REVIEW ARTICLE

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Piriformis syndrome – anatomical causes. Diagnosis and treatment

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Abstract

Introduction and Objective. Sciatica is a clinical condition characterized by pain radiating along the roots of the sciatic nerve, extending from the lumbosacral spine and buttock, through the posterior surface of the thigh and lower leg down to the foot. One of the frequent cause is piriformis syndrome where the sciatic nerve is compressed by the piriformis muscle. There are many diagnostic tests and imaging studies available, but the most crucial aspect is to exclude other causes of sciatica. The aim of the review is to present the literature describing causes, diagnosis and treatment of the piriformis syndrome.

Review Methods. The review is based on 46 papers found in PubMed and PubMedCentral databases using key words: 'piriformis syndrome' and 'anatomical causes/diagnosis/treatment', published between 1947–2023.

Brief description of the state of knowledge. The variability in the course of the sciatic nerve and anatomical variations of the piriformis muscle have different impacts on the onset of piriformis syndrome. The diagnosis of this condition primarily aims to exclude other causes of sciatica, as there are no precisely confirmed diagnostic criteria. The preferred treatment is non-operative. When this is unsuccessful, surgical intervention may be considered.

Summary. There are numerous causes of piriformis syndrome. There is a discrepancy in the results of various studies regarding the impact of different anatomical variations of the sciatic nerve on the onset of symptoms of this condition. The primary goal of research should now be to conduct a large, representative study on patients diagnosed with sciatica, focusing on the presence of anatomical variations.

Key words

sciatica, sciatic nerve, pelvis, nerve compression syndromes, piriformis muscle syndrome

INTRODUCTION

Sciatica is a commonly occurring clinical condition [1]. It manifests as pain transmitted along the roots of the sciatic nerve, leading to varying degrees of impairment, especially in older individuals [2]. Additionally. sensory disturbances, tingling, and numbness in the same area may occur. Sciatica can result from spinal damage, pelvic tumours, diabetic neuropathy, and rarely – piriformis syndrome [3].

Piriformis syndrome is a type of sciatica caused by compression of the nerve by the piriformis muscle [4]. This triangular, flattened muscle extends between the sacrum and the greater trochanter, starting from the pelvic surface of the sacral bone. It runs laterally through the greater sciatic foramen and ends with a tendon on the medial side of the greater trochanter of the femur [5]. It is one of the six short muscles of the external rotators group [6]. When the hip is extended, it causes external rotation, and when flexed, it causes abduction. With a fixed leg, it tilts the pelvis and trunk [7]. The piriformis muscle is innervated by branches of the sacral plexus (L5. S1–5) and supplied by the upper and lower gluteal arteries from the internal iliac artery [5].

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The piriformis muscle divides the greater sciatic foramen into infrapiriform and suprapiriform foramens. The infrapiriform foramen contains the inferior gluteal vessels, inferior gluteal nerve, sciatic nerve and pudendal nerve, while the suprapiriform foramen contains the superior gluteal vessels and superior gluteal nerve [8].

The topic is explored due to the anatomical diversity and interest in the relationship between anatomical variations of the sciatic nerve, piriformis muscle, and others, and the occurrence of sciatica. Conducting research may increase awareness among doctors about existing connections and improve diagnostics, ultimately enhancing the quality of patient treatment.

The sciatic nerve is the widest peripheral nerve in the body and the final branch of the sacral plexus. Most commonly, it passes as a single trunk through the pelvic cavity, the gluteal region, and the posterior part of the thigh, reaching the upper angle of the popliteal fossa where it divides into the tibial and common fibular nerves. There are six different anatomical variations in the relationship between the sciatic nerve and the piriformis muscle [9]. Natsis and colleagues conducted dissections on 294 cadavers which revealed that in 94% of cases, the sciatic nerve and piriformis muscle have a typical anatomical arrangement. with the nerve as a single trunk passing under the undivided muscle [7].

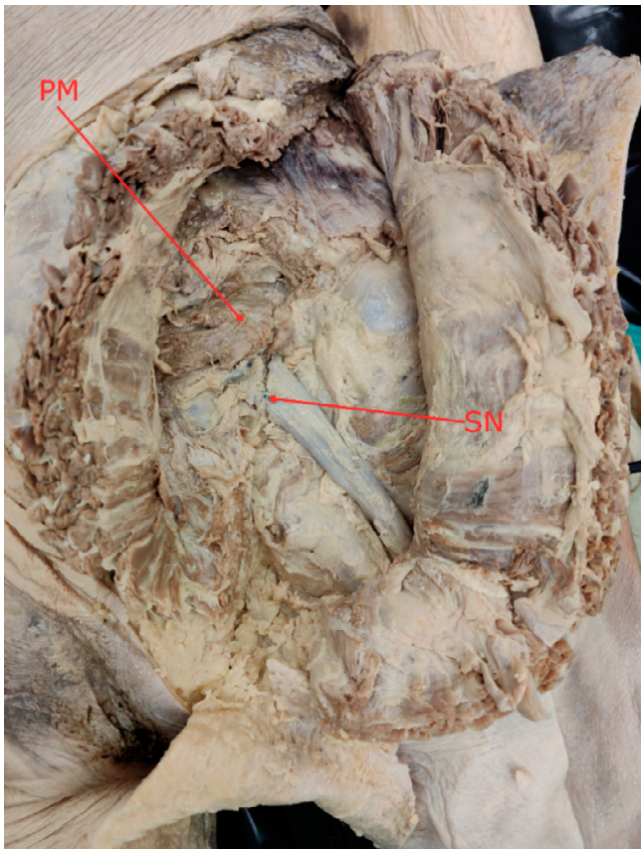

Figure 1. Piriformis muscle (PM) and sciatic nerve (SN).
Source: Collection of the Department of Normal Human Anatomy, Medical University, Lublin, Poland

Anatomical variations. There is a hypothesis proposed by Robinson, among others, that anatomical variations of the sciatic nerve and piriformis muscle may increase susceptibility to piriformis syndrome. Because of this, Barter et al. conducted a study to investigate this relationship, ultimately demonstrating that there is no significant difference in the occurrence of piriformis syndrome in patients with anatomical changes, compared to those with the traditional position of the sciatic nerve relative to the muscle [4]. In 1928, Yeoman was the first to speculate on the role of the piriformis muscle in degenerative disease of the sacroiliac joint as a cause of sciatica. Ten years later, Beaton and Anson described six anatomical variations of the sciatic nerve and piriformis muscle. Shortly thereafter, in 1937 they published a second work in which they stated that these anatomical variants are the cause of sciatic pain [10].

Relationships between piriformis muscle and sciatic nerve. According to the classification by Beaton and Anson, there are six types of anatomical positions of the piriformis muscle relative to the sciatic nerve:

1) the undivided sciatic nerve passes under the undivided piriformis muscle;
2) one branch of the sciatic nerve passes through the muscle, while the other passes under it;
3) part of the nerve passes above, and part passes below the undivided piriformis muscle;
4) the undivided sciatic nerve passes through the piriformis muscle;
5) the divided sciatic nerve passes above and through the piriformis muscle;
6) the undivided sciatic nerve passes above the undivided piriformis muscle [11.12].

Most commonly, the sciatic nerve passes undivided below the piriformis muscle (84% out of 120 cadavers prepared by Beaton and Anson, and 78% out of 130 cadavers studied by Pećina). The second most common variant is with a divided sciatic nerve passing through and below the piriformis muscle (12% of cases for Beaton and Anson. and 21% for Pećina [9]). The majority of cases describing the relationship between the piriformis muscle and the sciatic nerve have been reported only in individuals of the white race, with the exception of the work by Bardeen and Elting from the Autonomic Laboratory of Johns Hopkins University in Baltimore, Maryland, USA. They discovered that none of the following factors: gender. race. side of the body. or skeletal system condition. were related to the natural separation of the sciatic nerve [13]. Adam L. Bartret et al. conducted a study based on 1,039 MRI scans to investigate the relationship between the occurrence of piriformis syndrome and anatomical variations in the position of the sciatic nerve. Radiologists classified the anatomy of the sciatic nerve into the types mentioned by Beaton and Anson, excluding repetitive and technically insufficient studies. Ultimately, 783 studies were included in which 150 (19.2%) exhibited anatomical variations of the sciatic nerve. The syndrome occurred in 11.3% with variations and in 9% of individuals with a normal course. No significant difference in the frequency of piriformis syndrome was found between one of the variants and the traditional anatomical pattern [12].

Attachments of the piriformis muscle. In a study by G. Windisch, EM Braun and F. Anderhuber on 112 cadavers, differences were observed in the attachment of the piriformis muscle tendon. The results of the study showed that 53.6% of the examined cadavers had the traditional anatomical attachment of the muscle to the superior border of the greater trochanter of the femur. In 29.5% of cases, the tendon of the piriformis muscle was connected to the tendons of obturator internus muscle and the superior gemellus. Additionally, in 13.4% of cases, the tendon of the piriformis muscle joined with the tendons of obturator internus muscle and the gluteus medius muscle, before attaching to the greater trochanter (medial surface). The least common connection, observed in 3.6% of the cadavers, involved the attachment of the piriformis muscle tendon to the fibres of the gluteus medius muscle on the upper surface of the greater trochanter [11.35]. According to Eamon Koh, the most significant variant may be the one that occurs most commonly – type A, found in 63% of the population. In this type, with the coexistence of muscle hypertrophy, its lower head compresses and, along with other anatomical factors, shifts the sciatic nerve toward the acetabulum, which reduces the available space for it and further facilitates the occurrence of compression [36].

DIAGNOSIS

Physical examination. The physical examination is primarily aimed at excluding other causes of sciatica than Piriformis Syndrome (PS). In patients suspected of having the piriformis

Table 1. Distribution of types of relationships between the sciatic nerve and the piriformis muscle.docx

Year of publication	Author	A/1	B/2	C/3	D/4	E/5	F/6	Others*	Total
General Research									
1896	Parsons, Keith [14]	85.5%	12.3%	-	2.2%	-	-	-	**13**
1971	Anson, McVay [15]	89.1%	10.0%	0.7%	0.2%	-	-	-	**2,008**
1979	Pecina [16]	78%	21%	0.8%	-	-	-	-	**130**
2006	D. Pokorny [17]	79.1%	14.4%	4.4%	2.2%	-	-	-	**182**
2008	Mustafa Güvençer [18]	76%	16%	8%	-	-	-	-	**50**
2011	Joseph B. B. Brooks [19]	90%	-	-	10%	-	-	-	**40**
2013	Konstan-tinos Natsis [20]	93.5%	4.1%	0.3%	0.3%	-	0.3%	1.4%	**294**
2014	Adibatti M. V. S. [21]	92%	2%	2%	-	-	-	4%	**50**
2015	Birhane Alem Berihu [22]	75%	8.9%	1.8%	-	-	-	14.3%	**56**
2015	Robert Haładaj [23]	66.7%	20%	0.3%	-	-	-	10%	**30**
2015	Rupali Shastra-kar [24]	70%	16%	6%	-	-	-	8%	**50**
2016	Samara Lewis [25]	88.2%	8.8%	2.9%	-	-	-	-	**102**
2017	Vanja Varenika** [26]	86.8%	12.9%	0.3%	-	-	-	1.2%	**643**
2019	C. Marco, M. Miguel-Pérez [27]	71.9%	21.6%	6.5%	-	-	-	-	**59**
2020	Ameet Kumar Jha [28]	92.5%	2.5%	5%	-	-	-	-	**40**
2020	P Wan-Ae-Loh [29]	74%	22.5%	3.4%	-	-	-	-	**204**
2022	Juan Pablo Reynoso [30]	92.5%	5%	-	-	2.5%	-	-	**40**
2022	Atoni D. Atoni [31]	92.9%	3.6%	-	-	-	-	3.6%	**56**
Research on individuals with symptoms of syndrome									
2018	Adam L. Bartret [32]	80.8%	18.6%	0.38%	0.13%	-	-	-	**783**
2019	Hayat Khan. M.D., Stephen Ling** [33]	55.9%	41.9%	2.1%	-	-	-	-	**93**
2023	Upasana Upadhyay Bhara-dwaj*** [34]	74.8%	24.8%	-	-	-	-	0.4%	**254**

*Mainly, the sciatic nerve divided beneath the piriformis muscle, similar to type A/1, and various unclassified variations; *MRI; ***MRN

syndrome, the examination should involve a thorough assessment of the lumbar spine, pelvis and hip with the sacroiliac joint. It is also essential to consider the patient's gait. posture and leg length discrepancies, as well as sensory, motor, and deep tendon reflexes [7]. The examination involves primarily palpation and other diagnostic tests, including the Pace or Freiberg signs and the FAIR test. In a study by Durrani and Winnie, 92% of patients with piriformis syndrome exhibited tenderness upon deep palpation of the piriformis muscle. Additionally, Robinson described the presence of muscle fiber nodules on the piriformis muscle in some patients with PS during palpation [4].

Imaging tests. Imaging studies, such as computed tomography (CT), magnetic resonance imaging (MRI), or ultrasound (USG), are used not only to exclude or confirm other causes of pain than PS, but also to detect anatomical changes within the piriformis muscle that may contribute to the development of the piriformis muscle syndrome. The CT scan is useful in ruling out conditions causing compression of the sciatic nerve, such as tumour, allowing differentiation of the cause of the pain. MRI, on the other hand, may be helpful in excluding spinal canal stenosis or radiculopathy as the cause of sciatica, and enables the detection of enlargement of the piriformis muscle or anatomical changes [4]. Wenhua Zhang et al. conducted a study on the effectiveness of USG and MRI in diagnosing piriformis syndrome. They examined the piriformis muscles on both sides of the body in 33 patients diagnosed with PS and 26 healthy volunteers. The results of the study revealed that in patients with PS, both on USG and MRI, there was visible enlargement of the thickness (iTh) and cross-sectional area (iCSA) of the piriformis muscle on the symptomatic side, compared to the asymptomatic side. In healthy volunteers, no significant differences were detected on either side of the body. They also assessed the signal intensity (MRI) and ECHO (USG) of the piriformis muscle – they were higher in patients on the symptomatic side. Additionally, they observed that iCSA in MRI is larger than in USG, possibly due to the oblique orientation of the muscle [37].

Treatment. The treatment of piriformis syndrome can be either operative or non-operative. The latter is initially applied, with operative treatment considered only in the case of failure.

Non-operative treatment is the primary approach in the therapy of piriformis syndrome. It consists of the nonsteroidal anti-inflammatory drugs (NSAIDs). muscle relaxants. and neuropathic pain medications, such as gabapentin or pregabalin (increasing the synthesis and release of GABA). Additionally, physiotherapy (stretching of the gluteal muscles), intravenous injections (with cortisone, local anesthetics, or botulinum toxin) are considered [10]. In a study by Michel et al. on 250 patients diagnosed with piriformis syndrome, pharmacological treatment with NSAIDs and muscle relaxants, together with physiotherapy, led to the relief of pain symptoms in 128 out of 250 patients (51.2%) [4.38].

Table 2. Diagnostic tests used in the diagnosis of PS

Diagnostic test	Description
Freiberg Sign	Strong internal rotation of the painful leg when the patient is lying on their back. Positive when there is pain or paresthesia in the posterior pelvic region.
Pace Maneuver	The doctor limits hip abduction when the patient is in a sitting position. Positive when there is pain in the buttocks, weakness, or paresthesia on the affected side.
FAIR Test	The patient's hip is positioned in flexion, adduction, and internal rotation, in a supine or side-lying position. Positive when there is pain or paresthesia in the posterior pelvic region.
Beatty Maneuver	The patient lying on the side holds the flexed hip in abduction against gravity. Positive when there is pain in the buttocks, weakness, or paresthesia on the affected side.
Active Piriformis Test	The patient, in a lateral position, actively abducts and externally rotates the hip while the examiner provides resistance to this movement. Positive when there is pain.
Seated Piriformis Stretch Test	The patient is in the seated position. The examiner extends the knee and passively moves the flexed hip into adduction \ with internal rotation while palpating 1 cm lateral to the ischium (middle finger) and proximally at the sciatic notch (index finger) Positive when the recreation of the posterior pain at the lev of the piriformis or external rotators.
Lasegue's Test	The patient lies supine, and the examiner raises the affected leg in extension until it is fully flexed at the hip joint or until the patient complains of pain or paresthesia. Positive when there is pain. It may indicate other pathological causes of sciatica, not just piriformis syndrome.

First-line therapy for piriformis syndrome involves non-steroidal anti-inflammatory drugs, such as ibuprofen, which alleviate symptoms by reducing inflammation, but may cause gastric ulcers. For patients who do not respond to NSAID treatment, gabapentin and pregabalin are administered. The combination of mannitol and vitamin B has shown promising results. In a 2019 study, 22 patients received a 250 ml intravenous infusion and B vitamins (B1. B2. B12) for six weeks. Observations after three and six months showed a reduction in muscle tenderness and pain during rest, at night, and during physical activities, standing or lying [39.40].

For patients who do not respond to conservative treatment, NSAIDs, physiotherapy or steroid injections are administered. In a 2015 study by Rosales et al., 49 patients with piriformis syndrome were injected with a mixture of 20 ml saline, 4 ml 2% lidocaine, and 1 ml corticosteroid (40 mg methylprednisolone acetate) in the periradicular area, between the gluteus maximus muscle and the pelvic and femoral muscles. Among all patients, 73.7% reported pain relief; however, 50% reported pain recurrence. The treatment effect lasted about five weeks [41].

In a 2019 study by Christopher J. Burke, William R. Walter, and Ronald S. Adler, the application of hydrodissection of the sciatic nerve before ultrasound-guided corticosteroid injection was evaluated. Hydrodissection involves the injection of fluid to dissect the perineural tissue space. This method reduces adhesions and expands tissue spaces, facilitating the focal injection of anesthetics and corticosteroids. In a group of 38 patients, 17 received betamethasone and 21 received triamcinolone acetonide. Immediate pain relief was observed in 84% after injection, and 9 out of 19 patients reported sustained pain relief after an average of 33.6 days [42].

In the injection of botulinum toxin. the technique is crucial due to the small size and deep location of the piriformis muscle, as well as its anatomical relationship with other important neurovascular structures. An utrasound-guided injection of BoNT-A is non-invasive and effective. If the muscle is very thin or the patient is overweight, the use of MRI improves targeting. Injecting 100–200 units of BoNT-A intramuscularly leads to muscle weakening and atrophy, potentially reversing any nerve compression [40].

Operative treatment includes surgical interventions, such as resection of the piriformis muscle, bursectomy (partial removal of the synovial bursa) of the greater trochanter, and sciatic nerve neurolysis [43]. Before proceeding with operative treatment, it is essential to exclude other causes of sciatica than piriformis syndrome, and carefully select patients for surgical intervention. Some studies, including those conducted by Bensn and Schutzer, present positive outcomes of surgery, but the effectiveness and lesser invasiveness of conventional non-operative forms of therapy mean that surgical treatment is applied only in the case of failure of other methods [4].

CONCLUSIONS

Among the collected studies on anatomical variations of the sciatic nerve, the most common variant is consistently referred to as the basic A/1 type, followed B/2, C/3, D/4, E/5 and F/6. Minor studies, e.g. by J. B. B Brooks, reporting the uncommon D/4 as the surprisingly sole variant. Options E/5 and F/6 were extremely rare, each observed by only one of the two authors. D3 was mostly absent in the studies, and C3 never exceeded 8%. The impact of these variants is challenging to estimate. The most interesting variant appears to be B/2. with its frequency varying significantly from study to study, ranging from 2% – 42% in the data collected for the currentstudy; while in the dataset of N. R. Small, it ranged from 1.5% – 34%. The statistics collected, similar to a study by Bartret, suggest a lack of correlation between the occurrence of anatomical variants and sciatica. In the most extensive study examining the correlation between the occurrence of type B (II) conducted by Adam L. Bartret, the author suggests no statistically significant differences, noting only a slight increase in the proportional representation of type B among patients with sciatica symptoms.

Conversely, newer studies of this type, conducted on smaller samples by U. U. Bharadwaja and H. Khan, show a clear over-representation of the B variant among patients, compared to population study results. Additionally, Bharadwaj notes a positive correlation between larger and asymmetric dimensions of the sciatic nerve and sciatica symptoms, aligning with the theoretical assumptions of piriformis syndrome. This challenges the hypothesis by A. L. Bartet, although his work remains the most extensive recent study in this field. These researchers conclude that the differences in results may be due to genetic variations between the tested populations. They also demonstrated the effectiveness of using MRI/MRN techniques, not only in routine diagnosis, but also for accurately distinguishing types of piriformis muscle and sciatic nerve relationships, providing another tool (in addition to *post mortem* sections) for their assessment. V. Varenika was a pioneer in successfully collecting a large (>500) set of scans for evaluation of the sciatic nerve. Interestingly, massive differences in the occurrence rate of the B type was observed not only between

different studies, but also within Varenika's study: results came from two different institutions and differed by almost 10 percentage points.

The most important goal of research should now be the conducting of a large, representative study of diagnosed patients suffering from sciatica in terms of the presence of anatomical variations. It is generally agreed that further comprehensive studies comparing the results of those suffering from this syndrome with healthy individuals are necessary for the accurate determination of the degree of involvement of anatomical variants in piriformis muscle syndrome causes.

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REFERENCES

1. Boote J. Newsome R. Reddington M. Cole A. Dimairo M. Physiotherapy for Patients with Sciatica Awaiting Lumbar Micro-discectomy Surgery: A Nested. Qualitative Study of Patients' Views and Experiences. Physiother Res Int. 2017;22(3). doi:10.1002/PRI.1665
2. Siddiq MAB. Clegg D. Hasan S Al. Rasker JJ. Extra-spinal sciatica and sciatica mimics: a scoping review. Korean J Pain. 2020;33(4):305. doi:10.3344/KJP.2020.33.4.305
3. Park JH. Jeong HJ. Shin HK. Park SJ. Lee JH. Kim E. Piriformis ganglion: An uncommon cause of sciatica. Orthop Traumatol Surg Res. 2016;102(2):257–260. doi:10.1016/J.OTSR.2015.11.018
4. Probst D. Stout A. Hunt D. Piriformis Syndrome: A Narrative Review of the Anatomy. Diagnosis. and Treatment. PM&R. 2019;11:54–63. doi:10.1002/PMRJ.12189
5. Bochenek A. Reicher M. Anatomia człowieka. t. I. 13th ed. PZWL. 2016.
6. Chang C. Jeno SH. Varacallo M. Anatomy. Bony Pelvis and Lower Limb: Piriformis Muscle. StatPearls. Published online November 13. 2023. Accessed November 29. 2023. https://www.ncbi.nlm.nih.gov/books/NBK519497/
7. Cass SP. Piriformis syndrome: a cause of nondiscogenic sciatica. Curr Sports Med Rep. 2015;14(1):41–44. doi:10.1249/JSR.0000000000000110
8. Larionov A. Yotovski P. Filgueira L. Novel anatomical findings with implications on the etiology of the piriformis syndrome. Surg Radiol Anat. 2022;44(10):1397–1407. doi:10.1007/S00276–022–03023–5
9. Goidescu OC. Enyedi M. Tulin AD. et al. Overview of the anatomical basis of the piriformis syndrome-dissection with magnetic resonance correlation. Exp Ther Med. 2022;23(2):113. doi:10.3892/ETM.2021.11036
10. 10 Chang A. Ly N. Varacallo M. Piriformis Injection. In: StatPearls. Treasure Island (FL): StatPearls Publishing; August 4. 2023.
11. Son BC. Lee C. Piriformis Syndrome (Sciatic Nerve Entrapment) Associated With Type C Sciatic Nerve Variation: A Report of Two Cases and Literature Review. Korean J Neurotrauma. 2022;18(2):434. doi:10.13004/KJNT.2022.18.E29
12. Bartret AL. Beaulieu CF. Lutz AM. Is it painful to be different? Sciatic nerve anatomical variants on MRI and their relationship to piriformis syndrome. Eur Radiol. 2018;28(11):4681–4686. doi:10.1007/S00330–018–5447–6
13. Trotter M. The relation of the sciatic nerve to the piriformis muscle in American whites and negroes. Anat Rec. 1932;52(4):321–323. doi:10.1002/AR.1090520404
14. Pierce WC. Hewitt HE. Thomas S. Sixth Annual Report of the Committee of Collective Investigation of the Anatomical Society of Great Britain and Ireland. 1895–96. J Anat Physiol. 1896;31(Pt 1):31.
15. Beaton L. Anson B. The relation of the sciatic nerve and of its subdivisions to the piriformis muscle. Anat Rec. 1937; 70(1): 1–5.
16. Pećina M. Contribution to the Etiological Explanation of the Piriformis Syndrome. Acta Anat (Basel). 1979;105(2):181–187. doi:10.1159/000145121
17. Pokorný D. Jahoda D. Veigl D. Pinskerová V. Sosna A. Topographic variations of the relationship of the sciatic nerve and the piriformis muscle and its relevance to palsy after total hip arthroplasty. Surg Radiol Anat. 2006;28(1):88–91. doi:10.1007/S00276–005–0056-X
18. Güvençer M. Akyer P. Iyem C. Tetik S. Naderi S. Anatomic considerations and the relationship between the piriformis muscle and the sciatic nerve. Surg Radiol Anat. 2008;30(6):467–474. doi:10.1007/S00276–008–0350–5
19. Brooks JBB. Silva CAC. Soares SA. Kai MR. Cabral RH. Fragoso YD. Anatomical variations of the sciatic nerve in a group of Brazilian cadavers. Revista Dor. 2011;12(4):332–336. doi:10.1590/S1806–00132011000400009
20. Natsis K. Totlis T. Konstantinidis GA. Paraskevas G. Piagkou M. Koebke J. Anatomical variations between the sciatic nerve and the piriformis muscle: a contribution to surgical anatomy in piriformis syndrome. Surg Radiol Anat. 2014;36(3):273–280. doi:10.1007/S00276–013–1180–7
21. Adibatti M. Sangeetha V. Study on variant anatomy of sciatic nerve. J Clin Diagn Res. 2014;8(8):AC07-AC9. doi:10.7860/JCDR/2014/9116.4725
22. Berihu BA. Debeb YG. Anatomical variation in bifurcation and trifurcations of sciatic nerve and its clinical implications: in selected university in Ethiopia. BMC Res Notes. 2015;8(1):633. doi:10.1186/S13104–015–1626–6
23. Haładaj R. Pingot M. Polguj M. Wysiadecki G. Topol M. Anthropometric Study of the Piriformis Muscle and Sciatic Nerve: A Morphological Analysis in a Polish Population. Med Sci Monit. 2015;21:3760–3768. doi:10.12659/MSM.894353
24. Shastrakar R. Nakhate M. Sawant VG. STUDY OF VARIATION IN THE HIGH DIVISION OF SCIATIC NERVE AND ITS RELATIONSHIP WITH THE PIRIFORMIS MUSCLE. Med Res Chron. 2015;2(3):359–365. Accessed December 1. 2023. https://medrech.com/index.php/medrech/article/view/94
25. Lewis S. Jurak J. Lee C. Lewis R. Gest T. Anatomical variations of the sciatic nerve. in relation to the piriformis muscle. Translational Research in Anatomy. 2016;5:15–19. doi:10.1016/J.TRIA.2016.11.001
26. Varenika V. Lutz AM. Beaulieu CF. Bucknor MD. Detection and prevalence of variant sciatic nerve anatomy in relation to the piriformis muscle on MRI. Skeletal Radiol. 2017;46(6):751–757. doi:10.1007/S00256–017–2597–6
27. Marco C. Miguel-Pérez M. Pérez-Bellmunt A. et al. Anatomical causes of compression of the sciatic nerve in the pelvis. Piriform syndrome. Revista espanola de cirugia ortopedica y traumatologia (English ed). 2019;63(6):424–430. doi:10.1016/J.RECOT.2019.06.002
28. Jha AK. Baral P. Composite Anatomical Variations between the Sciatic Nerve and the Piriformis Muscle: A Nepalese Cadaveric Study. Case Rep Neurol Med. 2020;2020:1–6. doi:10.1155/2020/7165818
29. Wan-Ae-Loh P. Huanmanop T. Agthong S. Chentanez V. Evaluation of the sciatic nerve location regarding its relationship to the piriformis muscle. Folia Morphol (Warsz). 2020;79(4):681–689. doi:10.5603/FM.A2019.0140
30. Reynoso JP. De Jesus Encarnacion M. Nurmukhametov R. et al. Anatomical Variations of the Sciatic Nerve Exit from the Pelvis and Its Relationship with the Piriformis Muscle: A Cadaveric Study. Neurol Int. 2022;14(4):894–902. doi:10.3390/NEUROLINT14040072
31. Atoni AD. Oyinbo CA. Francis DAU. Tabowei UL. Anatomic Variation of the Sciatic Nerve: A Study on the Prevalence. and Bifurcation Loci in Relation to the Piriformis and Popliteal Fossa. Acta Med Acad. 2022;51(1):52–58. doi:10.5644/AMA2006–124.370
32. Bartret AL. Beaulieu CF. Lutz AM. Is it painful to be different? Sciatic nerve anatomical variants on MRI and their relationship to piriformis syndrome. Eur Radiol. 2018;28(11):4681–4686. doi:10.1007/S00330–018–5447–6
33. Khan H. Ling S. Ali S. et al. Sciatic Nerve Variants in Patients Diagnosed With Sciatica: Is There a Correlation? J Comput Assist Tomogr. 2019;43(6):953–957. doi:10.1097/RCT.0000000000000919
34. Bharadwaj UU. Varenika V. Carson W. et al. Variant Sciatic Nerve Anatomy in Relation to the Piriformis Muscle on Magnetic Resonance

Neurography: A Potential Etiology for Extraspinal Sciatica. Tomography. 2023;9(2):475–484. doi:10.3390/TOMOGRAPHY9020039
35. Windisch G. Braun EM. Anderhuber F. Piriformis muscle: clinical anatomy and consideration of the piriformis syndrome. Surg Radiol Anat. 2007;29(1):37–45. doi:10.1007/S00276–006–0169-X
36. Koh E. Webster D. Boyle J. Case report and review of the potential role of the Type A piriformis muscle in dynamic sciatic nerve entrapment variant of piriformis syndrome. Surg Radiol Anat. 2020;42(10):1237–1242. doi:10.1007/S00276–020–02440–8
37. Zhang W. Luo F. Sun H. Ding H. Ultrasound appears to be a reliable technique for the diagnosis of piriformis syndrome. Muscle Nerve. 2019;59(4):411–416. doi:10.1002/MUS.26418
38. Michel F. Decavel P. Toussirot E. et al. Piriformis muscle syndrome: diagnostic criteria and treatment of a monocentric series of 250 patients. Ann Phys Rehabil Med. 2013;56(5):371–383. doi:10.1016/J.REHAB.2013.04.003
39. Huang ZF. Lin BQ. Torsha TT. Dilshad S. Yang DS. Xiao J. Effect of Mannitol plus Vitamins B in the management of patients with piriformis syndrome. J Back Musculoskelet Rehabil. 2019;32(2):329–337. doi:10.3233/BMR-170983
40. Vij N. Kiernan H. Bisht R. et al. Surgical and Non-surgical Treatment Options for Piriformis Syndrome: A Literature Review. Anesth Pain Med. 2021;11(1):1–8. doi:10.5812/AAPM.112825
41. Rosales J. García N. Rafols C. Pérez M. Verdugo MA. Perisciatic Ultrasound-Guided Infiltration for Treatment of Deep Gluteal Syndrome. Journal of Ultrasound in Medicine. 2015;34(11):2093–2097. doi:10.7863/ULTRA.14.12030
42. Burke CJ. Walter WR. Adler RS. Targeted Ultrasound-Guided Perineural Hydrodissection of the Sciatic Nerve for the Treatment of Piriformis Syndrome. Ultrasound Q. 2019;35(2):125–129. doi:10.1097/RUQ.0000000000000360
43. Han SK. Kim YS. Kim TH. Kang SH. Surgical Treatment of Piriformis Syndrome. Clin Orthop Surg. 2017;9(2):136–144. doi:10.4055/CIOS.2017.9.2.136