The accessory soleus muscle: a report of 21 cases and a review of the literature

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ABSTRACT

Purpose of the study
Well known to anatomy specialists, the accessory soleus muscle was first demonstrated to be involved in painful syndromes in 1965 (Dunn). This supranumerary muscle situated in front of the calcaneum can be taken for a soft tissue tumor. The purpose of this work was to report a series of 21 patients with an accessory soleus muscle and to present the characteristic features, diagnostic methods, and treatment indications and modalities.

Material and methods
This series included 20 patients (one symptomatic bilateral case), fourteen men and six women, mean age 25 years. Seventeen patients practiced sports and ten had had a prior operation. All patients complained of exercise-related pain. The physical examination was normal with the exception of a tumefaction, which was soft at rest and hard at triceps contraction against resistance, lying laterally to the Achilles tendon. We studied plain x-rays, ultrasound studies, computed tomographies, and electromyograms and later MRI which became the reference method to demonstrate the details of normal muscle structure. Ten patients (one bilateral case) were not particularly bothered by the supranumerary muscle. Functional treatment was given and provided patient satisfaction. For the other ten patients, who wished to continue their physical activities, two underwent fasciotomy (including our first case where fasciotomy was undertaken because a tumor was suspected) and eight underwent resection of the supranumerary muscle.

Results
The patients were followed for 6 to 19 years. Outcome was very good in all patients who were free of pain and had complete joint movement with symmetrical muscle force. Normal sports activities were resumed.

Discussion
The accessory soleus muscle is found in 10% of individuals. It is often asymptomatic. The muscle inserts on the anterior aspect of the soleus muscle or on the posterior aspect of the tibia or the muscles of the deep posterior compartment. It lies anterior to the calcaneal tendon and terminates on the calcaneal tendon or the superior or medial aspect of the calcaneus via fleshy fibers or a distinct tendon. Frequent in primates, this anatomic variant is present during embryological development. Its persistence depends on phylogenetic evolution. Among other hypotheses (exercise-induced intermittent claudication, compression of the tibial nerve, excessive tension on the nerve innervating the accessory soleus muscle), this supranumerary muscle is generally considered to be the cause of a localized compartment syndrome. Pain experienced during exercise is the only symptom regularly reported by patients. A careful examination is required to rule out another local cause. Besides tumefaction lateral to the Achilles tendon, often found bilaterally, there is no other clinical sign. Plain x-rays, ultrasound and computed tomography simply demonstrate a "mass" in front of the Achilles tendon. MRI is the examination of choice enabling confirmation of the muscle nature of the mass and ruling out the possible diagnosis of tumor. Since there is no risk of aggravation, surgical treatment can be avoided if there is no complaint. If the patient is seriously impaired, surgery can be proposed. In our opinion, complete resection of the supranumerary muscle is the safest solution and should be preferred over simple fasciotomy.
INTRODUCTION

Like all other anatomical variations of the human muscular system, the accessory soleus muscle was well known to early anatomists. It had been described by the end of the 19th century by Luschka (1865), Bankart and Pye-Smith (1869), Testut (1884) and especially Ledouble (1897) (1). But it was not until 1965 that Dunn (2) established a relationship between a painful symptomatology of the posterior aspect of the ankle and a presence of a posterior medial tumefaction, lateral to the Achilles’ tendon, initially considered to be a soft-tissue tumor. Surgery was performed in one of the three cases reported and the accessory soleus muscle was discovered as the cause of the symptoms.

Since then, apart from the series by Romanus et al. (3) reporting 11 cases, other publications have been limited to 1-4 cases [Mestdagh et al. (4), Peterson et al. (5), Travis and Pitcher (6), Boisgard et al. (7), Downey and Siegerman (8), John and Borelli (9), Palaniappan et al. (10), Van Den Bossche et al. (11)] In 1997 Brodie et al. (12) summarized 67 cases reported in the English literature, including 4 personal cases. In 1998 we presented a series of 19 cases at the French Society for Orthopedic and Traumatic Surgery annual reunion [Kouvalchouk et al. (13)], a long after publishing our first cases [Kouvalchouk and Durey (14)].

The accessory soleus muscle is a supernumerary muscle bundle developed from the soleus muscle, situated in front of the Achilles’ tendon, ending either on the Achilles’ tendon or on the calcaneum itself (fig. 1). The muscle is composed of normal muscle fibers.

The purpose of this work is to report a series of 21 observations of 20 patients where the accessory soleus muscle was responsible for painful symptoms. To our knowledge this is the largest series published to date on this topic.

In addition to presenting the series, we discuss frequency and epidemiology, as well as the anatomy of the accessory muscle and its innervation, embryology and phylogeny, pathophysiology, symptomatology, the contribution of complementary explorations, and finally treatment modalities since the nature of palpable tumefactions can now be determined with magnetic resonance imaging (MRI). Earlier, as seen in our first case [Kouvalchouk and Durey (14)] and in many other cases in the literature [Dunn (2), Ger et Sedlin (15), Percy and Telep (16), Paul et al. (17), Wu (18)], surgery was required for accurate diagnosis.

STUDY SERIES

The series is composed of 21 observations of 20 patients seen between 1983 and 1996: 14 men and 7 women, mean age of 25 years (16 to 37 years). The tumefaction was localized on the right in eleven patient, on the left in eight, and on both sides in one. Seventeen patients participated in sports activities (seven were runners). Ten patients were treated surgically.
But, even when computerized tomography (7 patients) (fig. 3) and ultrasonography (3 patients) provided a perfectly delimited image, it was not possible to determine whether the observed mass was composed of normal muscular tissue or not.

In the most recent cases, MRI (8 patients) (fig. 1 and 4) has been the most contributive examination enabling confirmation of the normal nature of the muscle. In two patients, an electromyogram was obtained. It showed a perfect synchronism of the electric activity between the “mass” and the soleus muscle. The relative value of these exams will be evoked in the discussion.

We must add that in two of the cases we measured the pressure in the accessory muscle during exercise by means of a Stic Catheter®, but without convincing results because the numbers recorded did not permit an affirmation of a significant increase of the intramuscular pressure.

Treatment was as follows:

— Non surgical treatment in eleven patients (including the patient with bilateral symptoms). The diagnosis was confirmed by imaging. The well informed patient stated he was bothered little and was ready to adapt his physical activities. The treatment consisted of orthopedic insoles, physiotherapy, and stretching exercise sessions.

— Surgical treatment was used in ten patients. For our first case surgery was undertaken because of the doubtful diagnosis of a soft-tissue tumor. In the nine other patient the indication was based on functional discomfort and the patient’s desire to pursue physical activities with maximum performance. In the first patient, a simple fasciotomy was performed twice after an exploration that confirmed the absence of any suspect tissue. But for the other eight patients it appeared more logical to remove the supernumerary muscle: via a lateral approach to the Achilles’ tendon the accessory soleus muscle was easily separated from the muscles of the deep compartment and progressively freed on the posterior side from the anterior side of the soleus muscle and the Achilles’ tendon. The disinsertion at the distal extremity was always easy. Occasionally more difficulties were experienced for the proximal extremity:
a less neat separation. Nerve branches were electrocoagulated before section. After excision of the muscle (fig. 5), the space created was drained with aspiration for several days in order to prevent development of a local hematoma that might favor fibrosis. Stretching exercises were undertaken immediately so not to risk any limitation of dorsal flexion. Weight bearing was immediate.

The results were analyzed at 6 to 19 years follow-up (mean 10 years). There were no complications except one post operation hematoma with no significant consequence. Further treatment or revision were not needed.

Outcome was assessed on the basis of the physical examination without a functional score since the only preoperative symptoms were pain and not being able to pursue physical activities. Therefore history taking was particularly important. Range of motion was noted and compared with the other side, likewise for muscular strength, tested by jumping on one foot.

Outcome was excellent in all operated patients. All were pain free with normal range of motion and symmetrical muscular strength. All patients practicing sports were able to continue at their previous level. The two patients treated with simple fasciotomy had results equivalent to the patients with complete excision of the accessory soleus muscle without recurrent pain. The choice of the therapeutic technique is examined in the discussion section.

Similar results were obtained in the non-operated patients. These patients had been informed of the possibility of surgical treatment but decided that their functional impairment was not sufficient to require surgery. Easily adapting their physical activities, these patients did not return for consultation and did not request more radical treatment.

**DISCUSSION**

**Frequency and epidemiology**

The estimated frequency of accessory soleus muscle reported in anatomical studies is 8 to 10%. Downey and Siegerman (8) found 13 cases of accessory soleus muscle in a study of 689 cadavers, giving a rate of 1.9%. A bilateral variant was observed in 30 to 50% of cases. Absence of symptoms is the rule [John and Borelli (9)] as demonstrated by the small number of truly symptomatic cases reported in the literature [Boisgard et al. (7), Brodie et al. (12)]. It is likely that the incidence of painful forms is underestimated due to the lack of correct diagnosis or the patient’s spontaneous adaptation of physical activities [Peterson et al. (5), Downey and Siegerman (8), Brodie et al. (12)].

In other respects, features reported in the literature support those of our series: young adult, no preferential side, male predominance corresponding with physical activity [Downey and Siegerman (8)].

**Anatomy**

**Insertions**

The proximal insertion is relatively constant: the posterior aspect of the tibia and the aponeurosis of the muscles of the deep compartment, the anterior aspect of the soleus muscle.

The distal insertion on the contrary is much more variable. Yu and Resnick (19) defined five different types: along the Achilles’ tendon, on the superior aspect of the calcaneum via a separate tendon or directly via the muscle body, on the medial aspect of the calcaneum, here too, either via a separate tendon or the muscle body. Bonnel and Cruess (20) observed a forked tendon inserted on either side of the calcaneum.

**Relationships and Dimensions**

The body of the muscle is situated in front of the Achilles’ tendon. The Achilles’ tendon runs through the muscle and, in front, enters in relationship with the muscles and tendons of the posterior compartment in the same way as the vascular nervous bundle. This is the reason why the muscle body can provoke a tarsal tunnel syndrome [Pla et al. (21)]. It usually measures about 10 cm, but can be as long as 20 cm [Mestdagh et al. (4)].

Finally, if you set aside our first observation [Kouvalchouk and Durey (14)] where the histological examination showed “muscle fibers dissociated by sclerosis” - an observation also reported by Romanus et al. (3), examined biopsies have all been free of anomalies [Brodie et al. (12), Ger and Sedlin (15), Paul et al (17)].

**Innervation**

Sekiya et al. (22) have provided most of our knowledge of the innervation. The accessory muscle is innervated by branches of the anterior branch of the soleus muscle, coming from the posterior tibial nerve. This fact seems to suggest that the supernumerary muscle derives form a part of the soleus muscle that is innervated by the anterior branch.

This type of common innervation explains the synchronism of electric activity registered by the electromyogram, on which the value of this test is based.
Embryology and Phylogeny

According to Gordon and Matheson (23), the human soleus muscle and gastrocnemius muscle have their own and separate origin. But, they can be incompletely divided, and therefore can have a common origin or can have stayed merged together along the entire length or can have experienced a different growth resulting in a disparity of size. Besides, their premature separation could explain the existence of supernumerary muscle. Ledouble (1) was the first to show that this accessory muscle does not derive from the plantar muscle, but from the soleus muscle.

The phylogeny was studied by Gordon and Matheson (23). Variations of the triceps muscle of the leg and the plantar muscle are frequent in primates even though they are not observed in inferior vertebrates. Apes and humans carry their weight on the predominance of either the gemelli muscle or the gastrocnemius muscle and exhibit a different degree of independence between the gemelli and gastrocnemius muscles and the soleus muscle. They also can bear their weight because of the relative proportion between muscle and tendons. Notably, the fleshy body of the soleus muscle can descend all the way to the heel (Gorilla and Rhesus Ape). Therefore it would appear that the existence of these anomalies is dependent on the degree of differentiation and separation of the different muscles of the superficial posterior compartment and therefore dependent on the phylogenetic evolution.

The accessory soleus muscle is therefore present from the beginning of embryological development. The delay in the development of overt symptoms could be related to increase in muscle mass and activity starting with adolescence [Romanus et al. (3), Dowey et Siegerman (8)].

Pathophysiology

Even though the accessory soleus muscle is present at birth, painful symptoms, when present, do not appear until the end of adolescence or young adult age. The pathophysiological explanation for this is not clear and remains controversial. Four hypotheses are proposed:

— Exercise-related intermittent claudication possibly due to precarious blood supply. But Sekiya et al. (22) couldn’t find a proof for this during their anatomical studies.

— The compression of the posterior tibial nerve by the mass of the accessory soleus muscle. Pla et al. (21) seem to have presented a case.

— Excessive pressure on the nerve innervating the accessory soleus muscle, especially in the young adult in a phase of rapid muscular growth, during contraction of the triceps muscle of the leg. This was the hypothesis proposed by Sekiya et al. (22).

— A localized compartment syndrome. This is the most common explanation for the development of pain only during exercise and its resolution with rest [Downey and Siegerman (8), Brodie et al. (12), Kouvalchouk and Durey (14), Ger and Sedlin (15), Percy and Telep (16), Garg and Kilcoyne (24)]. The favorable results recorded after simple fasciotomy favor this hypothesis. But more precision is required. On the one hand the soleus muscle does not have its own aponeurotic compartment [Sekiya et al. (22)], yet it alone is painful, excluding the other muscles of the deep and superficial posterior compartment. On the other hand none of the publications mention pressure measures confirming the presence of a localized compartment syndrome, which we also were unable to confirm with the measurements made in two of our patients.

Clinical presentation

All of the patients of our study sought medical advice due to pain on the posterior aspect of the ankle during exercise. The pain was accompanied by a medial tumefaction lying lateral to the Achilles’ tendon. The pain ceased during rest. This same presentation was described by Brodie et al. (12) in their review of the literature for 67% of patients. But they found that 25% of patients consulted because of a tumefaction increasing in size during exercise but without pain.

In other respects, the possible insertion of the accessory muscle at the medial side of the calcaneum can cause club foot. Bonnel and Cruess (20) reported one case. Chittaranjan et al. (25) cited a case of a newborn with talipes equinovarus and Brodie et al. (12) found 3 cases in their review of the literature. Lozach et al. (26) noted that in their patient the varus deviation was accentuated during exercise.

The physical examination provides little information, generally limited to palpation of posterior medial tumefaction which appears soft during rest and becoming tight or painful during plantar flexion against resistance. A bilateral presentation is very suggestive and should always be searched for. Moreover, the remainder of the physical examination is normal, especially concerning range of motion.

Other causes of posterior pain of the ankle must be ruled out. Pain can results from a local disorder of the Achilles’ tendon or the posterior tibial tendon, a tenosynovitis involving the flexor hallucis longus muscle, or a posterior crossing-over syndrome of ankle joint. At this stage, the clinician must carefully search for specific signs of each one of these conditions and order complimentary imaging as needed. The differential diagnosis is a soft-tissue tumor [Dunnes (2), Ger and Sedlin (15), Paul et al. (17), Wu (18)].

Complimentary Tests

The contribution of complimentary tests is variable, but current methods can attribute the medial tumefaction lying lateral to the Achilles’ tendon to the presence of an accessory soleus muscle and therefore rule out a soft-tissue tumor (and subsequently the requirement for surgical exploration).

Standard x-rays (fig. 2) can visualize a long vertical image that shows the depth of the pre-achillean triangle of Kager. This is insufficient to ascertain the nature of the tumefaction, although with experience the clinical context can be highly suggestive.
Computed tomography shows a perfectly centered, homogeneous mass with the same density as the nearby muscles. The mass, of unknown nature, lies in the pre-achilleen space (fig. 3). A similar density can be produced by certain soft-tissue tumors, as emphasized by Downey and Siegerman (8) and Petterson et al. (27).

Ultrasonography has become a high performance test although some, including Brodie et al. (12) and Wu (18) noted the same criticisms as for computed tomography.

The electromyogram can be highly contributive, demonstrating synchronous electrical activity between the soleus muscle and the accessory soleus muscle, a synchronism linked to their identical innervation [Boisgard et al. (7), Downey and Siegerman (8), Ger and Sedlin (15), Percy and Telep (16), Paul et al. (17), Pla et al. (21), Chittaranian et al. (25)].

Since 1987, magnetic resonance imaging (MRI) has become the gold standard for diagnosis (fig. 4). Petterson et al. (27) have demonstrated its value, specifying that if the time of relaxation between T1 and T2 of the “lesion” and the normal muscle are the same, it can be confirmed that it is a normal muscular structure. They concluded that from this time on surgical exploration was no longer necessary to eliminate the possibility of a soft-tissue tumor. Since then, numerous publications have come to the same conclusion [Boisgard et al. (7), Downey and Siegerman (8), Brodie et al. (12), Paul et al. (17), Wu (18), Yu and Resnick (19), Pla et al. (21), Sekiya et al. (22), Garg and Kilcoyne (24)].

In addition, the MRI has the advantage of allowing a precise analysis, not only of the accessory soleus muscle, including the precise anatomical variations of the distal insertion [Boisgard et al. (7), Chittaranian et al. (25)], but also of the neighboring structures. Nevertheless, there were no studies establishing a correlation between the MRI data and symptoms produced or not by an accessory soleus muscle.

**Treatment**

The therapeutic indications are based on two elements:

— certain diagnosis of the accessory soleus muscle, which can be established with MRI, ruling out the possibility of a soft-tissue tumor and eliminating the need for surgical exploration. [Paul et al. (17), Wu (18), Petterson et al. (27)];

— confirmation that the accessory soleus muscle is responsible for the painful symptoms. Physical examination and appropriate complementary tests are needed to eliminate all other causes of posterior ankle pain when imaging findings fail to show a difference between a symptomatic and an asymptomatic accessory soleus muscle. [Brodie et al. (12)]. Treatment is warranted only if it can be definitely confirmed that the accessory soleus muscle is responsible for the symptoms and if the pain and the patient’s desire for physical activity are such that care is indicated. Therapeutic abstention is a perfectly licit option [Romanus et al. (3)] because no cases of worsening or specific complications have been reported. In addition, physiotherapy and stretching exercises can be proposed for all patients. On the other hand, if the impairment is serious and prevents the pursuit of physical activities at the level desired by the patient, treatment, which can only be surgical, can be justified.

Two techniques can be proposed

— Fasciotomy. Numerous publications with favorable results have been published [Romanus et al. (3), Petterson et al. (5), Downey and Siegerman (8), Brodie et al. (12), Ger and Sedlin (15), Percy and Telep 816), Wu (18), Chittaranian et al. (25)]. This option is warranted by the recorded results after simple exploration or biopsy or if a local compartment syndrome is suspected.

— The excision of the accessory muscle. In our opinion this is the method of choice if the pain is linked to the presence of the accessory muscle and if it has no functional value. Therefore it does not seem logical trying to preserve a non-functional element by performing fasciotomy. Even though surgical resection seems more invasive, there is no risk of a possible recurrence of the painful symptoms. This is also the opinion of Romanus et al. (3), Boisgard et al. (7), Van den Bossche et al. (11), Gordon and Matheson (23), Chittaranian et al. (25) so long as the diagnosis is confirmed and the surgical solution proposed is accepted.

In the series described in the literature and in our eight personal cases treated surgically, outcome has always been excellent with an uneventful postoperative period and fast recovery. We are thus very favorable for this option.

**CONCLUSION**

The accessory soleus muscle is a common but rarely symptomatic anatomical anomaly. When present, painful symptoms can develop, predominantly in physically active young adults.

Certain diagnosis of the presence of an accessory soleus muscle is ensured with current imaging methods. The problem remains however to determine whether or not the accessory muscle is the cause of symptoms. All other causes of posterior ankle pain must be ruled out. Surgery is the treatment of choice if the accessory muscle is the origin of the pain. If there is little impairment and if the patient accepts the limitation on physical activity, it is not necessary to prescribe treatment other than physiotherapy and stretching to improve functional. Otherwise, surgery is warranted. In our opinion, the best surgical option is total resection of the accessory soleus muscle.

**References**
