

Rethinking Sciatica In View of a Bilateral Anatomical Variation of the Sciatic Nerve, with Low Origin and High Division: Historical, Anatomical and Clinical Approach



Repensar a Cialgia Perante Variação Anatômica Bilateral do Nervo Isquiático, com Origem Baixa e Divisão Alta: Importância Histórica, Anatômica e Clínica

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ABSTRACT

Introduction: The aim of the present study is to report an original, unusual, case of bilateral anatomical variation of the sciatic nerve, with low origin and high division.

Material and Methods: Anatomical dissection was performed on a 66 year-old female cadaver. The corpse was embalmed and conserved through our original embalming techniques.

Results: The particular anatomical variation was first detected during routine dissection classes for undergraduate students. The study was completed with contralateral dissection to unveil bilateral variation. In both hind limbs, the sciatic nerve had a low origin, deep below the mid-gluteal region, and suffered high division, near the lower margin of the gluteal region, after a short length of circa 8 cm, to divide into the common fibular and tibial nerves.

Discussion: We detect several cases of sciatic nerve high division, in the reports of the earliest anatomists, such as Leonardo da Vinci, Vesalius, Da Cortona, or Eustachius. Such ancestral interest for these anatomical variations demonstrates the importance of their knowledge for health professionals of different areas.

Conclusion: The accurate study of sciatic nerve anatomical variations bears evident surgical, anaesthesiology and clinical applications. As more meticulous as our anatomical studies may get, one will never reach the state of perfection to consider such studies as definitive.

Keywords: Cadaver; Sciatic Nerve/anatomy

RESUMO

Introdução: O objectivo do presente estudo é o relato de um caso de variação anatómica do nervo isquiático, por origem baixa e divisão alta bilateral.

Material e Métodos: Foi dissecado um cadáver feminino de 66 anos, conservado pelas técnicas originais desenvolvidas no nosso departamento.

Resultados: No trabalho regular de dissecação cadavérica da disciplina de Anatomia Regional II detectou-se nervo isquiático, em ambos os membros, com pequeno trajecto, de aproximadamente, 8 - 10 cm, dividido em nervos fibular comum e tibial, ao nível da margem inferior do músculo glúteo máximo.

Discussão: Casos semelhantes aos do presente estudo, foram descritos por alguns autores desde Leonardo da Vinci, Da Cortona, ou Eustachius, demonstrando a importância desse conhecimento, tanto em termos clínicos, como cirúrgicos ou anestesiológicos. Diversas ilações são possíveis, por revisão do presente caso, infrequente.

Conclusão: Para além de proporcionar conhecimento prévio da anatomia loco-regional, o estudo das variações do nervo isquiático orienta o melhor seguimento de patologias, bem como acessos cirúrgicos e/ou anestésicos. Por mais meticulosos que sejam os nossos estudos anatómicos, jamais poderemos considerar terminada ou definitiva a investigação em anatomia humana.

Palavras-chave: Cadáver; Nervo Isquiático/anatomia

INTRODUCTION

Following the study published in *Acta Médica Portuguesa*,¹ the authors present an original case of bilateral low origin and high division of the sciatic nerve, not previously classified. The earliest description of a high division of the sciatic nerve was published in 1618.

The time in which human dissection more frequently took place overlapped for a short period with the golden age of cultural development and blooming of great enterprises and scientific discoveries (particularly associated

with the Egyptian or the Greek civilisation or, more recently, with the Renaissance). The comprehensive knowledge of the human body has encouraged the development of scientific curiosity and scientific reasoning (and the other way around...).² On the other hand, the time when human dissection was banned or neglected for different religious or cultural reasons corresponded to periods of decline in human knowledge and culture, similar to what happened during the medieval period.³ Upon a surprising step backwards

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by the end of the 20th century, we are now facing the resurgence of the awareness of the relevance of Anatomy and dissection in medical studies.⁴⁻¹¹

At NOVA Medical School de Lisboa, the regular practice of human dissection has remained from the first moment, in undergraduate as in postgraduate medical training, as well as in specialisation and/or surgical training (hands-on courses).^{12,13} To this end, a legalised list of human body donation has been promoted and maintained, as well as efforts aimed at the improvement of embalming techniques have been made, with the introduction of a pulsed infusion system into the embalming perfusion method and allowing for an improved capillary impregnation and subsequently a better tissue fixation and conservation.¹⁴ Based on the good results obtained with this system, international anatomists have applied for training, wishing to learn these conservation techniques and also to join our working teams in order to improve their cadaver dissection training. This is the case of two researchers and co-authors from the University of

Pernambuco, Brazil and from the University of Valparaiso, Chile, who have visited the department and took advantage of the quality of the Portuguese cadaveric material and have contributed with their work in the research used for this manuscript.

Historical background

The origin of the sciatic nerve, branches of the sacral plexus and the fourth lumbar nerve was clearly established in 1490 by Leonardo Da Vinci (Fig. 1A).¹⁵

The path of the sciatic nerve was comprehensively described in 1581 by Ambroise Paré,¹⁶ related to the relevance of the clinical presentation of sciatica. “The point of the hip joint through which remedies should be applied to cure the ‘ischiatric gout’ (*goute ischiatique*)” has been described by Paré at page XCIII (94) of his III Book, in an image of the gluteal region.¹⁶

An anatomical image of a very similar case to the one we are now describing 400 years later was represented by

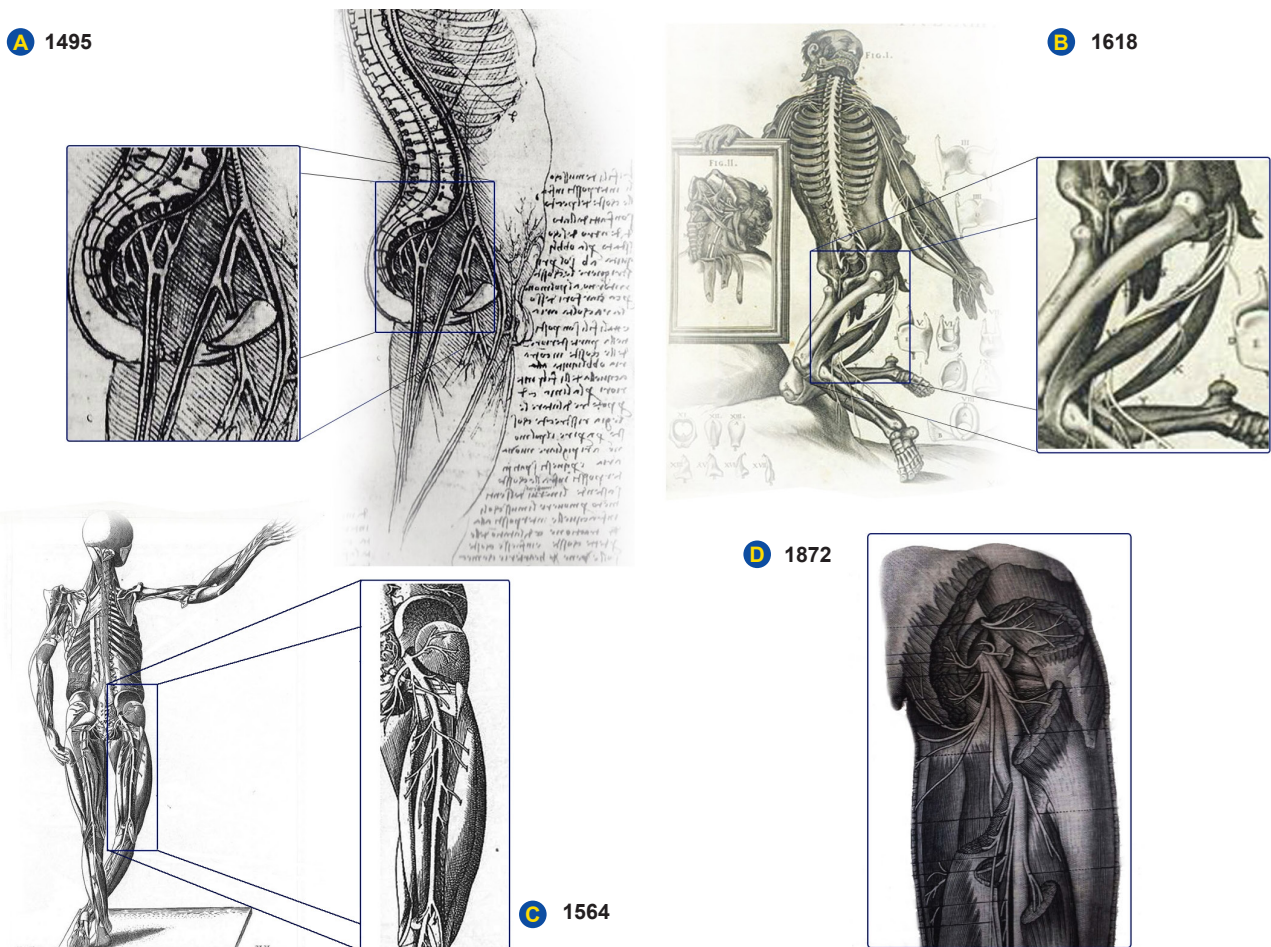


Figure 1 – History Layout of the Anatomy of the Sciatic nerve. **A:** 1495 - Leonardo da Vinci [Windsor Collection – Q IV f. 9 r/Clark 1911 4 r/c.1495 – 1499]: The four original branches of the nerve, in addition to the terminal branch of the abdominal aorta were represented. A duplication of the sciatic nerve throughout its pathway is shown; **B:** 1618 - A dissection image of the pathway of the sciatic nerve is shown by Pietro Da Cortona, divided in two branches from the origin up to the apex of the popliteal region, where the common tibial and peroneal nerves get separated; **C:** 1564 - The origin and path of the nerve, according to the more usual classification type, is represented by Bartolommeo Eustachius; **D:** 1872 - Ph. Sappey presents an image of gluteal dissection of the sciatic nerve and its branches, according to the more usual classification type (85%).

Pietro Da Cortona¹⁷ (Fig. 1B), even though an undivided sciatic nerve up to the apex of the popliteal region and deeply originating within the piriformis muscle was represented, fully corresponding to the most usual classification type (85%) in *Tabulae XVII* and *XIX*, dedicated to the posterior rami of spinal nerves. Cases of duplication of the sciatic nerve trunk have been described by these pioneer anatomists by means of figuration of the separation of the primitive elements of the nerve. In addition, Bartolommeo Eustachius¹⁸ (Fig. 1C) in 1564, as well as Ph. Sappey¹⁹ (Fig. 1D) or J. Cruveilhier later on,²⁰ have represented the origin, course and division of the nerve, according to the most frequent classification types in medical literature. Both have pointed the fact that the sciatic nerve can be divided at any level from the sacral plexus down to the popliteal fossa. As regards the hypothesis of high division of the sciatic nerve, Sappey (1867-72) has described the following division branches: "These two nerves, simply accolated/united to each other, may frequently become separated at higher levels and even close to the origin of the sciatic nerve".¹⁹

The six-group classification of the major anatomical variations of the sciatic nerve was proposed in 1937 by Beaton and Anson.²¹ In the most frequent classification type, which is found in 85% of the patients, an undivided sciatic nerve is found, with its origin below the piriformis muscle and, in 3% of the cases, with its origin and division below the piriformis muscle, as in the present case.

Clinical application

The knowledge on the origin, course and morphological variations of the sciatic nerve and its relationship with the surrounding anatomical structures is crucial in evidence-based clinical practice. Therefore, the relevance of this anatomical knowledge for a conservative action aimed at an adequate and efficient assessment, treatment and rehabilitation approach to patients with injuries to the sciatic nerve is worth mentioning, as well as for the development of preventive actions.

Nerve roots (L4 – S3) converging to form the sciatic nerve may become damaged by different factors, namely (i) an herniated disc (nerve root compression against the intervertebral disc); (ii) spondylolisthesis (slippage of one vertebra relative to the one below producing nerve root compression); (iii) mechanical injuries;^{22,23} (iv) inflammation;²⁴ (v) infectious process or tumours^{25,26} and (vi) enhanced responsiveness or nerve root compression due to gluteal varicosities, which is the most unusual presentation.²⁷⁻²⁹ The knowledge on the morphological aspects as well as on the embryo-foetal development of the sciatic nerve is crucial for subjective (medical history) and kinetic/functional patient assessment (with specific functional tests for the assessment of the sciatic nerve or the differential diagnosis with the piriformis syndrome).

An increased incidence (30%) of traumatic injuries to the sciatic nerve has been described by P.S. Issack in 2009, related to an increased prevalence of acetabular fractures and hip arthroplasty.²³ These injuries are usually associated

with (i) an incised injury to the nerve, (ii) a laceration due to fracture fragments, (iii) stretching injuries due to the orthopaedic manoeuvres in hip arthroplasty or (iv) with postoperative complications such as a haematoma-related compressive neuropathy.

According to Papadopoulos and Khan,³⁰ the piriformis syndrome was initially described by Robinson in 1947,³¹ corresponding to the compression or clamping of the sciatic nerve due to hypertrophy or contracture of the piriformis muscle or even to anatomical variations of the muscle. Patients present with sensitive, motor and/or trophic impairment along the innervation area of the sciatic nerve. This syndrome may correspond up to 6.5% of the patients with back pain, gluteal pain or pain to the remaining lower limb segments and surgery should only be considered in patients in whom all the remaining possible conservative treatment modalities have failed, according to Ortiz Sanchez *et al.*³² The previous knowledge on the anatomy of the sciatic nerve allows for the development of a specific rehabilitation approach tailored to patient's degree of disability and functional needs. The relevance of the relationship between the sciatic nerve and the surrounding muscles is worth mentioning. Apart from this syndrome, obturator internus syndrome, affecting both the sciatic and pudendal nerves, has also been described by Philippe Rigoard as a cause of non-discogenic sciatica.³³

MATERIAL AND METHODS

Human cadaveric material: This manuscript was based on a comprehensive work of careful dissection carried out by use of legally donated and previously embalmed human cadavers, which is the current practice in the laboratory of anatomy of the NOVA Medical School, according to the technique presented by Goyri-O'Neill in 2013.¹⁴

Two female cadavers (donor ages 89 and 66, respectively) with record number 0042 and 0071 from the body donation list were used for this study.

Both were embalmed in 2016, one year before the dissection and maintained in deep-freezing chambers (-20 to -30°C). By current rule at our department, both cadavers were previously manipulated in different postgraduate surgical and laparoscopy training courses.

An interesting anatomical variation has been found in cadaver 0071 throughout the eight sessions of dissection of the discipline of Regional Anatomy II. The second cadaver has been subsequently used as a control, for comparative dissection, in the study of the sciatic nerve bilateral anatomical variation.

RESULTS

Left lower limb (anatomical variation): In April 2017, during the regular classes of human cadaveric dissection at the NOVA Medical School, we were questioned by two students regarding a case of anatomical variation of the origin, course and division of the left sciatic nerve found in a 66-

year old female cadaver. Upon dissection and reflecting the gluteus maximus and medius muscles, a lower than usual origin of the main trunk of the sciatic nerve and four roots with a sacral origin below the piriformis muscle were found, involved by a common sheath and only convergent at the ischial tuberosity, already covered by the gluteal muscles (Fig. 2A).

Upon a short path of around 8 cm, the main trunk of the nerve emerged superficially at the gluteal fold and was immediately divided, deeply at the point of insertion of the femoral biceps (Fig. 3A).

Right lower limb (anatomical variation): In May and June 2017, taking the opportunity of the presence of two anatomists from the University of Pernambuco in training for technical improvement in human cadaveric dissection, a work team has been created and aimed at improving the dissection of the left lower limb, completing the work with a careful dissection of the whole contralateral limb of the same cadaver. This study was completed by using the

same dissection techniques in a third specimen of the sciatic nerve used in this study as a comparative control.

Similar origin and distribution of the sciatic nerve were found at the contralateral limb of the same female cadaver: high division at the upper third of the thigh, upon a short path, deeply within the gluteal muscles. The fibres of the nerve together with the sciatic artery (*arteria comitans nervi ischiadici*) were distinctively found within the sciatic sheath throughout the nerve pathway. (Fig. 3C)

Left lower limb (case-control): In June 2017, following these original observations on both limbs of cadaver 0071, the reproduction of the same techniques on a third case, used as a pattern, seemed relevant. The dissection of the cadaver 0042, also female, embalmed and maintained by the same technique from one year before the study, following the same technique, was carried out. The usual and most frequent classification type described by Beaton and Anson (85%) regarding the origin, course and relationships of the sciatic nerve was found in this third case.²¹

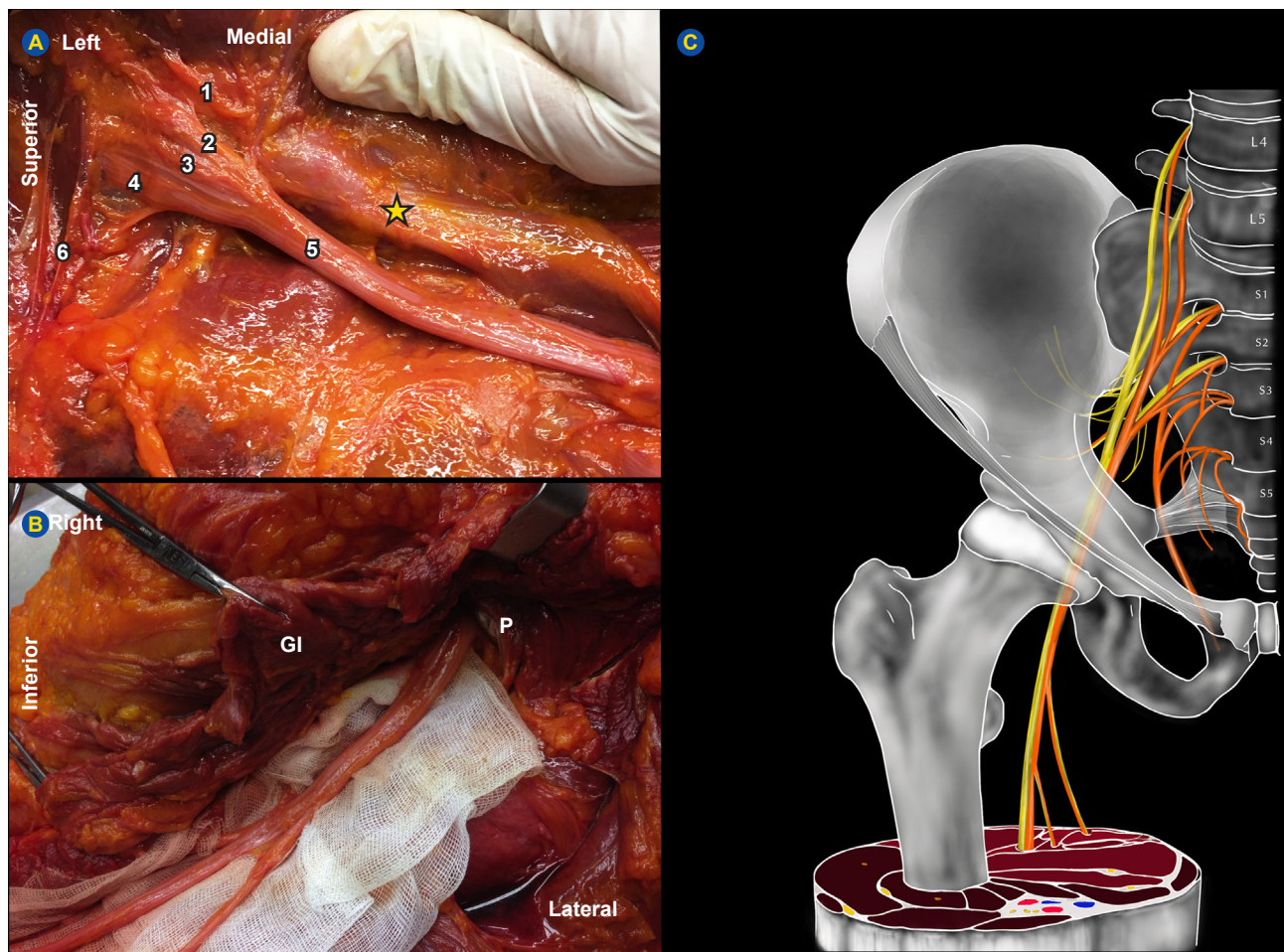


Figure 2 – Origin of the sciatic nerve, bilaterally dissected, in a 66-year female cadaver: **A:** Left lower limb – The low origin of the nerve (5) is shown, with the roots of the lumbosacral plexus (1; 2; 3; 4) merging together, upon the emergence of the superior and inferior gluteal nerves (6), deeply found within the gluteal region, up to the ischial tuberosity (★). **B:** Right lower limb – The dissection of the contralateral limb is shown in image B, in which the origin of the nerve is found below the Piriformis muscle (P), with a 10-cm short path to the ischial tuberosity, where the fibres of the common tibial and peroneal nerves run together with the sciatic artery and the whole of the components involved by the sciatic sheath. **C:** Artistic version of the origin of the sciatic nerve, by Daniel Casanova-Martinez (Chile), 2017.

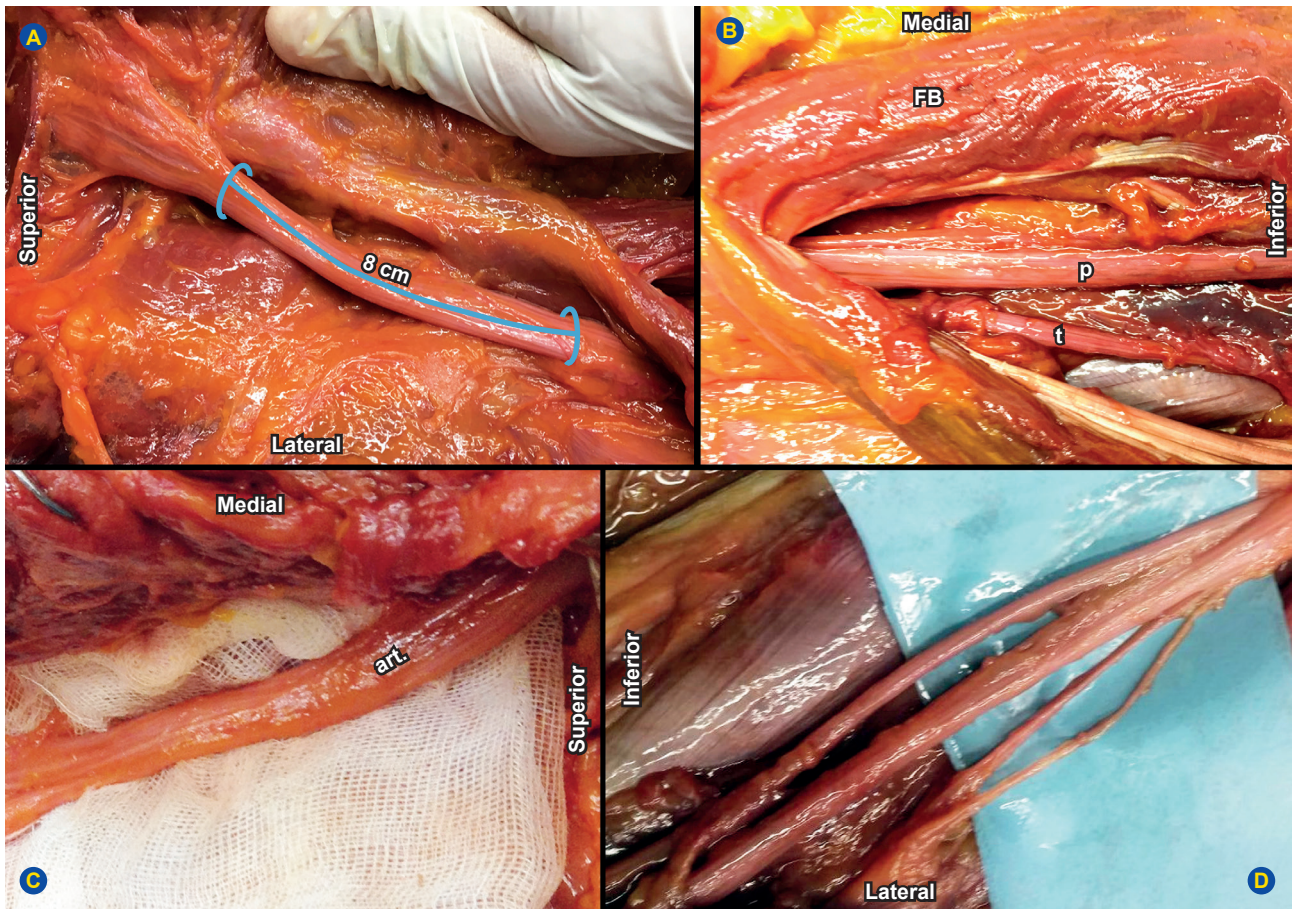


Figure 3 – Sciatic nerve pathway and division, bilaterally dissected, in a 66-year old female cadaver. On the left side, the main nerve trunk was dissected (A), completely covered by the gluteal muscles, over a 8-cm path and immediately divided at the ischial tuberosity, deeply to the insertion of the femoral biceps muscle (B “BF”), giving rise to the Common Tibial (B “t”) and Peroneal (B “p”) nerves. On the right, a high division of the nerve has also been found, slightly under the upper third of the dorsal side of the thigh, deeply to the hamstring muscles. Similar to the left limb, the path of the nervous fibres has been found, always divided within the sciatic sheath, together with the sciatic artery (C “art”). Upon careful removal of the involving sheath, the branches of the common peroneal nerve were isolated at the popliteal level, shown in image D and strangely reminding the proposal by Da Cortona 400 years ago (Fig. 1B).

DISCUSSION

The sciatic nerve is usually described as “the longest spinal nerve in the human body”.^{33,35-37} Therefore, the analysis of a bilateral anatomical variation seemed particularly interesting and led us thinking that we were in the presence of one of the most ‘short’ examples that have ever been described in medical literature, together with another case that was described in 2013 by the same co-authors.¹

K. Natsis *et al.* (2014) have shown the surgical relevance of the knowledge on the anatomical variations of the sciatic nerve related to the piriformis muscle (147 cases), focused on the less frequent cases (6.4%) in which the tibial nerve emerges under the lower margin of this muscle.³⁷

Upon a comprehensive bibliographic review including the oldest anatomical descriptions, we found the cases described by Leonardo da Vinci¹⁵ and Pietro Da Cortona,¹⁷ in which the authors reached the early and visionary conclusion that an ‘undivided’ trunk of the sciatic nerve would be a rare finding... The fibres of the common tibial and peroneal nerves would run through already divided within the sciatic

sheath, together with the sciatic artery and only united by the connective sheath involving them; both sets of nervous fibres would only individualise by separation at a variable height between the sacral origin and the apex of the popliteal region, according to the description of the anatomists Ph. Sappey¹⁹ or J. Cruveilhier.²⁰

Nerve agenesis would theoretically be found in the extreme case of a low origin and high division of the sciatic nerve, which has been described and appropriately proved by P. Coelho *et al.* in 2013.³⁸

The classification work by Beaton and Anson²¹ has been adopted by most authors, as found in the extensive review article by N. Apaydin in 2016, at the Bergman’s Comprehensive Encyclopaedia of Human Anatomic Variation³⁴ in which, as already described by Sappey and Cruveilhier, the point of division of the sciatic nerve is a variable finding leading to two terminal branches (common tibial and peroneal nerves) and even each one of these with a separate origin as direct branches of the sacral plexus. In addition, it is also described that the two terminal branches of the

sciatic nerve can be found as two distinct nerves throughout the whole pathway of the sciatic nerve, in around 11% of the cases, involved by a nerve sheath and allowing for the identification of the path of each of the nerves up to the original branches at a sacral level, once dissected. Within the analysis of non-discogenic causes of sciatica, carried out by A. Mallikarjun and V. Sangeetha,³⁹ different cases of high division of the sciatic nerve have been described in a literature review between 1997 and 2011 and high percentages (4.0% - 20.9%) of division of the sciatic nerve at the pelvic level have been found, when compared to their own group of 6% cases with pelvic level division.

International studies and attempts towards a modern clinical approach have focused on the piriformis syndrome as a cause for the clinical presentation of sciatica.^{40,41,42}

The hypothesis of a higher frequency of agenesis or short pathway of the sciatic nerve may lead to relevant clinical and surgical conclusions,³⁹ as in the case of local anaesthetic blockade,^{37,44} in the conservative treatment of sciatica⁴⁵ and mainly in technical procedures and clinical follow-up of patients having undergone hip arthroplasty,^{36,39,43-45} whose increasing number is due to ageing population, apart from an increasing healthcare population coverage worldwide.

The recent trend towards inactivity and excessive sitting, the repetitive 'compression' of the posterior region of the thighs and gluteal region could be co-responsible for the recently increasing prevalence of cases of high division of the sciatic nerve, so many times described in literature in recent years (three more cases of high division of the sciatic nerve have been found in eight cadavers in 2017 only).

The international recognition of the originality and factual modernisation of the techniques of cadaveric conservation in use at the Department of Anatomy of the NOVA Medical School is worth mentioning.

Intermittent perfusion with diethylene glycol allows for the maintenance of freshness appearance for dissection, even several months upon embalming, including cases in which the same cadaver has been used for different postgraduate courses of laparoscopic surgical training, prior to the use for dissection aimed at anatomical research. The fact that no formaldehyde was added to the embalming fluid allows for several hours of dissection without any unpleasant smell or any health concerns related to formaldehyde exposure. Our technique has been ranked at the top of the list by Balta⁴⁶ in 2015, in a comparative study of the different cadaveric embalming and conservation techniques over the centuries, as the most innovative and improved. In 2017, Nazreen Shariff and Alia Amin⁴⁷ have returned to the subject and described our techniques as allowing for cadaveric conservation during over more than one year, even though good conservation conditions have been found beyond five years. Following the introduction of the practice of arterial perfusion with diethylene glycol instead of formaldehyde, by Esperança Pina, Goyri-O'Neill has developed and improved the quality of tissue impregnation by the introduction of an intermittent arterial infusion mechanism with an infusion

pump embedded into a patented digital system that allows for flow and pressure regulation according to the individual body mass index (BMI).

CONCLUSION

Different conclusions may be reached with the review of the present case of infrequent bilateral anatomical variation of the sciatic nerve, beyond the obvious clinical and surgical relevance.

No matter how accurate our anatomical studies are, research in human anatomy may never be considered as completed or definitive. New fields of knowledge and new opportunities for research will emerge with further anatomical knowledge.

The efforts of those who teach and research on the anatomical subject and the art of dissection should never be neglected. Research and development of a better clinical practice are based on the crucial value of the anatomical study.

Therefore and based on the images of the present anatomical and clinical case, the maintenance of the efforts towards a better development of the technique and the practice of human cadaveric dissection are very relevant for better quality in undergraduate medical studies as well as for the improvement of postgraduate and surgical training, with a contribution for better rationale of clinical and surgical reasoning.

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HUMAN AND ANIMAL PROTECTION

The authors declare that the followed procedures were according to regulations established by the Ethics and Clinical Research Committee and according to the Helsinki Declaration of the World Medical Association.

DATA CONFIDENTIALITY

The authors declare that they have followed the protocols of their work centre on the publication of patient data.

CONFLICTS OF INTEREST

The authors declare that there were no conflicts of interest in writing this manuscript.

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