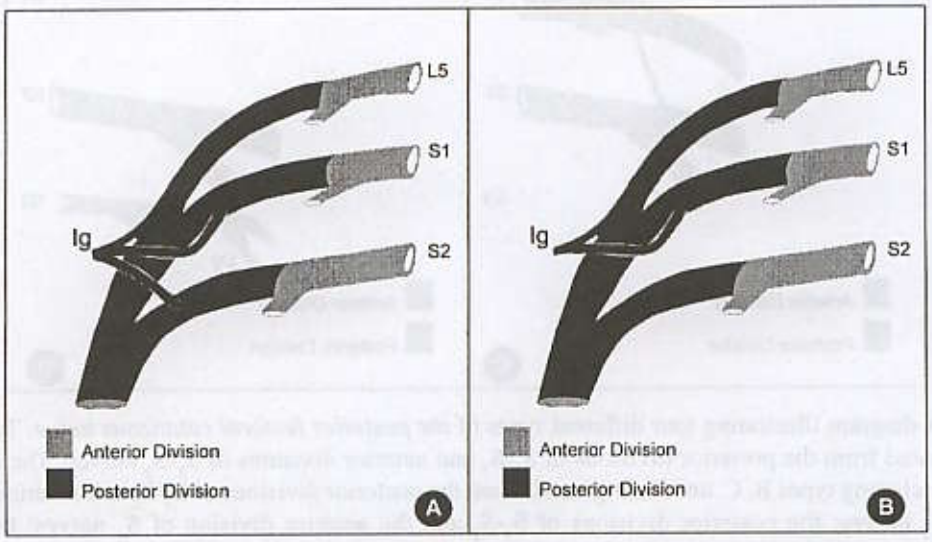

Figure 5. A diagram illustrating two different types of the *inferior gluteal nerve*. Types A and B originated from the posterior divisions of L_5 through S_2 nerves (L_5-S_1-S_2), L_5 through S_1 nerves (L_5-S_1). (Ig, Inferior gluteal nerve)

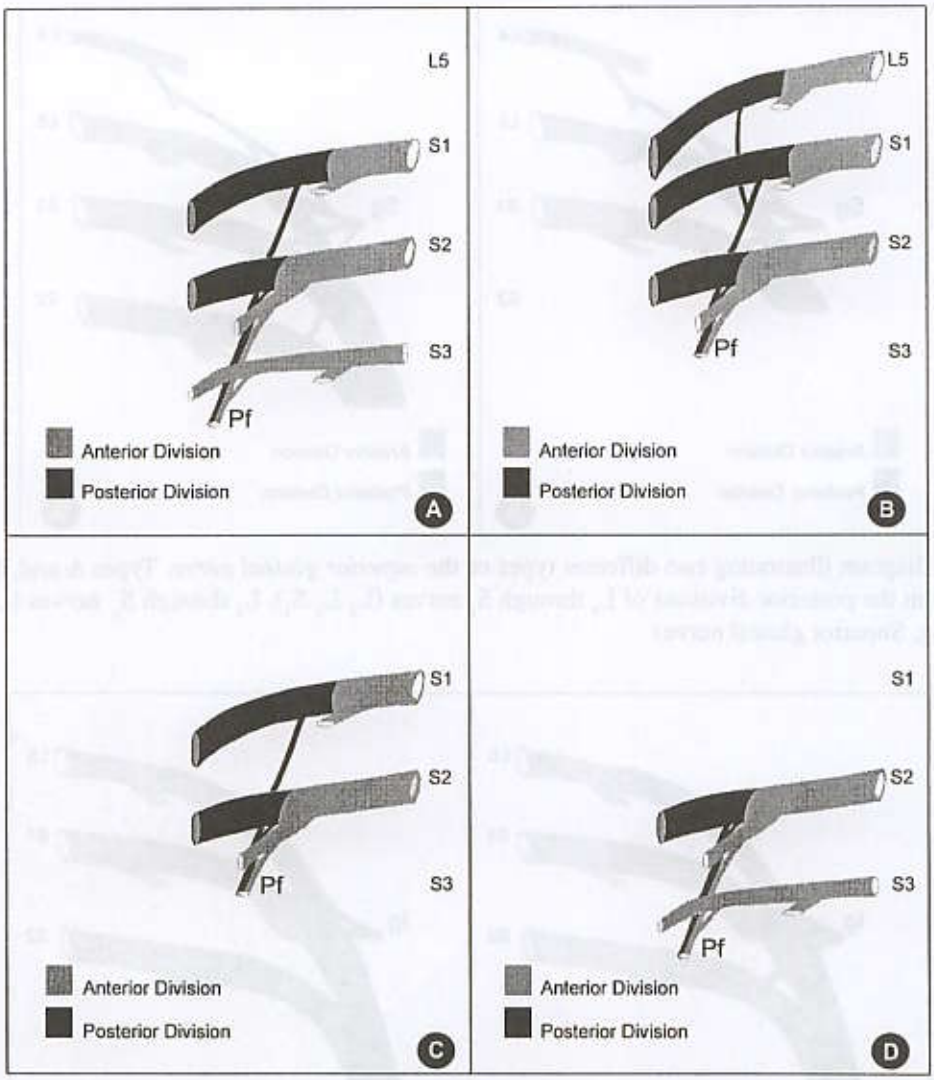

Figure 6. A diagram illustrating four different types of *the posterior femoral cutaneous nerve*. Type A originated from the posterior divisions of S_1-S_2 and anterior divisions of S_2-S_3 nerves. The other types, including types B, C, and D, originated from the posterior divisions of L_5-S_2 and anterior division of S_2 nerves; the posterior divisions of S_1-S_2 and the anterior division of S_2 nerves; the posterior division of S_2 and the anterior divisions of S_2-S_3 nerves. (Pf, Posterior femoral cutaneous nerve)

first and second (S_1-S_2) and anterior divisions of the second and third sacral nerves (S_2-S_3) in 148 cases or 98.67%, was classified as a normal pattern. The other types included types B, C and D, which originated from the posterior divisions of the fifth lumbar and the second sacral and anterior division of the second sacral nerves (L_5-S_1-S_2) in 1 case or 0.67%; the posterior divisions of the first and second sacral and anterior division of the second sacral nerves (S_1-S_2) in 1 case or 0.67%; the posterior division of the second sacral, and anterior divisions of the second and third sacral nerves (S_2-S_3) in 1 case or 0.67%, respectively. All types except type A were classified as variation patterns.

The Sciatic nerve is the largest nerve in the body and supplies nearly the whole of the skin of the

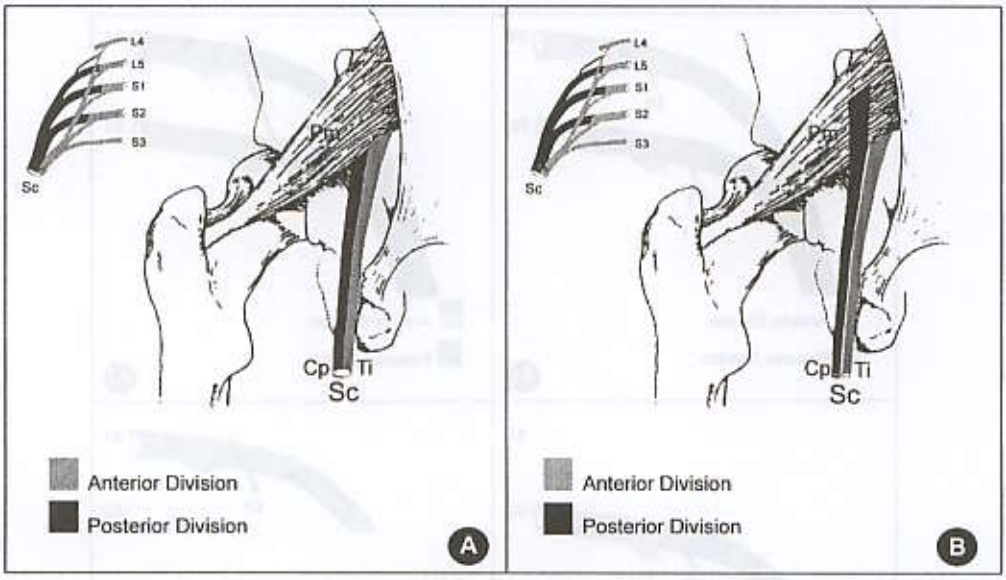

Figure 7. A diagram illustrating two different types of the *sciatic nerve*. Type A, in which the tibial and common peroneal were joined at the anterior surface of the piriformis, was classified as a normal formation. Meanwhile, type B in which the common peroneal pierced the muscle and joined with the tibial inferior to the muscle, was classified as variation formation. (Cp, Common peroneal nerve; Pm, Piriformis muscle; Ti, Tibial nerve)

leg, the muscles of the back of the thigh, and those of the leg and foot. It is divided into two large branches, the tibial and common peroneal nerves. The tibial nerve originated from the anterior divisions of the fourth lumbar through third sacral nerves (L_4-L_5-S_1-S_2-S_3), whereas the peroneal nerve originated from the posterior divisions of the fourth lumbar through second sacral nerves (L_4-L_5-S_1-S_2). Therefore, all sciatic nerves (150 cases or 100%) originated from L_4 through S_3 nerves and were classified as normal patterns of origin. Based on its formation relating to the piriformis, two different types of the nerve were distinguished (Figure 7). Type A, in which the tibial and common peroneal nerves joined at the anterior (pelvic) surface of the piriformis, was classified as a normal formation (124 cases or 82.67%). Meanwhile, type B, in which the common peroneal nerve pierced the muscle and joined with the tibial nerve inferior to the muscle, was classified as a variation formation (26 cases or 17.33%).

The Nerve to the Piriformis arose from the posterior divisions of the first and second sacral nerves (S_1-S_2), or the posterior division of the first sacral nerve (S_1) or second sacral nerve (S_2), and the anterior division of the third sacral nerve (S_3) (Figure 8). It entered the pelvic surface of the piriformis within the pelvis. Based on origins from the sacral plexus, four different types of this nerve were distinguished (Figure 8). Type A, which originated from two roots, the first and second sacral nerves (S_1-S_2) in 88 cases or 58.67%, was classified as a normal pattern. This normal pattern was subdivided into two subtypes: type A1 (79 cases or 52.67%) in which two nerves originated directly from the posterior divisions of the first and second sacral nerves, whereas type A2 (9 cases or 6%) originated from the common trunk of the posterior divisions of the first and second sacral nerves. The other types which originated from the posterior division of the second sacral (S_2) in 58 cases or 38.67%, first sacral (S_1) in 2 cases or 1.33%, the posterior division of the second and the anterior division of the third sacral nerves (S_2-S_3) in 2 cases or 1.33% and classified as type B, C, and D, respectively.

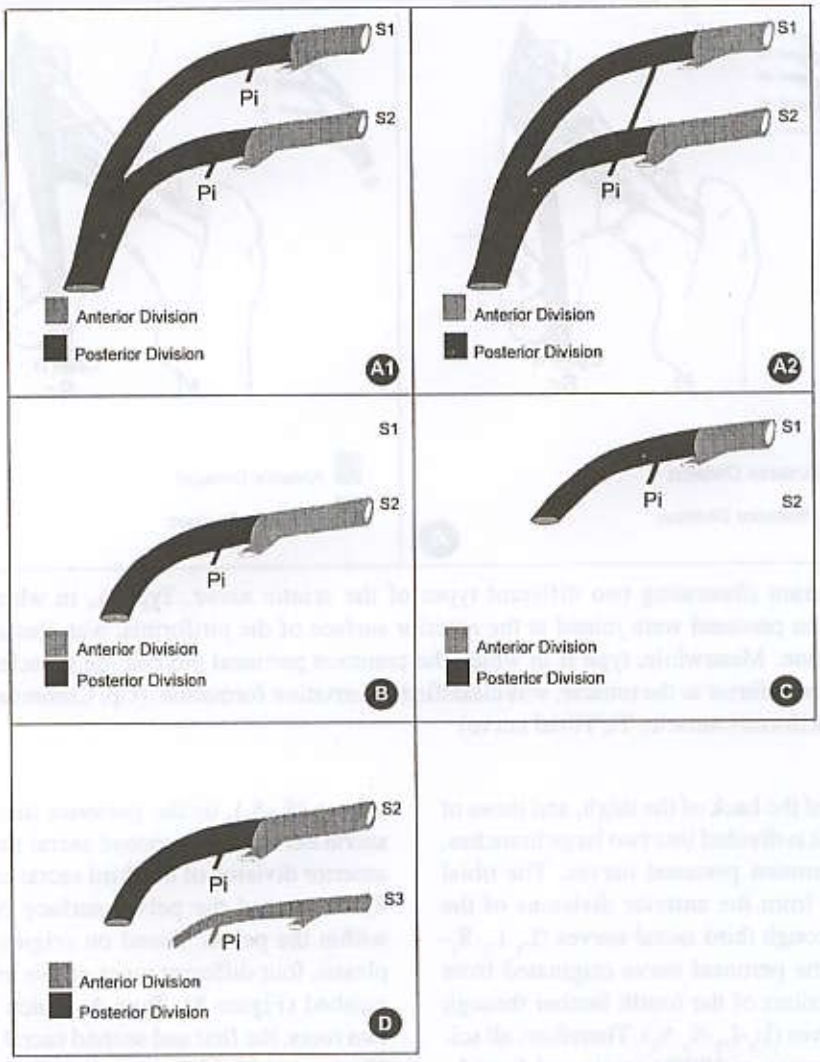

Figure 8. A diagram illustrating four different types of the *nerve to the piriformis*. Type A, which originated from S_1-S_2 nerves, was subdivided into two subtypes: type A1 and type A2, which originated directly from the posterior divisions of S_1-S_2 nerves and the common trunk of those nerves. The other types including type B, C, and D originated from the posterior division of S_2 nerve, S_1 nerve, the posterior division of S_2 and anterior division of S_3 nerves. (Pi, nerve to the piriformis)

The Pudendal nerve is the main nerve of the sacral part of the lumbar plexus. It accompanies the internal pudendal vessels, passed through the lesser sciatic foramen into the perineum, and enters the pudendal canal on the obturator fascia of the lateral wall of the ischiorectal fossa. This nerve arose from the anterior divisions of the second through fourth sacral nerves (S_2-S_3-S_4) in 150 cases or 100%, and was classified as a normal pattern (Figure 9).

The Pelvic Splanchnic Nerves consists of the preganglionic parasympathetic fibers. Three different types of the nerve were distinguished (Figure 10). Type A, which originated from the ventral rami of S_2 through S_4 in 58 cases or 38.67%, was classified as a normal pattern. The other types include types B and C originating from the ventral rami of S_3 through S_4 in 80 cases or 53.33%; and the ventral rami of S_2 through S_3 in 12 cases or 8%,

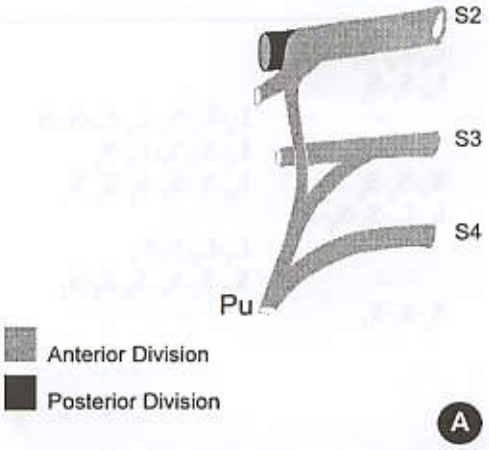

Figure 9. A diagram illustrating the *pudendal nerve* originated from the anterior divisions of S_2 through S_4 nerves (S_2-S_3-S_4). (Pu, pudendal nerve)

respectively. They were classified as variant patterns.

Briefly, all branches from the sacral plexuses were present in 100% of the 150 cases. The variant of origin and formations of the sacral plexus and its branches occurred on both sides. There were no statistical differences with regard to either gender or side.

DISCUSSION

Our results indicated that most of the sacral plexuses originated from the lumbosacral trunk (L_4-L_5) and the ventral rami of the first through fourth sacral nerves (S_1-S_4). This finding was similar to those of previous studies[17] and the usual textbook descriptions[1-5]. Origins of these plexuses varied as these were derived from the ventral rami of the fourth lumbar through fifth sacral ventral rami (L_4-S_5)[2,15]. Additionally, each branch of the plexuses was found to have many types of variations.

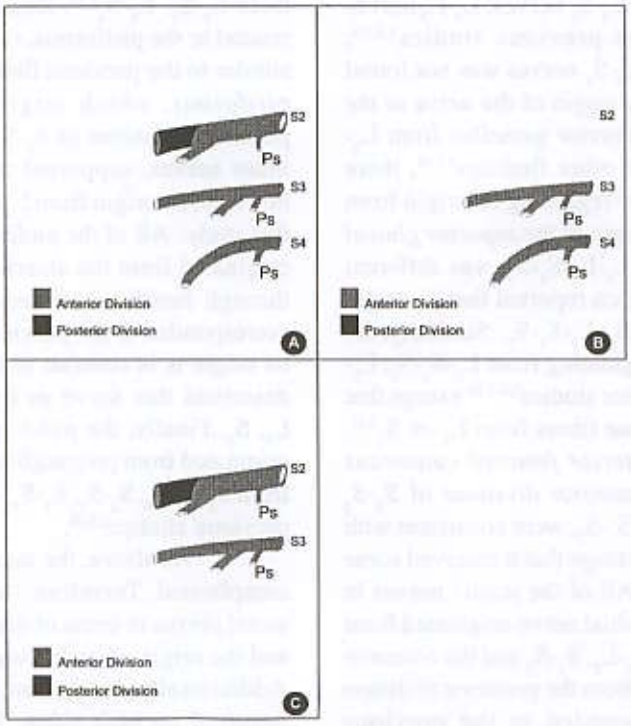

Figure 10. A diagram illustrating three different types of *the pelvic splanchnic nerves*. Type A originated from the ventral rami of S_2 through S_4 nerves. The other types including type B and C originated from S_3 through S_4 nerves; S_2 through S_3 nerves. (Ps, Pelvic splanchnic nerve)

Table 1. The origin of nerves of the sacral plexus was variable. The range of these variations from this study is tabulated below.

Nerves	Ant. divisions	Post. divisions
1. Nerve to quadratus femoris and gemellus inferior	L_4-L_5, L_4-L_5-S_1	-
2. Nerve to obturator internus and gemellus superior	L_5-S_1-S_2	-
3. Superior gluteal nerve	-	L_4-L_5-S_1, L_4-L_5-S_1-S_2
4. Inferior gluteal nerve	-	L_5-S_1-S_2; L_5-S_1
5. Posterior femoral cutaneous nerve	S_2, S_2-S_3	L_5-S_1-S_2, S_1-S_2, S_2
6. Sciatic nerve - Tibial nerve	L_4-L_5-S_1-S_2-S_3	-
- Common peroneal nerve	-	L_4-L_5-S_1-S_2
7..Nerve to piriformis	-	S_1, S_1-S_2, S_2, S_2-S_3
8. Pudendal nerve	S_2-S_3-S_4	-
9. Pelvic splanchnic nerves (preganglionic parasympathetic fibers from S_2 through S_4, S_2 through S_3, S_3 through S_4		

A comparison of described variations to that known from former studies was performed as follows. The origin of the *nerve to the quadratus femoris and Inferior gemellus* from L_4-L_5-S_1 nerves; L_4-L_5 nerves was consistent with the previous studies[2,4,15]; however, its origin from L_5-S_1 nerves was not found in this study. Although the origin of the *nerve to the obturator internus and superior gemellus* from L_5-S_1-S_2 was consistent with other findings[4-5,19], there were conflicting reports[15,18] regarding its origin from L_4-L_5-S_1-S_2, S_1-S_3. The origin of the *superior gluteal nerve* from L_4-L_5-S_1; S_2, L_4-L_5-S_1-S_2, was different from a previous study[2] which reported that its origin derived from L_4-L_5;S_1; L_5-S_1; L_5-S_1-S_2. Similarly, the *inferior gluteal nerve*, originating from L_5-S_1-S_2; L_5-S_1, was consistent with other studies[2,4-5,20] except that the nerve may receive some fibers from L_4 or S_3[2,15]. Most origins of the *posterior femoral cutaneous nerve*, derived from the anterior divisions of S_2-S_3 and posterior divisions of S_1-S_2, were consistent with previous studies[2,4-5,15,18,21] except that it received some fibers from L_5 or S_4[2,15,18]. All of the sciatic nerves in this finding, in which the tibial nerve originated from the anterior divisions of L_4-L_5, S_1-S_3 and the common peroneal nerve originated from the posterior divisions of L_4-L_5, S_1-S_2, corresponded to the previous studies[4-5,19,22-24]. Although the variation in origin of the sciatic nerve was absent in this result; its origin was in contrast to the previous studies which described this nerve as having major contributions from L_3-S_5, L_4-S_4[2,15]. Based on its formation which related to the piriformis, two types of the nerve were similar to the previous findings[25-26]. The *nerve to the piriformis*, which originated directly from the posterior divisions of S_1-S_2 or the common trunk of those nerves, supported the earlier studies[4-5,19,22,27]; however, its origin from L_4-L_5 or S_3[2] was not found in this study. All of the *pudendal nerves* in this finding originated from the anterior divisions of the second through fourth sacral nerves (S_2-S_3-S_4). This result corresponded to the pervious studies[4-5,15,28]; however, its origin is in contrast to the other reports[2,15] which described this nerve as having contributions from L_5, S_5. Finally, the *pelvic splanchnic nerves*, which originated from preganglionic parasympathetic fibers from S_2-S_3-S_4, S_2-S_3, S_3-S_4, were similar to findings of previous studies[2,5,29].

As above, the sacral plexus was varied and complicated. Therefore, the different features of the sacral plexus in terms of the variable origin, branches, and the origin of each branch may be related to race. Additionally, variation patterns of the plexus occurred on both sides. The anatomic variability, however, of the plexus was not statistically different

with regard to either side or gender. This finding provides additional information and new insights into the sacral plexus in terms of its origins, branches, and variations of each branch which may be helpful in the applications to medicine, anesthesia, physical therapy, and surgery.

ACKNOWLEDGMENTS

The authors thank Assistant Professor Kasorn Sripaoraya for her kind permission to do this study.

REFERENCES

1. Basmajian JV, Slonecker CE. Grant's method of anatomy: A clinical problem solving approach. 11th ed. Baltimore: William & Wilkins; 1989.
2. Hollinshead WH. Textbook of anatomy. New York: Harper & Row; 1962.
3. McMinn RMH, Gaddum-Rosse P, Hutchings RT, Logan BM. McMinn's functional & clinical anatomy. Barcelona: Mosby; 1995.
4. Romanes GJ. Cunningham's textbook of anatomy. 12th ed. Edinburgh: E&S Livingstone; 1968.
5. William PL, Warwick R. Gray's anatomy. 36th ed. Yugoslavia: Oxford University; 1987.
6. Bareither DJ, Genau JM, Massaro JC. Variation in the division of the tibial nerve: application to nerve blocks. J Foot Surg 1990; **29:** 581-83.
7. Birnbaum K, Prescher A, Hessler S, Heller KD. The sensory innervation of the hip-joint-an anatomical study. Surg Radiol Anat 1997; **19:** 371-75.
8. Oldershaw JB, Salem A, Storrs BB, Milner B, Omer GE. Sciatic nerve entrapment in the upper thigh caused by an injury sustained during World War II at the battle of Anzio. Case report. J Neurosurg 2004; **100:** 295-97.
9. Bos JC, Stoeckart R, Klooswijk AI, van Linge B, Bahadoer R. The surgical anatomy of the superior gluteal nerve and anatomical radiologic bases of the direct lateral approach to the hip. Surg Radio Anat 1994: **16:** 253-58.
10. Shafik A, El-Sherif M, Youssef A, Olfat ES. Surgical anatomy of the pudendal nerve and its clinical implications. Clin Anat 1995; **8:** 110-15.
11. Papadopoulos SM, McGillicuddy JE, Albers JW. Unusual cause of "piriformis muscle symdrome". Arch Neurol 1990; **47:** 1144-46.
12. Schraffordt SE, Tjandra JJ, Eizenberg N, Dwyer PL. Anatomy of the pudendal nerve and its terminal branches: a cadavers study. Anz J Surg 2004: **74:** 23-26.
13. Bardeen CR, Elting AW. A statistical study of the variations in the formation and position of the lumbosacral plexus in man. Anat Anz 1901; **19:** 124-28, 209-32.
14. Bardeen CR. A statistical study of the abdominal and border nerves in man. Am J Anat 1901-02; **1:** 203-28.
15. Bardeen CR. Development and variation of the nerves and musculature of the inferior extremity and of the neighboring regions of the trunk in man. Am J Anat 1906-07; **6:** 259-90.
16. Asato F, Butler M, Blomberg H, Gordh T. Variation in rat sciatic nerve anatomy: implications for a rat model of neuropathic pain. J Peripheral Nervous System 2000; **5:** 19-21.
17. Bergman RA, Thompson SA, Affini AK, Saddeh FA. Compendium of human anatomic variation. 1st ed. Munich: Urban & Schwarzenberg, 1988.
18. Jamieson EB. Some anomalies in nerves arising from the lumbar plexus, and a bilaminar musculus pectineus in a foetus; and on variations in the nerve supply in man and in some other mammals. J Anat Physiol 1903; **37:** 266-86.
19. Sinnatamby CS. Last's anatomy, regional & apply. 10th ed. London: Harcourt; 1999.
20. Pansky B. Review of gross anatomy. 5th ed. New York: Macmillan; 1984.
21. Mathers LH, Chase RA, Dolph J, Glasgow EF, Gosling JA. Clinical anatomy study system. 1st ed. USA: Von Hoffman; 1996.
22. Rogers AW. Textbook of anatomy. 1st ed. Hong Kong: Churchill Livingstone; 1964.
23. Loseph J. A textbook of regional anatomy. 1st ed. Hong Kong: Macmillan; 1982.
24. Kanagasuntheram R, Sivanandasing P, Krishnamutri A. Anatomy regional, functional, and clinical. 1st ed. Singapore: PG; 1987.
25. Beaton LE, Anson BJ. The sciatic nerve and piriformis muscle: their interrelation a possible course of coccygodynia. J Bone Surg 1938; **20:** 686-88.
26. Moore KL. Clinically oriented anatomy. 2nd ed. Baltimore: William & Wilkins; 1985.
27. Ellis H, Feldman S. Anatomy for anesthetists. 6th ed. Singapore: Blackwell Scientific; 1993.
28. Lindsay DT. Functional human anatomy. 1st ed. Missouri: Mosby - Year Book; 1996.
29. Snell RS. Clinically anatomy for medical students. 2nd ed. Boston: Litte, Brown; 1981.