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Case Report
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Double Piriformis Muscle: Anatomical Characterization and Relationship with the Sciatic Nerve and Inferior Gluteal Nerve

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ABSTRACT

Introduction: the anatomical complexity of the gluteal region, particularly the piriformis muscle (PM) and its neurovascular relationships, is crucial for clinical practice, as variations can cause painful conditions like piriformis syndrome. This necessitates a deep anatomical understanding for accurate diagnoses and procedures. This article aims to characterize a rare anatomical variation: a double PM, detailing its relationships with the sciatic nerve (SN) and an atypical emergence of the inferior gluteal nerve (IGN), emphasizing their clinical relevance. The reported case describes the dissection of a 35-week-old fetal left gluteal region, revealing a double PM with distinct superior and inferior bellies. A high SN division was observed, where the common fibular nerve (CFN) emerged between the two PM bellies, passing posteriorly to the inferior PM, while the tibial nerve (TN) appeared anteriorly. Both SN divisions reunited distally. Additionally, the IGN emerged atypically between the superior and inferior PM, medial to the CFN. This peculiar configuration challenges established anatomical classifications, highlighting the region's complexity. The identification of this double piriformis, associated with a high SN division and atypical inferior gluteal nerve emergence, offers a unique perspective on gluteal anatomy. Such unusual variations, often not covered by current classifications, underscore the need to re-evaluate anatomical "normality." Continuous documentation of these findings is vital for academic advancement, improving diagnostic accuracy, optimizing surgical safety (e.g., hip arthroplasties, intramuscular injections), and refining modern medical treatment strategies.

Introduction

The piriformis muscle (PM) is widely described as one of the six lateral rotators in the gluteal region, primarily during hip extension, although its abductor action during hip flexion is of great importance. Its attachments generally occur at the sacrotuberous ligament and the anterior surface of the sacrum (pelvic aspect), running laterally through the greater sciatic foramen and inserting into the superomedial margin of the greater trochanter of the femur (Chang *et al*., 2023). Despite its standard morphology presenting a single, flattened, pear-shaped belly, anatomical variations are frequent, whether unilaterally or bilaterally (Beaton, Anson, 1937; Smoll, 2010; Natsis *et al*., 2013).

In addition to the musculature, the gluteal region contains important neurovascular structures that may require various clinical and surgical approaches. From this point of view, understanding the anatomy and variations of the PM, as well as its relations with the sciatic nerve (SN) and other gluteal structures, becomes indispensable. Indeed, there are many studies describing and classifying anatomical variations in this region, especially in relation to the PM and SN (Beaton, Anson, 1937; Smoll, 2010; Natsis *et al*., 2013; Sulak *et al*., 2013; Asmall *et al*., 2020; Poutoglidou *et al*., 2020; Aragão *et al*., 2022).

Clinically, studies suggest that PM variations may be related to compression of the SN, common fibular nerve (CFN), or superior gluteal nerve (SGN), leading to painful disorders such as piriformis syndrome and "foot drop." These anatomical variations can also reduce the sensitivity of physical examinations used to diagnose the source of pain in the gluteal and hip regions, in addition to being surgically relevant in approaches for total hip arthroplasties and arthroscopies (Smoll, 2010; Hopayian, Danielyan, 2018; Bartret *et al*., 2018).

The inferior gluteal nerve (IGN) is derived from the sacral plexus and provides motor function to the gluteus maximus muscle (GMM), the main muscle involved in hip extension and external rotation of the joint. This nerve emerges from the pelvis, runs through the greater sciatic foramen, caudally to the inferior margin of the PM and superficial to the SN, accompanying the inferior gluteal artery. It divides into several branches that enter the deep aspect of the overlying GMM (Dalley II, Agur, 2024). In the literature, descriptions of IGN anatomical variations are rare, however, they highlight the importance of

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this knowledge for healthcare teams when performing intramuscular injections, gluteal surgeries, and treating piriformis syndrome, as such variations may increase the risk of injuries (Golmohammadi, Delbari, 2021; Lesser *et al*., 2023). In this paper, it is reported a double PM associated with a rare anatomical variation of the IGN, combined with a high division of the SN in a human fetus.

Case Report

The PM was dissected in the left gluteal region of a 35-week fetus during routine dissection. After skin removal, the GMM was carefully dissected (Figure 1) and an oblique section was performed in its belly, passing perpendicularly to the arrangement of the muscle fascicles. The two portions of the GMM were retracted to visualize the gluteus medius and PM (Figure 2). At this point of the dissection, after superficial and deep fascia removal, it was possible to observed a high division of the SN and a double PM, one superior and one inferior (Figure 3).

The superior PM, long and conical in shape, had its proximal attachment laterally on the anterior (pelvic) surface of the sacrum, in a superior and slightly posterior position relative to the inferior PM. Its distal attachment occurred via a short tendon in a posteromedial position on the superior margin of the greater trochanter of the femur. On the other hand, the inferior PM also had its proximal attachment on the anterior surface of the sacrum, but more anterior and inferior relative to the superior PM. Additionally, this belly was triangular in shape, and its distal attachment tendon was located immediately superior to the common insertion of the superior gemellus, obturator internus, and inferior gemellus muscles in the trochanteric fossa. The tendon was notably long, spanning approximately 2/3 of the length of this segment of the PM (Figure 3).

Regarding the SN, a high division occurred, where approximately 1/3 of the most lateral fibers, which usually constitute the division called CFN of the SN, emerged in the middle third between the superior and inferior PM, following posteriorly to the inferior PM (Figure 3). Meanwhile, the remaining 2/3 of the SN, corresponding to the TN, appeared anterior to the inferior PM (Figure 3). These two portions of the SN united caudaly to the inferior margin of the inferior PM, aligned with the superior gemellus and obturator internus muscles, continuing united until the inferior third of the posterior compartment of the thigh. The position of the CFN and TN in relation to the SN was confirmed by observing these divisions in the popliteal fossa (Figure 4).

Additionally, the fibers of the IGN also emerged between the superior and inferior PM, medial to the CFN fibers. Upon passing through the inferior margin of the superior PM, this nerve branched, and its fascicles distributed on the deep aspect of the GMM (Figure 3).

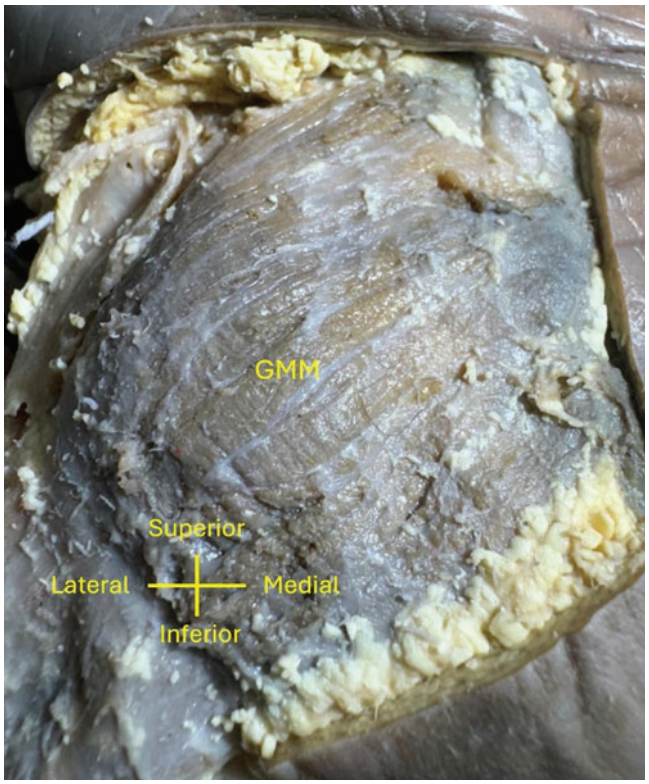

Figure 1. Posterior view of the left gluteal region. The skin was removed and the gluteus maximus muscle (GMM) was exposed.

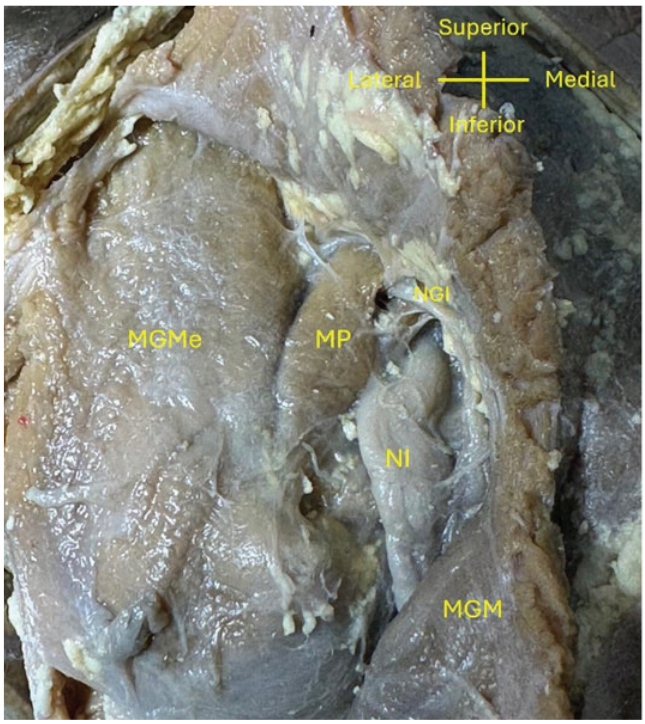

Figure 2. Posterior view of the left gluteal region. Sectioning and retraction of the gluteus maximus muscle (GMM). Note the gluteus medius muscle (GMeM), piriformis muscle (PM), sciatic nerve (SN), and inferior gluteal nerve (IGN), all still covered by superficial and deep fascia.

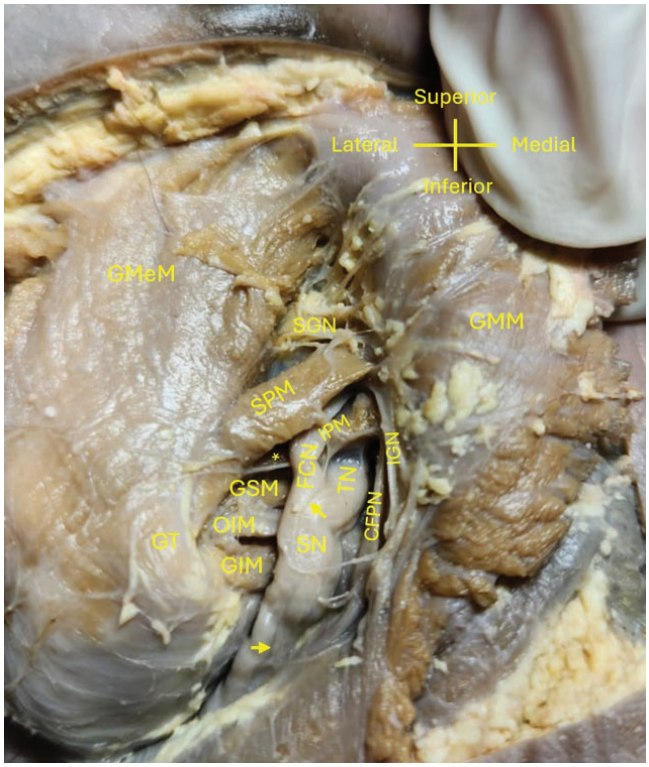

Figure 3. Posterior view of the left gluteal region. Retraction of the gluteus maximus muscle (GMM). Note the duplication of the piriform muscle (PM), the early division of the sciatic nerve (SN), and the apparent origin of the inferior gluteal nerve (IGN) between both PM. GMeM: gluteus medius muscle; SGN: superior gluteal nerve; SPM: superior piriform muscle; IPM: inferior piriform muscle; CFN: common fibular nerve; TN: tibial nerve; PCFN: posterior cutaneous femoral nerve; GSM: gemellus superior muscle; OIM: obturator internus muscle; GIM: gemellus inferior muscle; GT: greater trochanter; * tendon of the IPM; the yellow arrows indicate the united divisions of the SN.

Discussion

The description of the double PM anatomical variation reported in this article adds a new perspective to the understanding of the structures in the gluteal region. This variation, along with the high division of the SN and the atypical emergence of the IGN, highlights the anatomical complexity and clinical importance of these variations. The anatomical relationship between the PM and SN has been a topic of interest for a long time Early studies by Parsons and Keith (1896), Trotter (1932), Fukumoto (1935), and Beaton and Anson (1937) have explored this relationship. The classic work by Beaton and Anson (1937) described six possible types of anatomical variations of the SN in relation to the PM and is considered a classic reference in this field.

Żytkowski *et al.* (2021) examined anatomical normality and variability through a historical and methodological perspective. The aim of the study was to delve into the concept of what constitutes normalcy in macroscopic anatomy and the criteria used to identify a structure as normal. The study also evaluated how the concept of normality in anatomy has evolved over time, based on repeated observations and common patterns described in anatomy textbooks.

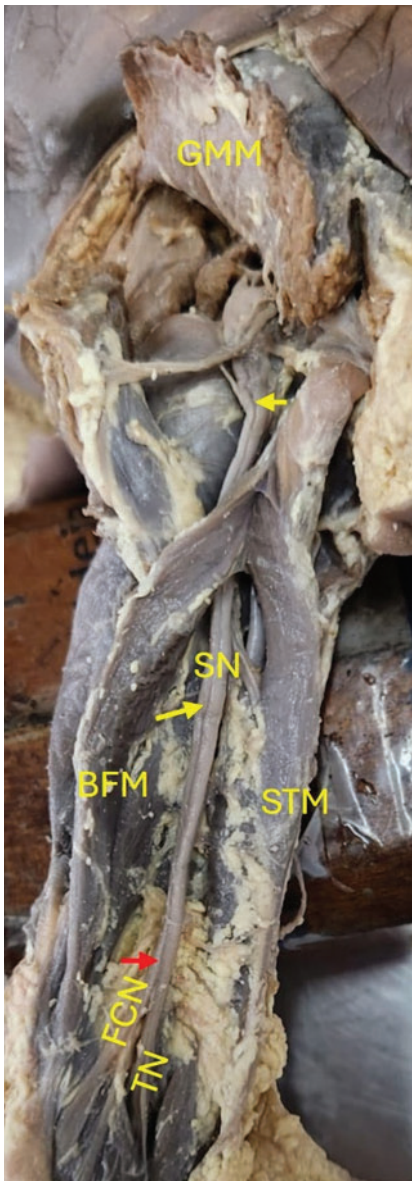

Figure 4. Posterior view of the left gluteal region, thigh, and popliteal fossa. Retraction of the gluteus maximus muscle (GMM). Observe the course of the sciatic nerve (SN) from the gluteal region to the popliteal fossa.
CFN: common fibular nerve; TN: tibial nerve; BFM: biceps femoris muscle; STM: semitendinosus muscle; the yellow arrows indicate the regions where the TN and CFN are joined together, forming the SN; the red arrow indicates the SN dividing into the CFN and TN in the popliteal fossa.

Furthermore, the study explores the first historical sources that refer to anatomical variations and discusses the importance of these variations for modern medical practice. It underscores the importance of a thorough understanding of these variations for precise diagnostic and therapeutic interventions. In this sense, it is possible to understand the importance of continuously describing and updating anatomical variations observed in dissections.

Even after Beaton and Anson (1937) dissected 120 cadavers and classified the anatomical variations between the SN and PM into 6 categories, other recent studies have shown that other types of SN/PM

variations can be observed and need to be considered in clinical practice and routine observations (Kozioł *et al*., 2022; Olewnik *et al*., 2024). The present study identified a double PM in the left gluteal region of a fetus, with distinct lateral and medial attachments. The fact that the PM presented with different attachments leads to the belief that it was a case of a duplicated PM, meaning that these are two different muscles and not a biceps muscle. Natsis *et al*. (2013) analyzed 294 lower limbs and highlighted that 1.4% of these limbs presented anatomical variations that were not classified within Beaton and Anson (1937) categories, such as a duplicated or even triplicated PM, which was the case of this study. The work by Tomaszewski *et al*. (2016) also reported a case of duplicated PM, associated with duplication of the superior gemellus muscle. This association had already been previously described by Arifoglu *et al*. (1997), who reported the simultaneous presence of double piriformis, double superior gemellus, and a high division of the SN, reinforcing the complexity and anatomical variability of the gluteal region. A different morphology was described by Kozioł *et al*. (2022), in a case where the PM presented three heads with distinct proximal attachments and a single distal attachment at the greater trochanter of the femur, thus being a triceps muscle. All these studies, associated with the present work, show how varied the muscular morphology of the gluteal region can be. Furthermore, if we add the correlations with variations in nerve pathways, we can more broadly understand the clinical importance in identifying such variations, given that this is a region frequently affected by piriformis syndrome, accessed in surgical procedures such as hip arthroplasty, and for intramuscular injections (Smoll, 2010; Natsis *et al*., 2013; Tomaszewski *et al*., 2016; Chang *et al*., 2023).

In the dissection os this study, it was observed two types of anatomical variations in nerves of the gluteal region. The first variation is relatively common and described in the literature as a high division of the SN (Beaton and Anson, 1937; Natsis *et al*., 2013; Tomaszewski *et al*., 2016). In this variation, the CFN and TN, which together form the SN, emerge separately between the PMs. In this case, the more lateral fibers that constitute the CFN emerge between the superior and inferior PMs, running posteriorly to the inferior PM, while the TN had its apparent origin anterior to the inferior PM. The two portions of the SN soon united inferior to the inferior margin of the inferior PM, aligned with the superior gemellus and obturator internus muscles, remaining united until the inferior third of the posterior compartment of the thigh. Except for the type of PM present, according to Beaton and Anson (1937) classification, the high division of the SN is very frequent in 50% of the types of anatomical variations of this nerve, however, in all described types, the divisions of the SN are not related to a duplicated PM.

The second nerve variation observed in the gluteal region was the apparent origin of the IGN which innervates the GMM. Medial to the CFN, it was observed the apparent origin of the IGN fibers, which also emerged between the superior and inferior PMs. Anatomical variations of the IGN appear to be frequent and were classified by Chiba (1992) into 13 types, however, the number of descriptions in the literature on the subject is scarce when compared to the descriptions of other variations in this region. The review by Yan *et al*. (2013) showed that the most frequent course of the IGN is to cross superior to the PM in 4.26% of the individuals analyzed. If it is considered that the main portion of the PM in our study is the superior PM, the IGN emerged inferior to the PM, differently from what was reported by Yan *et al*. (2013). Still correlating with the frequent anatomical variations of the IGN, there are studies showing that the IGN can emerge by piercing the PM (Lesser *et al*., 2023) or even be absent (Sumalatha *et al*., 2014). It is a fact that these IGN variants seem to be strongly associated with the ipsilateral division of the SN by the PM, and it is possible that a shared embryological origin may explain these variations (Sumalatha *et al*., 2014; Kasapuram *et al*., 2021).

Conclusion

The gluteal region is anatomically complex, and its variations are clinically significant. In this study, a unique variation involving a double PM with two distinct heads, a high division of the SN, and an atypical emergence of the IGN was observed. These variations, often not covered by current classifications, underscore the imperative need to revise and expand traditional parameters of anatomical normality. Describing new variations, like those presented in this study, is crucial for advancing anatomical knowledge and enhancing safety in clinical and surgical procedures in the region. Therefore, updating anatomical descriptions is not only important for academic purposes but also essential for modern medical practice.

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