Focused gluteal region dissection on the human sciatic nerve

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Abstract

Dissection provides an understanding of human anatomy that is difficult to achieve solely with the use of textbooks. The knowledge obtained from anatomical dissection has allowed medical practitioners the ability to understand the anatomy that forms that basis of a particular clinical presentation, and more effectively treat the condition. These conditions include piriformis syndrome and sciatica. Clinical conditions may also arise due to anatomical variations which are rare presentations, absences, or arrangements of structures. The ultimate goal of the dissection in this report was to discern the pathway of the sciatic nerve and its divisions. In this report, the dissection of the gluteal region of a left leg from a female cadaver is detailed. The findings reveal two anatomical variations, a high division of the sciatic nerve and a muscular slip lateral to the long head of the biceps femoris. Additional research is needed to determine the implications of these anatomical variations in the clinical context. This prosection will be an important educational resource for future students, and could not have been possible without the generous donors.

Table 1: Acronym and abbreviations

Acronym/ Abbreviations	Definition
Adductor Magnus	AMag
Biceps Femoris	BF
Biceps Femoris Slip	BFS
Common Peroneal Nerve	CPN
Gluteus Maximus	GMax
Gluteus Medius	GMed
Gluteal Region Muscles	GRM
Gracilis	Grc
Inferior Gluteal Vessels	IGV
Long Head of Biceps Femoris	LHBF
Piriformis	PRF
Posterior Femoral Cutaneous Nerve	PFCN
Semimembranosus	SMem
Semitendinosus	STen
Short Head of Biceps Femoris	SHBF
Superior Gluteal Vessels	SGV
Tibial Nerve	TN

Introduction

The sciatic nerve is the largest peripheral nerve in the human body (2) and care is required to avoid injury during intramuscular (IM) injections. The dorsogluteal injection site is the gluteus maximus (GMax) in the superior lateral aspect of the gluteal region when it is divided into four equal parts (Fig. 1A) (3). The ventrogluteal injection site is located in the gluteus medius (GMed): more superior, lateral, and anterior to the dorsogluteal site (Fig. 1B) (3). As there is less risk to the sciatic nerve if the injection is given to the gluteus medius, the ventrogluteal site is preferred for IM injections (3).

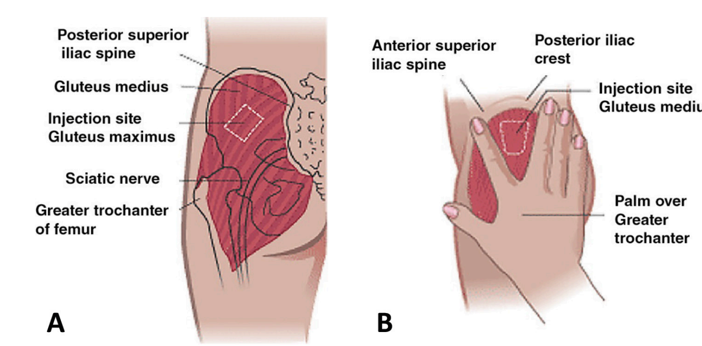

Figure 1: Sites for Intramuscular Injections. Adopted from springer.com (1) (A – Dorsogluteal site, B – Ventrogluteal site)

Another clinical consideration with regards to the sciatic nerve is a radiculopathy commonly known as sciatica. Sciatica is a condition that affects approximately 40% of adults at some point in their lives (4). Patients who suffer from sciatica often experience a sharp and aching back and unilateral leg pain that radiates from the gluteal region to the lower leg and often to the toes (5). Associated symptoms might also include tingling, numbness, or loss of muscle strength in the affected leg (5). The most common cause of sciatica is a prolapsed intervertebral disc in the lumbar spine between L4-L5 or S1-S2 causing nerve entrapment and inflammation (4). Diagnosis is usually based on clinical presentation, but imaging may also be performed when there is suspicion of a malignancy or infection (6).

For females, sciatica can also be caused by endometriosis and pregnancy (7). Lower back pain and sciatica is a common occurrence in pregnancy due to the pressure of the fetus in the uterus on the surrounding anatomical structures (8). A rare cause of sciatica is piriformis (PRF) syndrome, a neurological disorder that causes the PRF to spasm and compress the sciatic nerve as it exits the greater sciatic foramen (9). The treatment for sciatica consists of physiotherapy, exercise, pain medications or surgery (6). In the case of PRF syndrome, botulinum toxin injections might be recommended (7).

Anatomical knowledge is a core component of every medical student's education. The clinical presentation of many conditions can be better understood with a high level of anatomical knowledge. The process of dissecting cadavers creates a deeper understanding of the anatomical layers, orientation, and position. Reflection and documentation are important aspects of this educational experience. This report contains information detailing a 7-day dissection of the posterior thigh with a focus on the gluteal region of a left leg from a female cadaver. The structures studied included the muscles of the gluteal region, posterior thigh muscles, superior and inferior gluteal vessels, posterior femoral cutaneous nerve, and sciatic nerve branches. The age and cause of death of the cadaver were not known.

Methods

On day 1, the initial incision into the gluteal skin was made using a size 20 scalpel blade on a size 4 handle (referred to as scalpel blade from this point forward throughout the text). The superficial incision was made transversely just below the location of the inferior border of the GMax, visualized on the medial aspect of the left leg cadaver. Next, a deeper dissection was performed using the scalpel blade while ensuring the underlying muscle was not accidentally cut. Blunt dissection with fingers was used on the medial side of the cadaver to pull apart the subcutaneous tissue from the gluteal muscles. Next, the scalpel blade was used to reflect the layer of tissue covering the GMax using feathering motions with light pressure. After completion of the lateral reflection, there was subcutaneous tissue remaining that needed to be cleaned to visualize the GMax.

On day 2, the scalpel blade continued to be used until the layer covering the GMax was thin enough to see the color of the muscle. At this stage, the fascia protecting the GMax was lifted using forceps and cut with a pair of small scissors until the muscle was entirely exposed. These two surgical instruments were the choice for cleaning of all anatomical structures for the remainder of the project.

On day 3, tissue was cleaned from the GMed using the same techniques described for exposing the GMax. Afterwards, large portions of fat were removed from the lateral aspects of the GMax by cutting with small scissors. Finally, two additional superficial incisions were made using a scalpel blade in the lower region of the posterior thigh. One incision was made transversely in the posterior thigh region, and another was made in the frontal plane on the medial aspect of the cadaver. Both incisions intersected with each other, and the frontal incision also intersected with the original incision made below the inferior border of the GMax. Thus, a window was created that was reflected laterally to allow for exposure of the thigh muscles.

On day 4, the posterior muscles of the thigh were cleaned of fat. Next, a lateral incision was made along the GMax with a long, sharp blade. Medial resection of the GMax began with blunt dissection, using fingers to pry the muscle away from the underlying anatomical structures. To continue the resection, a scalpel blade was used. The resection was completed by the beginning of day 5. The remainder of day 5 was used to clean the structures underlying the anterior surface of the GMax.

Day 6 was spent cleaning the biceps femoris (BF), semitendinosus (STen), semimembranosus (SMem), adductor magnus, and gracilis. On the final day, cleaning was completed for the tibial nerve (TN), common peroneal nerve (CPN), posterior femoral cutaneous nerve (PFCN), and anterior surface of the GMax. By the end of the final day of the dissection, the gluteal and posterior thigh regions of the cadaver were exposed to show several anatomical structures in detail.

Results

The cadaver was received after a transverse and median cut was made through the pelvis. Thus, the subcutaneous tissue and muscle layers of the gluteal region could be identified on the medial aspect of the cadaver (Fig. 2).

By the end of day 2, the GMax had been completely exposed but the GMed remained covered. It was noted that the GMax was smaller than expected. Figure 3 depicts the exposed and cleaned GMax and GMed muscles.

Several vessels were cut to ensure full resection of the muscle was possible. During the resection, a large vessel was grazed by the scalpel blade as it was difficult to distinguish the vessel from the surrounding tissue. To avoid severing the vessel, as it was hypothesized to be the sciatic nerve based on the large diameter, the resection was continued but followed a path much closer to the GMax.

Figure 2: **Presentation of Cadaver Prior to Dissection of Gluteal Region.** The initial superficial incision was made transversely along the dotted line. Blunt dissection with fingers was used along the solid line to divide the subcutaneous tissue from the underlying anatomical structures.

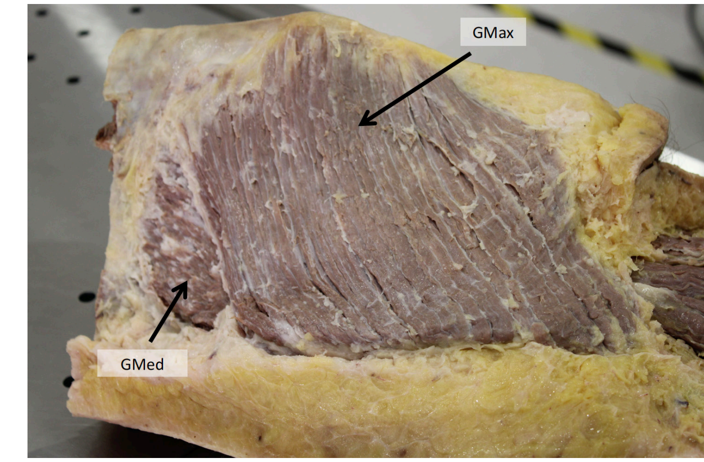

Figure 3: **Gluteus Maximus and Gluteus Medius of a Gluteal Region in the Left Leg of a Female Cadaver.** The subcutaneous tissue has been removed with forceps and a pair of small scissors to expose both muscles. (GMax – Gluteus maximus, GMed – Gluteus medius)

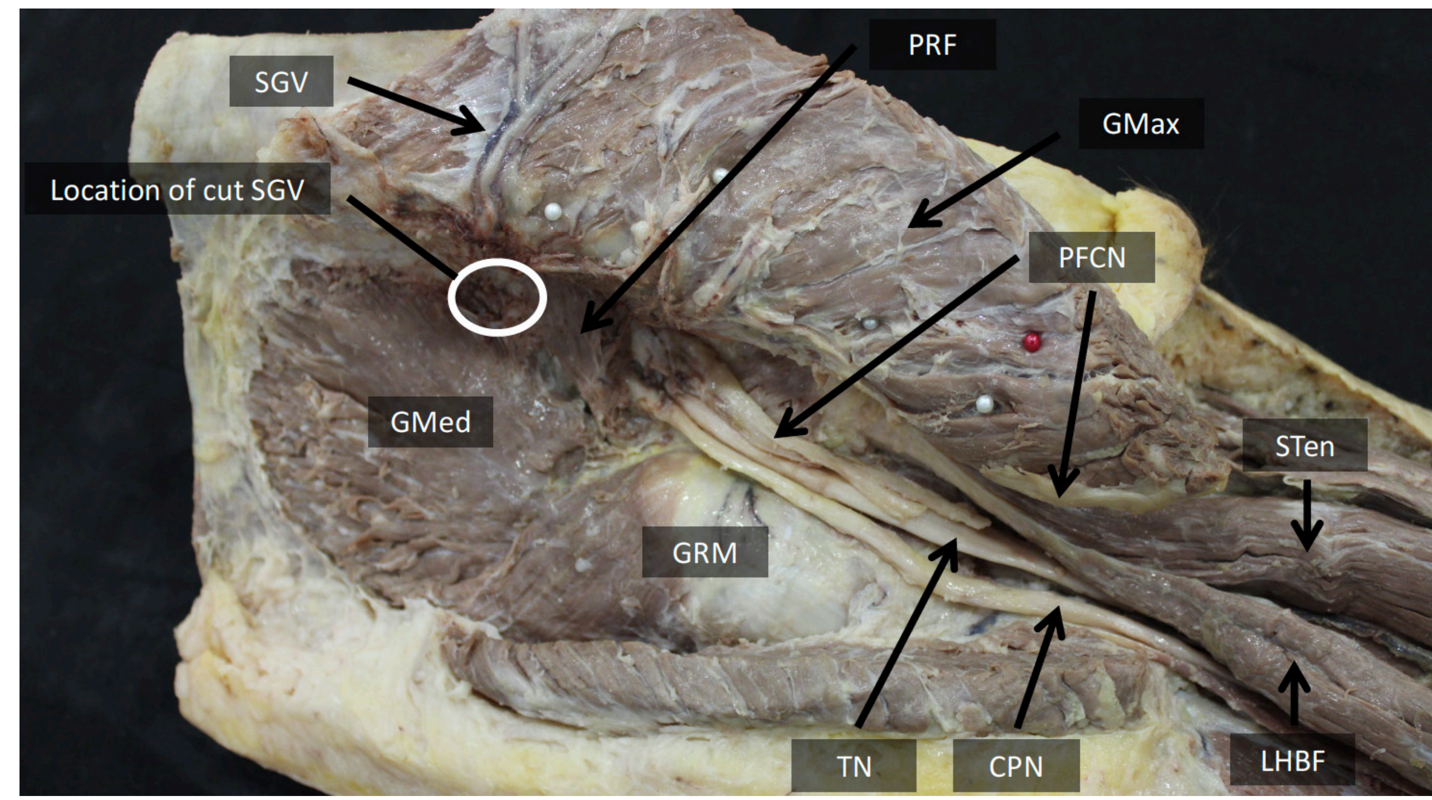

Figure 4: **Gluteal Region in the Left Leg of a Female Cadaver.** Resection of the gluteus maximus and removal of subcutaneous tissue was performed. (SGV – Superior gluteal vessels, PRF – piriformis, GMed – Gluteus medius, GMax – Gluteus maximus, GRM – Gluteal region muscles, PFCN – Posterior femoral cutaneous nerve, TN – Tibial nerve, CPN – Common peroneal nerve, STen – Semitendinosus, LHBF – Long head of biceps femoris)

During the process of cleaning the anterior portion of the GMax, it was observed that the superior gluteal vessels (SGV) including the artery, vein and nerve were perfectly preserved in the fascia located in the superior region and on the anterior side of the GMax (Fig. 4). A piece of a large vessel was also observed attached to the inferior region of fascia on the anterior aspect of the GMax. The identity of this vessel, as a part of the posterior femoral cutaneous nerve (PFCN), was not discovered until after the contents of the gluteal region were cleaned.

The first structure in the gluteal region clearly identified was the PRF muscle based on the triangular shape and the superior medial location (Fig. 5). The pathways of the superior and inferior gluteal vessels (IGV) were clearly seen above and below the muscle (Fig. 5). It was noted that the PRF was very atrophied.

After cleaning around the PRF, it was observed that three additional vessels emerged from the inferior region. The most medial vessel was cut and seemed to fit with the piece of a vessel remaining on the GMax. Thus, this vessel was identified as the PFCN (Fig. 4 and Fig. 6). The lateral two vessels followed paths consistent with the sciatic nerve (10). Therefore, the most lateral

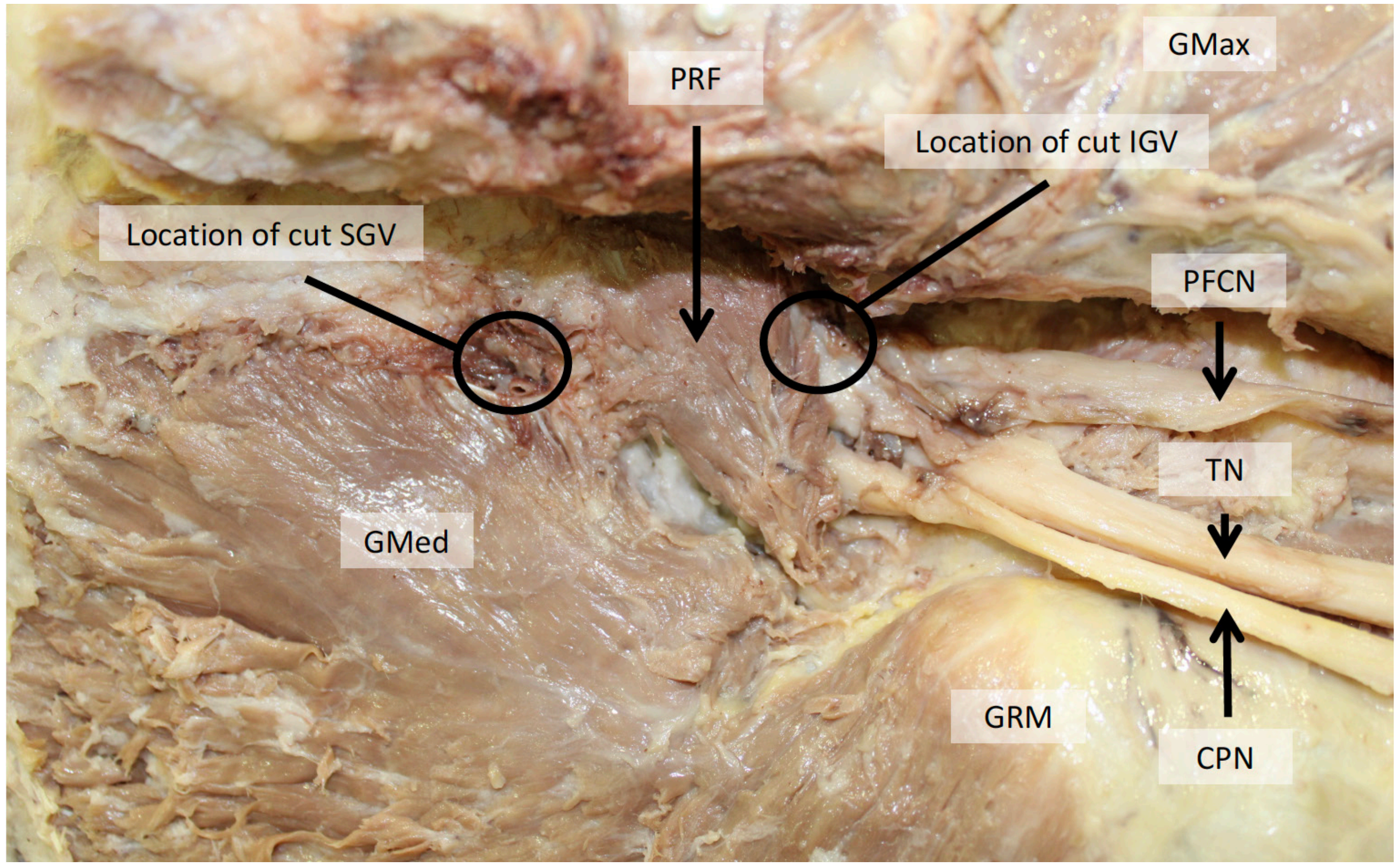

Figure 5: **Piriformis as a Landmark in the Gluteal Region.** Piriformis muscle was used to identify the superior gluteal vessels, inferior gluteal vessels, posterior femoral cutaneous nerve, and divisions of the sciatic nerve. (SGV – Superior gluteal vessels, IGV – Inferior gluteal vessels, PRF – piriformis, GMed – Gluteus medius, GMax – Gluteus maximus, GRM – Gluteal region muscles, PFCN – Posterior femoral cutaneous nerve, TN – Tibial nerve, CPN – Common peroneal nerve)

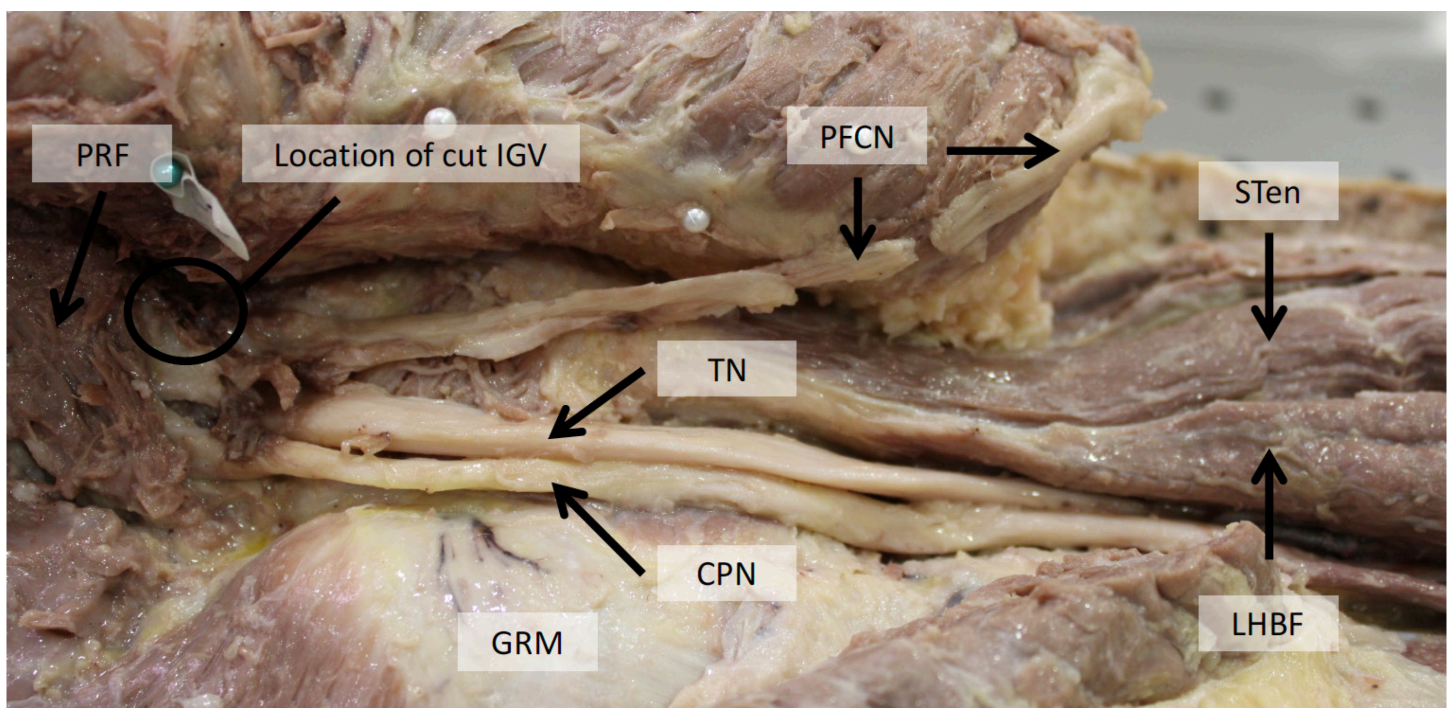

Figure 6: **Pathway Followed by the Divisions of the Sciatic Nerve in the Gluteal Region.** In this prosection, the divisions of the sciatic nerve, the tibial and common peroneal nerves, pass over the gluteal region muscles including the obturator internus, superior gemellus, inferior gemellus, and quadratus femoris before entering the posterior region of the thigh. The posterior femoral cutaneous nerve was cut during the dissection, but a piece of the vessel remained on the gluteus maximus. The remaining portions of the posterior femoral cutaneous vessel could not be demonstrated in this dissection. (IGV – Inferior gluteal vessels, PRF – piriformis, GMax – Gluteus maximus, GRM – Gluteal region muscles, PFCN – Posterior femoral cutaneous nerve, TN – Tibial nerve, CPN – Common peroneal nerve, STen – Semitendiosus, LHBF – Long head of biceps femoris)

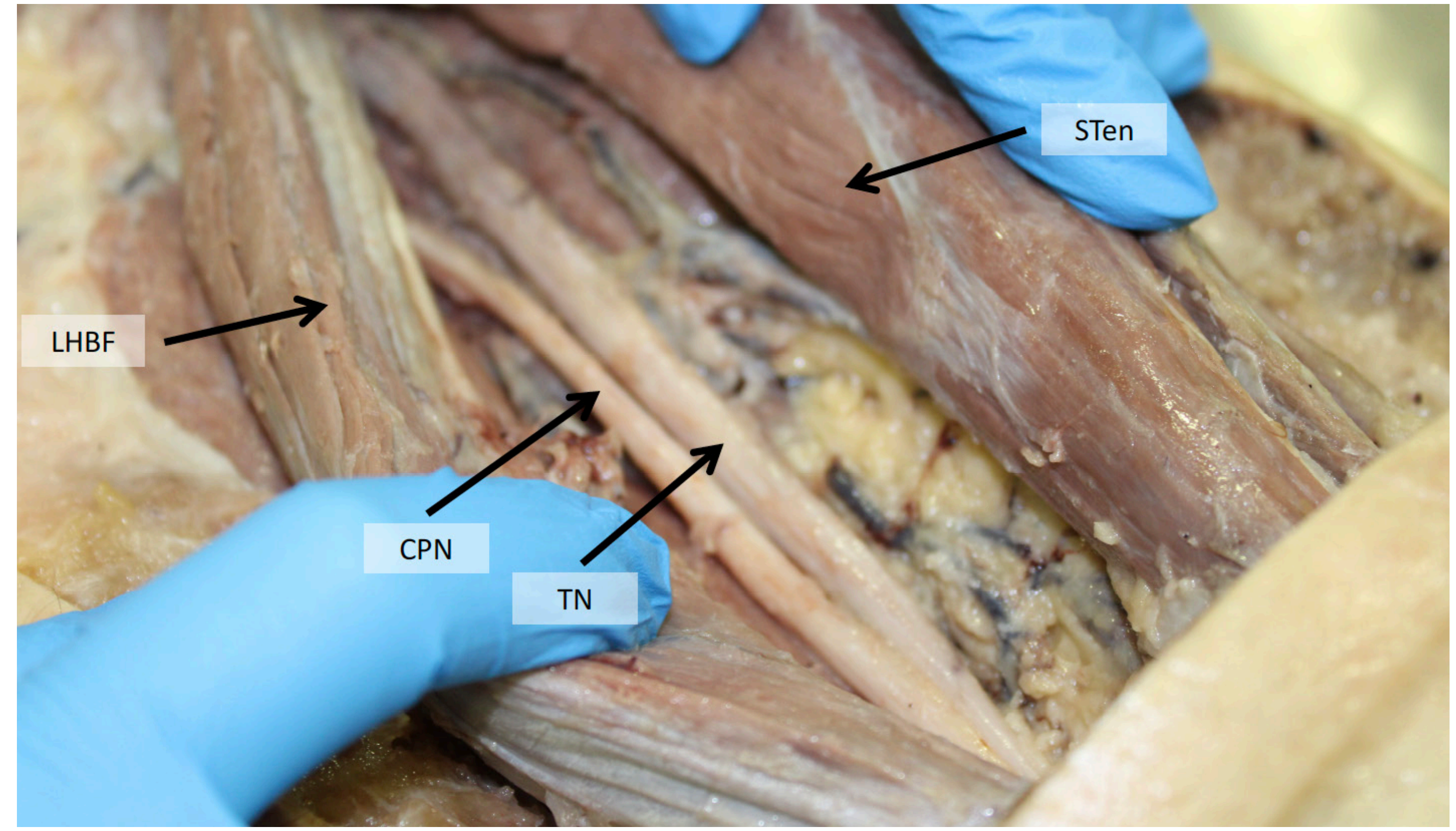

Figure 7: **Pathway Followed by the Divisions of the Sciatic Nerve in the Posterior Thigh Region.** In this prosection, the divisions of the sciatic nerve, the tibial and common peroneal nerves, travel between the semitendinosus and long head of the biceps femoris in the posterior region of the thigh. (TN – Tibial nerve, CPN – Common peroneal nerve, STen – Semitendiosus, LHBF – Long head of biceps femoris)

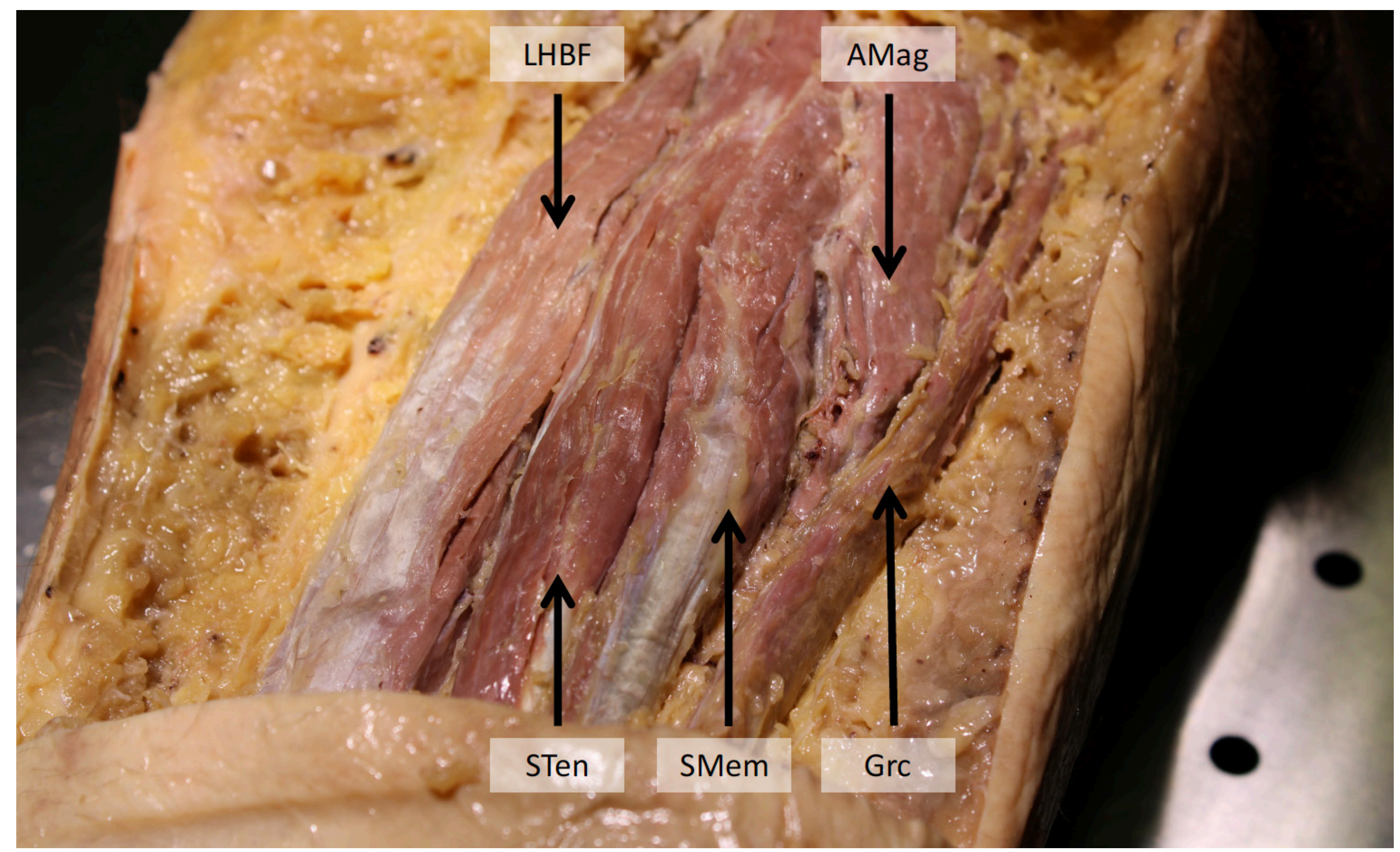

Figure 8: **Posterior Thigh Muscles in the Left Leg of a Female Cadaver.** The subcutaneous tissue has been removed with forceps and small scissors to expose all muscles. (LHBF – Long head of biceps femoris, STen – Semitendinosus, SMem – Semimembranosus, Grc – gracilis, AMag – Adductor magnus)

vessel was identified as the common peroneal nerve (CPN) and the vessel medial to this one was identified as the tibial nerve (TN), two branches of the sciatic nerve.

Both branches of the sciatic nerve passed over the obturator internus, gemelli muscles, and the quadratus femoris before traveling between the long head of the biceps femoris (LHBF) and

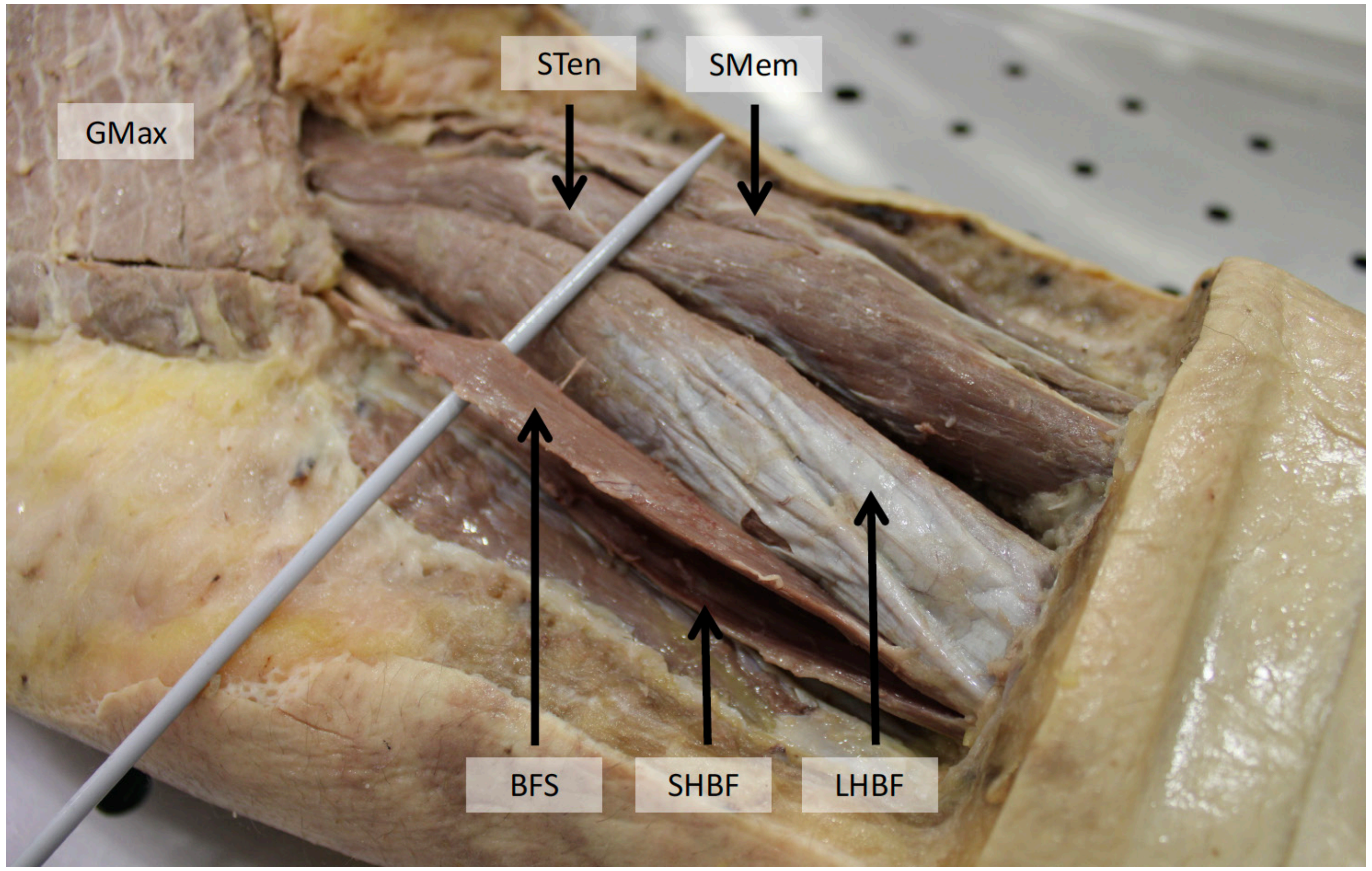

Figure 9: **Anatomical Variation of the Long Head of the Biceps Femoris.** A slip of muscle was identified lateral to the long head of the biceps femoris and medial to the short head of the biceps femoris. (GMax – Gluteus maximus, STen – Semitendiosus, SMem – Semimembranosus, LHBF – Long head of biceps femoris, BFS – Biceps femoris slip, SHBF – Short head of biceps femoris)


Figure 10. **Overview of the Dissection of the Gluteal and Posterior Thigh Region.** For the dissection, a left leg of a female cadaver was used. The methods and techniques used for the dissection are detailed in this report.

the semitendinosus (STen) muscle (Fig. 6 and Fig. 7).

The muscles of the posterior thigh are shown in Figure 8. The muscles were orientated anatomically as expected. The muscles in this compartment listed from most lateral to medial are LHBF, STen, SMem, adductor magnus (AMag) and gracilis (Grc). These muscles were embedded under a thinner layer of subcutaneous tissue compared to the GMax in the gluteal region.

Exploration of the posterior thigh led to discovery of a muscular slip lateral to the LHBF. The slip appeared to originate from the fascia surrounding the femur head, anterior to the GMax and medial to the insertion of the GMax on the gluteal tuberosity. It was thin, delicate, highly mobile and continued alongside the LHBF into the lower leg (Fig. 9).

Discussion

The divisions of the sciatic nerve were revealed in this dissection after medial resection of GMax. Medial resection is the dominant surgical method used when attempting to expose and treat lesions of the proximal sciatic nerve (11). The sciatic nerve innervates all posterior thigh muscles, all foot and ankle muscles, and provides sensation to skin in the lower limb (10). More specifically, the TN supplies the muscles of the posterior compartment of the leg (12) and the CPN supplies the lateral and anterior compartment (13). In four previous studies, it was observed that the sciatic nerve could divide into its divisions either before or after entering the pelvis (14-17). Unfortunately, it is not possible to determine where the sciatic nerve divided in the current project because the PRF was blocking visualization of the nerve's exit through the greater sciatic foreman. If the PRF had not been atrophied, a window or resection of the PRF might have been considered. Atrophy of muscles is experienced by patients who experience extended bed rest (18). It was decided not to dissect the PRF as not to reduce the educational value of the prosection. The sciatic nerve can also divide at various locations after entering the pelvis. The most common location is at the upper angle of the popliteal fossa (14). In one study, 8% of cadavers acquired from India, contained a sciatic nerve characterized by high division in the posterior thigh (14). Rare instances of the sciatic nerve entering the gluteal region from above the PRF have also been observed (19). In the current prosection, the sciatic nerve exhibited a rare occurrence of division before emerging from below the PRF.

An important and rare anatomical variation was discovered in the posterior thigh. There was a BF slip found lateral to the LHBF. BF slips have been previously reported in the literature (20). Additional anatomical variations of the BF have been reported including absence of the short head and presence of additional heads (21). Further research is required to understand the impact of these anatomical variations on the clinical presentation of a patient and the physical challenges that might be encountered.

There were a few limitations to the project. After the gluteal region was cleaned, it was determined that the GMed would be too small and frail to transect. In addition, the obturator internus, gemelli muscles and the quadratus femoris were difficult to distinguish from each other unlike in anatomical textbooks. There was a tough, white layer of fascia covering the lateral regions of these muscles that could not be cut with a scalpel. Thus, it was decided not to expose the insertion sites on the head of the femur. Despite these limitations, the main objective of the project to observe the path of the sciatic nerve and its divisions through the gluteal region and posterior thigh of the left leg of a female cadaver was achieved.

Conclusion

The ultimate goal of this dissection was to discern the path of the sciatic nerve and its divisions. Most of the steps in the dissection plan were completed, although in a slightly different order. The steps that could not be completed included transection of the gluteus medius, exposure of the insertion points on the head of the femur and cutting the PRF to observe the greater sciatic foramen. Performing these steps was reconsidered after encountering a few unexpected issues including severe muscle atrophy and a layer of fascia that could not be cut with the tools available. However, upon completion of the project, the path of the sciatic nerve divisions was visible.

The inspiration behind the project was the sciatic nerve. However, during the dissection, decisions were made to preserve anatomical structures that were not mentioned in the original dissection plan. For example, the PFCN and posterior gluteal muscles. The dissection also revealed an anatomical variation, a muscular slip lateral to the LHBF. This cadaver will serve well for educational purposes as it demonstrates that not all human bodies have the same anatomy, a difficult concept to grasp in first year anatomy classes.

In conclusion, this project provided a greater understanding of human anatomy that could not be achieved solely with the use of a textbook. The cadaver will serve as a useful educational resource for future students to understand the clinical relevance of various medical conditions and clinical procedures related to the gluteal region. In addition, the format of the prosection provides a unique experience as it unfolds like a book and allows the demonstrator to explain to the students the various layers that conceal the gluteal region. Telling a story while teaching the students could help with information retention and make the learning process more fun.

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References

1. Soliman E, Ranjan S, Xu T, Gee C, Harker A, Barrera A, Geddes J. A narrative review of the success of intramuscular gluteal injections and its impact in psychiatry. Bio-design Manuf. 2018;1(3):161–70.
2. Sladjana UZ, Ivan JD, Bratislav SD. Microanatomical structure of the human sciatic nerve. Surg Radiol Anat. 2008;30(8):619–26.
3. Coskun H, Kilic C, Senture C. The evaluation of dorsogluteal and ventrogluteal injection sites: a cadaver study. J Clin Nurs. 2016;25(7–8):1112–9.
4. Dudeney S, O'Farrell D, Bouchier Hayes D, Byrne J. Extraspinal Causes of Sciatica. Spine. 1998;23(4):494–6.
5. Jensen RK, Kongsted A, Kjaer P, Koes B. Diagnosis and treatment of sciatica. BMJ. 2019;367:l6273.
6. Koes BW, Tulder MW van, Peul WC. Diagnosis and treatment of sciatica. BMJ. 2007;334(7607):1313.
7. Al-Khodairy A-WT, Bovay P, Gobelet C. Sciatica in the female patient: anatomical considerations, aetiology and review of the literature. Eur Spine J. 2007;16(6):721–31.
8. Katonis P, Kampouroglou A, Aggelopoulos A, Kakavelakis K, Lykoudis S, Makrigiannakis A, Alpantaki K. Pregnancy-related low back pain. Hippokratia. 2011;15(3):205–10.
9. Hopayian K, Song F, Riera R, Sambandan S. The clinical features of the piriformis syndrome: a systematic review. Eur Spine J. 2010;19(12):2095–109.
10. Drake RL, Vogl W, Mitchell AWM. Gray's Anatomy for Students. International Edition. Philadelphia, Pennsylvania, USA: Elsevier Inc.; 2005. 509 p.
11. Patil PG, Friedman AH. Surgical Exposure of the Sciatic Nerve in the Gluteal Region: Anatomic and Historical Comparison of Two Approaches. Oper Neurosurg. 2005;56(suppl_1):ONS-165-ONS-171.
12. Moretti E, Silva IB, Boaviagem A, Barbosa L, Lima AMJ, Lemos A. "Posterior Tibial Nerve" or "Tibial Nerve"? Improving the reporting in health papers. Neurourol Urodynam. 2020;39(2):847–53.
13. Katirji B. Peroneal Neuropathy. Neurol Clin. 1999;17(3):567–91.
14. Adibatti M, V S. Study on variant anatomy of sciatic nerve. J Clin Diagnostic Res. 2014;8(8):AC07-9.
15. Ogeng'o JA, El-Busaidy H, Mwika PM, Khanbhai MM, Munguti J. Variant anatomy of sciatic nerve in a black Kenyan population. Folia Morphol. 2011;70(3):175–9.
16. Prakash, Bhardwaj AK, Devi MN, Sridevi NS, Rao PK, Singh G. Sciatic nerve division: a cadaver study in the Indian population and review of the literature. Singap Med J. 2010;51(9):721–3.
17. Güvençer M, Iyem C, Akyer P, Tetik S, Naderi S. Variations in the high division of the sciatic nerve and relationship between the sciatic nerve and the piriformis. Turk Neurosurg. 2009;19(2):139–44.
18. LeBlanc A, Rowe R, Evans H, West S, Shackelford L, Schneider V. Muscle Atrophy During Long Duration Bed Rest. Int J Sports Med. 1997;18(S 4):S283–5.
19. Pais D, Casal D, Pires MAB, Furtado A, Bilhim T, Angélica-Almeida M, Goyri-O'Neill J. Sciatic nerve high division: two different anatomical variants. Acta Médica Portuguesa. 2013;26(3):208–11.
20. Koulouris G, Connell D. Hamstring Muscle Complex: An Imaging Review. Radiographics. 2005;25(3):571–86.
21. Tubbs RS, Shoja MM, Loukas M. Bergman's Comprehensive Encyclopedia of Human Anatomic Variation. 3rd edition. Hoboken, New Jersey, USA: John Wiley & Sons Inc.; 2016. 1057–61p.