

Third head of the gastrocnemius: an MR imaging study based on 1,039 consecutive knee examinations

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Abstract

Objective The objectives of this study were to determine the frequency of a third head of the gastrocnemius and to describe the course, morphology, and insertion of the third head as seen on the basis of routine magnetic resonance (MR) imaging of the knee.

Materials and methods This study was a prospective study of 1,039 consecutive knee MR examinations which were performed for symptoms of pain not associated with claudication. The examinations were performed between September 2004 and January 2005 and were evaluated for the presence of an anomalous third head of the gastrocnemius and to determine its origin and course. Examinations were performed on a variety of magnets ranging from 0.2 to 1.5 T.

Results Of the 1,039 knees, 20 (1.9%) demonstrated an anomalous third head of the gastrocnemius which was seen arising near the midline of the posterior distal femur, between the mid and medial aspect, and joining the medial aspect of the lateral head of the gastrocnemius. The size of the third head varied from a thin threadlike muscle to a rather bulky muscle. In all of these patients, the third head coursed lateral to the popliteal vessels, and none coursed between the vessels. One additional case of a third head of the gastrocnemius was seen which joined the medial head of the gastrocnemius.

Conclusion A third head of the gastrocnemius joining the lateral head is not an uncommon variant, seen in 1.9% of knee MR examinations. Most are not associated with vascular symptoms.

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Introduction

The gastrocnemius, which contributes to plantar flexion of the foot, usually originates as two heads from the femoral condyle. The medial head, the larger of the two, takes its origin from a depression at the upper and back part of the medial condyle and from the adjacent part of the femur superiorly. The lateral head arises from an impression on the side of the lateral femoral condyle and from the popliteal surface of the femur immediately superior to the lateral part of the condyle. Both heads also take origin from the joint capsule of the knee which is immediately adjacent to these origins [1].

A third head of the gastrocnemius was initially described in 1813 by Kelch [2], with a more detailed description of the anatomic variations by Frey in 1919 [3]. It is the most common variation of the gastrocnemius and is defined as a

congenital muscular or tendinous head which usually arises from some part of the posterior and inferior surface of the femur to join the medial or lateral head of the gastrocnemius [3]. The frequency within the population is estimated to be between 2.9% [3] and 5.5% [4].

Although initial descriptions of the third head of the gastrocnemius came from the anatomic literature in which the third head was found incidentally in cadavers [2, 3, 5, 6], the third head has gained attention more recently for sometimes being implicated in entrapment and functional occlusion of the popliteal artery or vein [4, 7–16]. Popliteal vascular entrapment syndrome is a rare entity, with an estimated prevalence of 0.165% in young males entering the military service [17] and a prevalence of up to 3.5% in a cadaver study [18]. This syndrome typically affects young athletic males who present with symptoms of claudication and is caused by an anomalous relationship of the muscle and vasculature in the popliteal fossa, resulting in extrinsic vascular compression. While several different classification schemes exist for describing the different anatomical variations that may result in this syndrome and have been described extensively elsewhere [19–21], a common type described has been an accessory slip or head originating from the medial head of the gastrocnemius and entrapping the popliteal artery and/or vein [4, 7–16]. These classification schemes are by no means exhaustive and do not fully account for all the different anatomic variations that may exist and result in this syndrome. There have recently been reports of rare causes of popliteal vascular entrapment syndrome in which an accessory slip or head joining the lateral head of the gastrocnemius has resulted in the compression of the popliteal vessels [22–24].

The purpose of this study was to determine the frequency of the third head of the gastrocnemius and describe its course, morphology, and insertion on the basis of routine magnetic resonance (MR) imaging of the knee.

Materials and methods

Our study included 1,039 consecutive knee examinations which underwent routine MR imaging between September 2004 and January 2005. The examinations were performed on patients who had knee pain or swelling and in which an internal derangement of the knee was suspected, such as injury of the ligaments, meniscus, or cartilage. Symptoms of knee pain were frequently preceded by an injury. No patient had a primary complaint or symptoms of claudication. The examinations were reviewed prospectively by one of the three experienced musculoskeletal radiologists at a single institution (MR, PG, and DWP). The study was approved by and performed in accordance with policies set forth by our Institutional Review Board.

The MR examinations were performed on a variety of magnets, ranging from 0.2 to 1.5 T. The MR protocol varied depending upon the magnet used, but all studies included the following sequences: sagittal proton density and T2-weighted conventional spin-echo or fast spin-echo, coronal T1-weighted conventional spin-echo, coronal proton density or T2-weighted fast spin-echo, and axial T2-weighted fast spin-echo images. Contrast administration was not performed.

The clinical records of all patients with a third head of the gastrocnemius were retrospectively reviewed to ascertain if any of the patients had symptoms of claudication.

Results

A third head of the gastrocnemius was identified in 21 examinations (2.0%). In 20 of the anomalous third heads, 1.9% of total knees examined, the third heads arose near the midline of the posterior distal femur, between the mid and medial aspect, and joined the medial aspect of the lateral

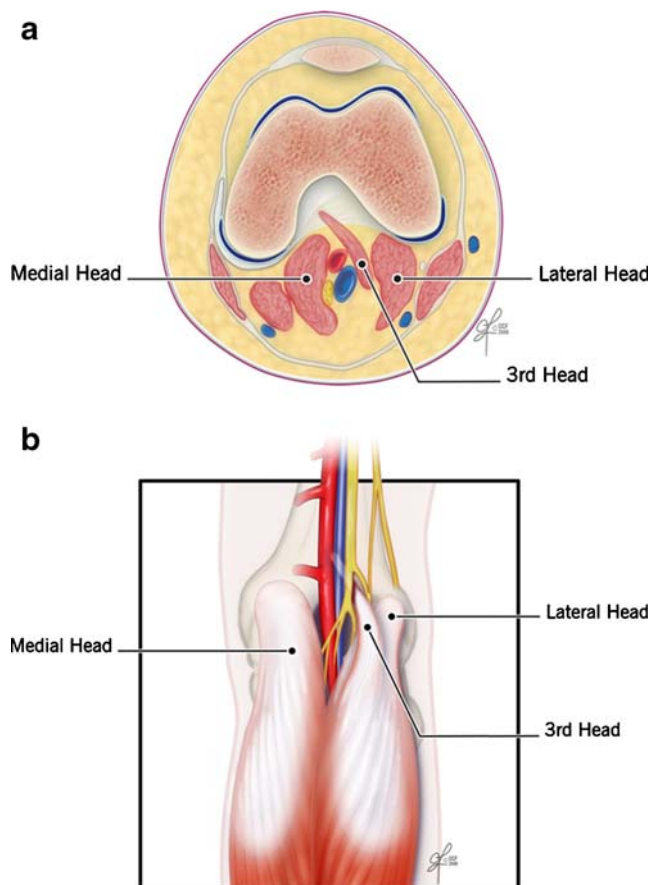
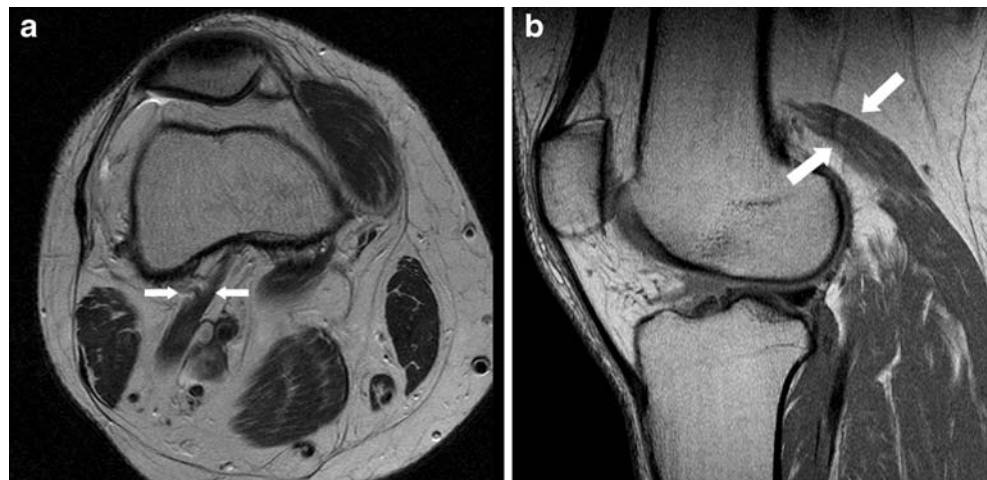


Fig. 1 Illustration of an anomalous third head of the gastrocnemius arising near the midline of the posterior distal femur in a left knee and joining the medial aspect of the lateral head of the gastrocnemius. Axial (a) and coronal (b) view

Fig. 2 Right knee of a 34-year-old female. **a** T2-weighted axial image shows a thin threadlike third head (*white arrows*) arising near the midline of the distal femur and coursing anterolateral to the popliteal vessels. **b** Proton density sagittal image shows the aberrant third head (*white arrows*) which will join the lateral head more distally



head of the gastrocnemius (Fig. 1). This variant occurred in 19 patients (ten males, nine females). One male had this finding in both knees. The range of ages of these patients was 13 to 67 years. None of the patients had experienced symptoms of claudication.

The size of the third head varied from a thin threadlike muscle (Fig. 2) to a rather bulky muscle (Fig. 3). In all of these patients, the third head coursed lateral to the popliteal vessels, and none coursed between the vessels. One of these cases had both a third and a fourth head of the gastrocnemius (Fig. 4). One larger accessory head joined the medial aspect of the lateral head, and a second smaller accessory head arose inferior to the larger one and joined the confluence of the medial and lateral heads.

Several other variants were also found in the study. One case of a third head joining the medial head was seen. The plantaris muscle was found to arise from the lateral retinaculum in 19 cases (Fig. 5). Three patients had an accessory popliteal muscle [25].

Discussion

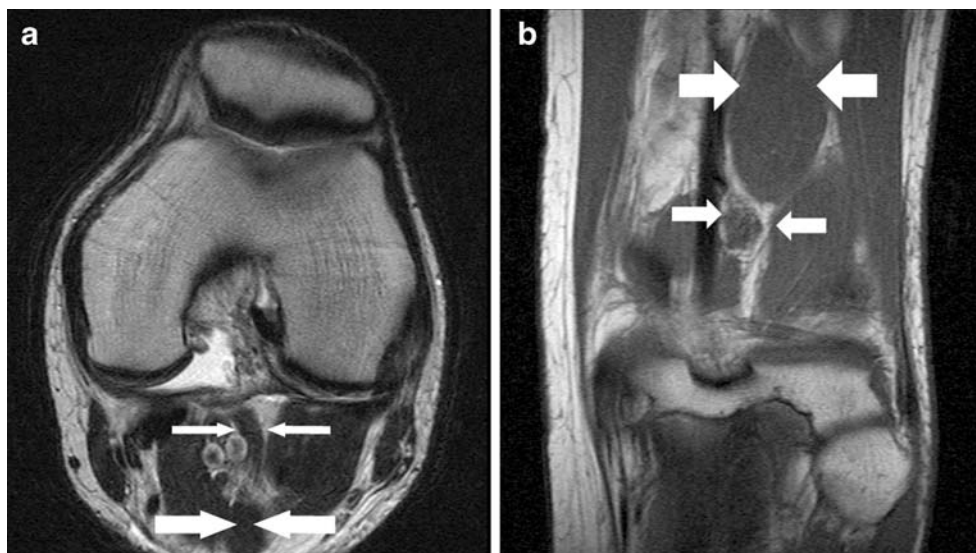
The presence of a third head of the gastrocnemius is a well-studied variation in the anatomic literature and is the most common variation of the muscle [3]. First described by Kelch in 1813, with subsequent scattered descriptions by other anatomists [5, 6], the third head was described in great detail by Frey with identification of 12 variants [3]. While this was an anatomic study, several of these variants described presented potential situations in which the popliteal artery and vein may become entrapped by the third head, most notably those variants in which the third head would cross over the popliteal vessels during its course to insert onto the medial or lateral head.

Following these anatomic studies of the gastrocnemius, the third head gained attention for the role that it was found to play in the entrapment of the popliteal artery and/or vein. Although the third head arising from the medial head has been most frequently attributed as a cause of popliteal

Fig. 3 Left knee of a 15-year-old female. T2-weighted axial image (**a**) and T1-weighted coronal image (**b**) shows a bulky third head (*white arrows*) lateral to the popliteal vessels and medial to the lateral head of the gastrocnemius



Fig. 4 Left knee of a young male. **a** T2-weighted axial image demonstrates a large accessory head (*large white arrows*) which will join the medial aspect of the lateral head of the gastrocnemius. A second smaller accessory head (*small white arrows*) arises inferior to the larger accessory head and will join the confluence of the medial and lateral heads. **b** T1-weighted coronal image shows the larger accessory head (*large white arrows*) and the second smaller accessory head (*small white arrows*)



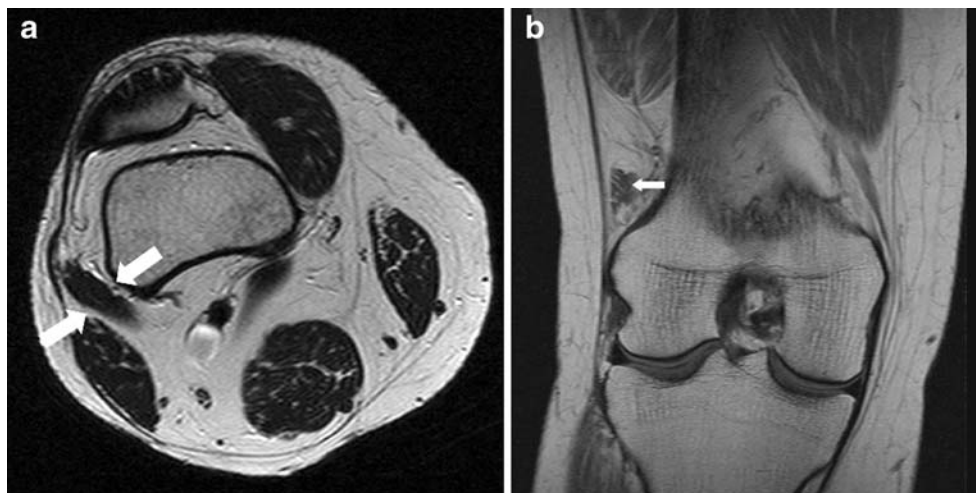
vascular entrapment syndrome [4, 7–16], only a few rare recent cases of a third head arising from the lateral head have been described as causing this syndrome [22–24]. Liu et al. [22] was the first to describe two cases of entrapment of the popliteal vein and/or popliteal artery by an aberrant slip which joins the lateral head with a subsequent report of eight affected limbs in five patients by Kim et al. [23].

Several variations of the course of a third head in relation to the popliteal vessels have been described. Common causes of popliteal artery or vein entrapment include cases in which a third head originates contralaterally, crossing the midline between the artery and vein, and thus resulting in compression of the artery or vein which is entrapped [9, 23]. A third head may also originate contralaterally, curving around the popliteal vessels and resulting in their compression [12, 22]. Other common cases also include origin of the third head on the posterior surface of the ipsilateral epicondyle, with continuation of the third head on the same side as it courses between the artery and vein prior to insertion onto the ipsilateral head of the gastrocnemius. This results in

compression of the artery or vein which is encased by the third head and ipsilateral head of the gastrocnemius [10, 11]. An uncommon cause of compression of the popliteal vessels includes a case in which a third head arose on the ipsilateral epicondyle, but, as the belly of the third head was bulky and crossed over the midline, this resulted in compression of the underlying popliteal vessels [4]. From these cases, it can be seen that a third head does not need to cross midline, but, instead, it is the relation of the third head and the popliteal vessels that may determine if compression of the vessels occurs.

We have described 20 cases in which the third head was found to arise from the lateral head in 1,039 knee examinations performed by MR imaging for reasons other than claudication or potential vascular entrapment. With a frequency of 1.9%, we conclude that the third head joining the lateral head is not an uncommon variant. In all of these cases, the third head was seen coursing lateral to the popliteal vessels and so the absence of claudication symptoms in these patients is not surprising. However, in some of the cases, the

Fig. 5 Right knee of a young adult male. T2-weighted axial image (**a**) and T1-weighted coronal image (**b**) demonstrates the plantaris muscle (*white arrows*) which arises from the lateral retinaculum



third head was observed to be rather bulky, and the popliteal vessels were surrounded and abutted by the medial and third head with very little surrounding fat. Yet these patients did not experience claudication symptoms, and, instead, most had a preceding injury with subsequent pain, prompting the MR imaging examination. Other isolated reports exist in the literature in which a third head had been observed incidentally on cross-sectional imaging to arise from the medial head without causing vascular entrapment [26]. Thus, the finding of a third head underscores the need to correlate imaging findings with clinical history symptoms.

Overall, 21 cases of a third head were found to be present in 1,039 examinations, resulting in a frequency of 2.0%. This is slightly lower than the reported frequency of 2.9% to 5.5% [3, 4] but is still close to the expected range. However, the majority of the cases (20/21) were found to join the lateral head. This predominance of lateral head insertion is greater than expected, as the third head in previous studies has been most commonly found to join the medial head [3, 4].

Our finding of two accessory heads of the gastrocnemius in one of the patients is a very rare variant, with only one other case report found in the literature [24]. In this report, a duplicated head was seen to arise both from the medial and the lateral head and resulted in compression of the popliteal artery with claudication symptoms. In our case of two accessory heads, there was very little fat surrounding the popliteal vessels. However, the patient was free of claudication symptoms.

During the course of the study, other muscle variants were found incidentally in the popliteal fossa. Nineteen cases of the plantaris were found to arise from the lateral retinaculum, and three cases of an accessory popliteal muscle were observed. The plantaris is a poorly developed remnant of the original common flexor tendons of the toes and may be considered a counterpart of the palmaris longus of the forearm [27]. It normally arises from the femur just above the lateral condyle and from the adjacent posterior ligament of the knee joint capsule. It forms a small fusiform belly which may be 7 to 10 cm in length and terminates as a long thin tendon which traverses obliquely between the gastrocnemius and soleus to insert or fuse onto the medial border of the calcaneal tendon distally [1]. Anatomic studies of the plantaris have described variations in origin of both the origin and the insertion [27], although variations in insertion occur more commonly than those of the origin [28]. It may be absent in 4% to 8% of the population; it may have an accessory head or may itself be the third head and join the gastrocnemius. The significance of the variation of the plantaris demonstrated in this study is unclear. We have also identified three cases of an accessory popliteal muscle. This has been described in one other case in the literature [25] and represents a rare variant. Other rare

accessory muscles have been described in the popliteal fossa, such as the tensor fasciae suralis [29], or more rare variants that appear to be a combination of the tensor fasciae suralis and the third head of the gastrocnemius [30]. These were not found in our study.

A third head of the gastrocnemius which joins the medial aspect of the lateral head is a not an uncommon finding on MR examinations of the knee, occurring in 1.9% of cases. The size of the third head may be quite variable, ranging from a small threadlike muscle to a large bulky muscle, necessitating careful examination of the popliteal fossa to identify this variant. Although none of the patients in our study exhibited signs of popliteal vessel entrapment, the third head has been associated with this syndrome. Therefore, we believe it is important to describe the presence, size, and relationship of the third head to the popliteal vessels when it is identified on MR examinations. In summary, a third head of the gastrocnemius is a relatively common variant that is usually clinically innocuous, with some variations in course and size that should be recognized for what it is.

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*Although Kelch is cited as the first author to have described a third head of the gastrocnemius, the current authors have been unable to obtain and read a copy of his report.