ORIGINAL ARTICLE

Nr 2023;13 (2):228-233

Anatomical Variation of the Sciatic Nerve in Relation to the Piriformis Muscle: An MRI Study

Mona I. Almuhaish[1], Iba I. AlFawaz[1], Tarek M. Hegazi[1], Sulaiman A. Al-Mousa[2], Shayma S. Alsubaie[2], Abdulaziz A. Alkhaldi[3], Majed M. AlMutairi[3], Talal H. Alshammari[3], Hussain F. Alhowaish[3], Mohammad M. Alzahrani[2]

[1] *Department of Radiology, Imam Abdulrahman Bin Faisal University, King Fahd Hospital of the University, Khobar, Saudi Arabia*

[2] *Department of Orthopedic Surgery, Imam Abdulrahman Bin Faisal University, King Fahd Hospital of the University, Khobar, Saudi Arabia*

[3] *Imam Abdulrahman Bin Faisal University, College of Medicine, Dammam, Saudi Arabia*

CORRESPONDING AUTHOR:
Mohammad M. Alzahrani
Imam Abdulrahman Bin Faisal University
King Faisal Road
Dammam, Saudi Arabia 34212
E-mail: mmalzahrani@iau.edu.sa

DOI:
10.32098/mltj.02.2023.05

LEVEL OF EVIDENCE: 3

SUMMARY

Background. The sciatic nerve is the largest and thickest branch of the lumbosacral plexus. It separates into numerous branches and exhibits multiple anatomical variations that may result in nerve compression, a factor that is attributed to its location in the pelvis. This study aims to detect sciatic nerve branch variation and its association with the piriformis muscle and to establish the prevalence of each variant using routine pelvic MRI examinations.

Methods. This was a cross-sectional retrospective study of patients who underwent pelvic MRI studies from January 2018 to December 2020. Collected data included patient demographics, anatomical type of sciatic nerve (according to the Beaton and Anson classification system) and history of radiculopathy or sciatic nerve symptoms. Data was collected, and descriptive statistics were analyzed with a $p < 0.05$ considered as statistically significant.

Results. A total of 188 patients were included in the study. The majority (95.7%) of the patients exhibited the type 1 variant, while type 2 and type 3 variants exhibited a prevalence of 3.2% and 1.1%, respectively. No statistically significant difference in history of radiculopathy and sciatica was identified between the different anatomical variants.

Conclusions. The sciatic nerve's anatomical variation in relation to the piriformis muscle can be identified on routine pelvic MRI scans, with most of the detected variants being type 1. This study confirms the anatomical variations of the sciatic nerve in the pelvic region which can be detected on routine MRI.

KEY WORDS

Sciatic nerve; anatomical variation; piriformis muscle; sciatica; MRI.

INTRODUCTION

The sciatic nerve is the largest nerve in the human body which is composed from the union of the ventral roots of the L4-S3 spinal segments (1, 2). Sciatic nerve compression anywhere along its course can lead to various clinical manifestations including buttock and/or leg pain, sensory alterations, and muscle weakness, which are commonly referred to as "sciatica" (3). These manifestations are extremely commonplace, usually affecting adults in their fourth or fifth decades

with a life span prevalence of approximately 43% (3). Compression typically occurs as it the nerve exits the spinal canal near its origin and is normally attributed to a herniated disc or other spinal pathology. However, along its course, the sciatic nerve passes in close proximity to the piriformis muscle as it exits the pelvis and could be subjected to compression by the muscle, thereby giving rise to sciatica symptoms in a clinical entity that is referred to as "piriformis syndrome" (1). Nerve compression in piriformis syndrome is thought to result from inflammation or irritation of the nerve as a result of muscle hypertrophy but may also occur due to piriformis muscle or sciatic nerve congenital variations (3, 4).

Beaton and Anson classified the anatomical variation of the sciatic nerve in relation to the piriformis muscle into six types (5). The three most common types are described as follows: Type 1 depicts an undivided sciatic nerve that passes below the piriformis muscle, with a prevalence of 80-90%. Type 2 is when the common peroneal division passes through the piriformis muscle and the tibial nerve division passes below the piriformis muscle. This type is considered the second most common variant with a prevalence of 10-15% (3, 6). Type 3 describes the variant where the common peroneal division passes above the piriformis muscle and the tibial division passes below the piriformis muscle and is the third most common variant with a prevalence of 1-3% (3). Researchers have postulated that certain anatomical types may result in more sciatica-like symptoms (1).

The purpose of this study is to determine the prevalence of the various sciatic nerve anatomical variations in relation to the piriformis muscle in a middle eastern population and how it differs from the international data published in the literature. The study also seeks to establish if there are any correlations between the sciatic nerve anatomical variant and the presence of radiculopathy or sciatica-like symptoms.

MATERIALS AND METHODS

Institutional Review Board approval, IRB-2020-01-303, was obtained for this study (Committee: Imam Abdulrahman Bin Faisal University - Date of approval: October 25, 2020). A cross-sectional retrospective study design was employed. The data were obtained from the patient electronic medical records and included all patients 18 years of age or older, who underwent a pelvic MRI study from October 2018 to October 2020. Studies with axial T1 and/or axial T2 non-fat saturated sequences were included in this study. The exclusion criteria include any pathology related to the sciatic nerve, such as neuritis, neurofibromas, schwannoma, neoplastic processes in or around the sciatic nerve, or significant pelvic bone fractures. Patients were also excluded if they had a history of prior surgery in the hip/pelvic area that may alter the anatomy. Additionally, all duplicate exams and technically inadequate studies (lacking non-fat saturated sequence) were not included.

MR imaging was conducted at our institution with a 1.5 Tesla scanner (Optima MR450w; General Electric, Boston, United States) and a 3 Tesla scanner (Magnetom Skyra; Siemens, Munich, Germany). Evaluation of the sciatic nerve was primarily performed on the axial plane. The protocol and image parameters varied depending on the exam indication. Nonetheless, the standard protocol of the (2D) axial T1-weighted sequence was repetition time (TR) = 1000-1400 ms, echo time (TE) = 11-18 ms, ≤ 4 mm slice thickness, and a field of view (FOV) = 330-370 mm. The standard protocol of axial (2D) T2-weighted sequence was a TR = 2800-3100 ms, TE = 90-95 ms, ≤ 4 mm slice thickness, and a FOV = 330-370 mm.

Three radiologists reviewed the MRI studies, two of whom were subspecialized in musculoskeletal imaging. All the MRI studies contained an axial T1 sequence, which is the most sensitive sequence for the observation of anatomical variation (3). The anatomical relationship between the sciatic nerve and the piriformis muscle was classified according to the Beaton and Anson classification system (3). The presence of a split sciatic nerve, defined as a discrete separation of the common peroneal and tibial nerve bundles by a fat plane (of any thickness) at the level of the ischial tuberosity, was also recorded (**figure 1**). The number and percentage of each type of anatomical variation were recorded in addition to the patient's demographic information. The patient health records were reviewed for any previous history of sciatica or radiculopathy. The patient's file was reviewed for any previous spine imaging that may indicate back pain, radiculopathy or sciatica. Patients were contacted to inquire about any history of low back, sciatica or radiculopathy pain.

Sample size calculation was performed based on previous literature, the expected prevalence of sciatic nerve splitting is 5-15%. Assuming a prevalence of 10%, a sample size of 152 patients was required to achieve an error margin of 4% at a 95% confidence level (5% level of significance). Data was analyzed using the Statistical Package for the Social Sciences (SPSS) and chi-square test of independence was used to assess the association

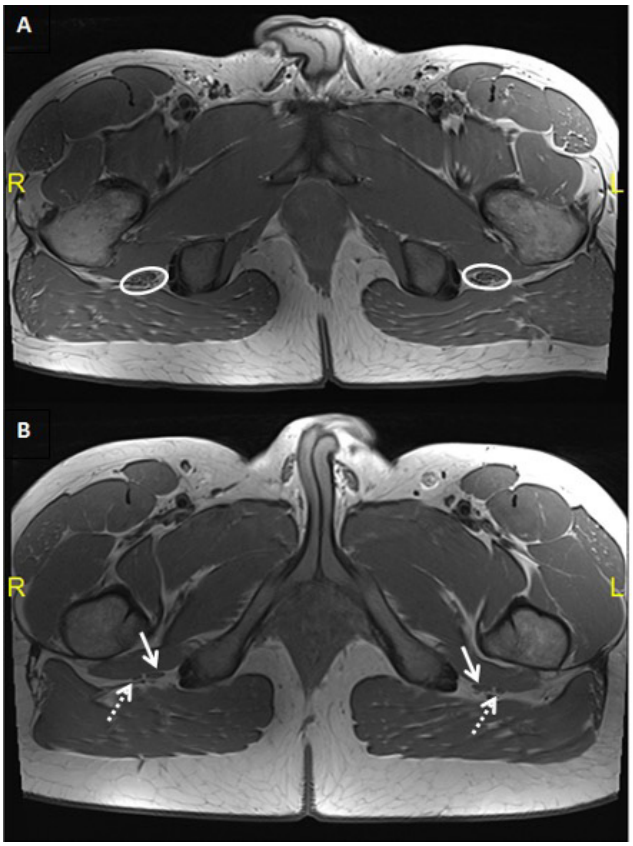

Figure 1. (A) Axial T1-weighted MRI at the ischial tuberosity level revealing a non-split sciatic nerve (white circle); **(B)** Axial T1-weighted MRI at the ischial tuberosity level revealing a split sciatic nerve with common peroneal (dashed white arrow) and tibial (solid white arrow) components of the nerve.

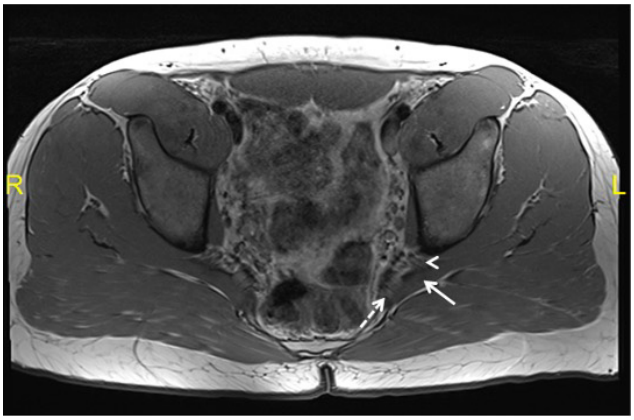

Figure 2. Axial T1-weighted MRI image of type 2 sciatic nerve.

Solid white arrows: piriformis muscle; dashed white arrow: common peroneal component piercing the piriformis; white arrowhead: tibial component passing anterior/below the piriformis.

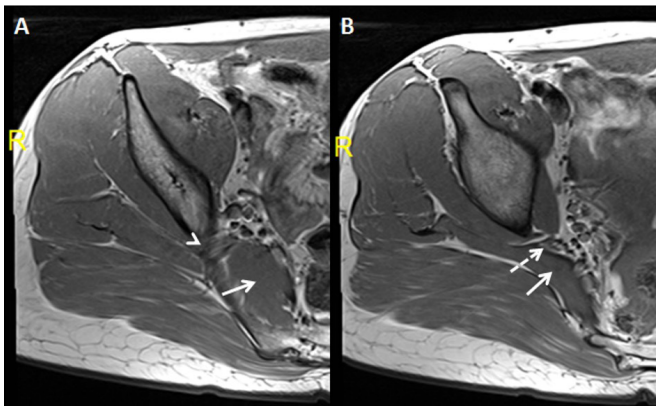

Figure 3. Axial T1-weighted MRI images of type 3 sciatic nerve.

Solid white arrows: piriformis muscle; white arrowhead: the common peroneal component passing posterior/above the piriformis muscle; dashed white arrow: tibial component passing anterior/below the piriformis muscle.

between categorical variables. Hypothesis testing was performed at 5% level of significance.

RESULTS

A total of 188 patients who fit the inclusion and exclusion criteria of the study were included in the study. The patient cohort included 114 (60.6%) males and 74 (39.4%) females (**table I**). The mean age of the cohort was 35.4 ± 16.7 years. Upon review of the sciatic nerve variation types, type 1 was identified in 180 (95.7%) cases, thus making it the most common form. Type 2 was the second most common type which was observed in six patients (3.2%) and type 3 was observed in two patients (1.1%) (**table II**). Patients exhibiting types 4 to 6 were not identified in this study (**figures 2, 3**). Sciatic nerve splitting was documented in 8% of patients, all with type 1 (**table III**). A total of 43 patients (22.9%) had history of low back pain or radiculopathy, while only 14.4% of the cohort showed signs of compression on spine MRI. There was no statistically significant correlation between the sciatic nerve variation type and the presence of a history of radiculopathy or sciatica, but was associated with older age and signs of compression on MRI (**table IV**). In addition, the presence of nerve splitting was also not associated with history of radiculopathy or sciatica (**table III**).

DISCUSSION

Our current cross-sectional retrospective study explored the prevalence of sciatic nerve variations in relation to the piriformis muscle in a middle eastern cohort. We found that 95.7% of patients had a type 1 variation, while only 3.2% and 1.1% had a type 2 and type 3 variant, respective-

Table I. Demographic and clinical characteristics of the included patients.

	n (%)
Gender	
Female	74 (39.4%)
Male	114 (60.6%)
Age category	
< 18	13 (6.91%)
18-35	103 (54.8%)
35-65	57 (30.3%)
> 65	15 (7.98%)
Variation type	
Type 1	180 (95.7%)
Type 2	6 (3.2%)
Type 3	2 (1.1%)
Splitting	
No	173 (92.0%)
Yes	15 (8.0%)

Table II. Association between splitting and characteristics of the included patients.

	Type 1 (n = 180)	Type 2 (n = 6)	Type 3 (n = 2)	P-value
Gender				0.715
Female	72 (40.0%)	2 (33.3%)	0 (0.00%)	
Male	108 (60.0%)	4 (66.7%)	2 (100%)	
Age category				0.659
< 18	12 (6.67%)	1 (16.7%)	0 (0.00%)	
18-35	97 (53.9%)	4 (66.7%)	2 (100%)	
35-65	56 (31.1%)	1 (16.7%)	0 (0.00%)	
> 65	15 (8.33%)	0 (0.00%)	0 (0.00%)	
Spine MRI compression				0.703
Yes	27 (15.0%)	0 (0.00%)	0 (0.00%)	
No	153 (85.0%)	6 (100%)	2 (100%)	
Splitting				1.000
Yes	15 (8.33%)	0 (0.00%)	0 (0.00%)	
No	165 (91.7%)	6 (100%)	2 (100%)	

ly. These findings are similar to previously published literature in different cohorts, which also showed that the type 1 variant was the most common type detected (79-87%), while other types were less common or even considered rare (1-3, 7, 8). Knowledge of prevalence of different variations is critical to assist during surgical planning and while performing interventional procedures such as total hip arthroplasty, intramuscular injections, and nerve blocks with a goal to subsequently minimizing potential iatrogenic injuries (9).

In our cohort we found that 8% of the patients were shown to have splitting of the sciatic nerve at the level of the ischial tuberosity, which also corresponds with previously published studies with a prevalence 6-9.8% of splitting (1, 3, 8). Variations of sciatic nerve splitting can be a direct cause of piriformis syndrome resulting from nerve compression or entrapment (10, 11). This syndrome has been increasingly detected with the advances in MRI imaging and has been linked to multiple etiologies including trauma, muscle hypertrophy or overuse, and variant anatomy leading to sciatic

Table III. Factors associated with splitting.

	Yes (n = 15)	No (n = 173)	P-value
Gender			0.743
Female	7 (46.7%)	67 (38.7%)	
Male	8 (53.3%)	106 (61.3%)	
Age cat			0.620
< 18	0 (0.00%)	13 (7.51%)	
18-35	10 (66.7%)	93 (53.8%)	
35-65	5 (33.3%)	52 (30.1%)	
> 65	0 (0.00%)	15 (8.67%)	
Spine MRI compression			0.700
Yes	1 (6.67%)	26 (15.0%)	
No	14 (93.3%)	147 (85.0%)	
Variation type			1.000
Type 1	15 (100%)	165 (95.4%)	
Type 2	0 (0.00%)	6 (3.47%)	
Type 3	0 (0.00%)	2 (1.16%)	

Table IV. Factors associated with radiculopathy and sciatica.

	Yes (n = 40)	No (n = 14)	P-value
Splitting			1.000
Yes	3 (7.50%)	12 (8.11%)	
No	37 (92.5%)	136 (91.9%)	
Age cat			< 0.001
< 18	3 (7.50%)	10 (6.76%)	
18-35	8 (20.0%)	95 (64.2%)	
35-65	18 (45.0%)	39 (26.4%)	
> 65	11 (27.5%)	4 (2.70%)	
Gender			0.036
Female	22 (55.0%)	52 (35.1%)	
Male	18 (45.0%)	96 (64.9%)	
Variation type			0.759
Type 1	38 (95.0%)	142 (95.9%)	
Type 2	2 (5.00%)	4 (2.70%)	
Type 3	0 (0.00%)	2 (1.35%)	
Spine MRI compression			< 0.001
Yes	21 (52.5%)	15 (10.1%)	
No	19 (47.5%)	133 (89.9%)	

nerve entrapment (12, 13). Therefore, correct recognition of this anatomical variation can improve the diagnostic accuracy and management decisions of such cases (11, 12).
Interestingly, Wan-ae-loh *et al*. found that in the Asian population type 2 was more prevalent compared to Caucasian or African ethnicities and showed a higher association with nerve impingement and piriformis syndrome in their cohort (14). In our study, the data analysis findings did not identify any significant association between the variation type or sciatic nerve splitting and presence of back pain, radiculopathy or sciatica.
We noted some possible limitations in our current study. The sample size examined was small compared with other studies, with 188 patients, but we believe that our study is adequately powered as per our sample size analysis. Another possible limitation is the retrospective nature of the study, which may increase the likelihood of recall bias.

CONCLUSIONS

The findings of this cross-sectional retrospective study established that type 1 sciatic nerve variant is the most common variant in our middle eastern cohort. Moreover, there was no correlation between the sciatic nerve variant and the presence of radiculopathy or sciatica. Understanding the different variations of the sciatic nerve anatomy and its relation to the piriformis muscle can help plan surgical and/or interventional procedures to minimize potential iatrogenic sciatic nerve injuries and their adverse effects.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

MIA, TMH, SAA-M, MMA: conceptualization, design. IIA, AAA, MMA, THA, HFA: literature research, patients recruitment, data collection. SSA: statistical analysis. All authors: writing – review and editing, final approval.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. 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):953-7. doi: 10.1097/RCT.0000000000000919.
2. Guvencer 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. Available at: http://www.turkishneurosurgery.org.tr/pdf/pdf_JTN_652.pdf.
3. 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):751-7. doi: 10.1007/s00256-017-2597-6.
4. Guvencer 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):467-74. doi: 10.1007/s00276-008-0350-5.
5. Ro TH, Edmonds L. Diagnosis and Management of Piriformis Syndrome: A Rare Anatomic Variant Analyzed by Magnetic Resonance Imaging. J Clin Imaging Sci. 2018;8:6. doi: 10.4103/jcis.JCIS_58_17.
6. 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):4681-6. doi: 10.1007/s00330-018-5447-6.
7. Ogeng'o JA, El-Busaidy H, Mwika PM, Khanbhai MM, Munguti J. Variant anatomy of sciatic nerve in a black Kenyan population. Folia Morphol (Warsz). 2011;70(3):175-9. Available at: https://pubmed.ncbi.nlm.nih.gov/21866528/.
8. Tomaszewski KA, Graves MJ, Henry BM, et al. Surgical anatomy of the sciatic nerve: A meta-analysis. J Orthop Res. 2016;34(10):1820-7. doi: 10.1002/jor.23186.
9. Pokorny D, Jahoda D, Veigl D, Pinskerova 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.
10. Adibatti M, Sangeetha V. Study on variant anatomy of sciatic nerve. J Clin Diagn Res. 2014;8(8):AC07-9. doi: 10.7860/JCDR/2014/9116.4725.
11. 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):273-80. doi: 10.1007/s00276-013-1180-7.
12. Kraus E, Tenforde AS, Beaulieu CF, Ratliff J, Fredericson M. Piriformis Syndrome With Variant Sciatic Nerve Anatomy: A Case Report. PM R. 2016;8(2):176-9. doi: 10.1016/j.pmrj.2015.09.005.
13. Hopayian K, Danielyan A. Four symptoms define the piriformis syndrome: an updated systematic review of its clinical features. Eur J Orthop Surg Traumatol. 2018;28(2):155-64. doi: 10.1007/s00590-017-2031-8.
14. 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):681-9. doi: 10.5603/FM.a2019.0140.