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Quadratus femoris muscle: spectrum of MR imaging findings in 51 patients presenting with painful hip

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ABSTRACT

Purpose: To provide an overview of magnetic resonance (MR) imaging findings related to quadratus femoris muscle (QFm) pathologies in symptomatic patients.

Material and Methods: MR imaging studies from 51 patients, who were retrospectively recruited within a 2-year period, in 5 health care centers were reviewed. Inclusion criteria included: (i) hip pain; (ii) QFm abnormal signal; (iii) identification of other pathology in the QFm anatomical area. Exclusion criteria included: (i) other symptomatic hip/pelvic pathology; (ii) incomplete MR examination.

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The presence/location of QFm oedema and configuration of QFm fibers were evaluated and classified. Hamstring tendons were assessed for tendinosis/tear. Ischiofemoral impingement syndrome (IFIs) was indicated by QFm oedema and restriction of ischiofemoral space (IFS)/quadratus femoris space (QFS). QFm tears were categorised as complete/partial/chronic. Fisher's exact test was used for statistical analysis.
Results: IFIs diagnosis, related to various aetiologies, was suggested in 39 patients. The absence of severe QFm oedema and crowded configuration of QFm fibers correlated with IFIs diagnosis ($p<0.05$). In 18/39 (46.2%) of patients, restriction of the IFS/QFS was due to an underlying pathology. QFm tears were diagnosed in 5 patients. QFm oedema, usually mild, located at the myotendinous junction, was revealed in 4/5 patients. In 7 patients various pathologies related to the QFm were disclosed, which broadly included neoplastic disorders, myositis and bursitis.
Conclusions: MR imaging can depict and characterise various QFm pathologies including IFIs, traumatic lesions, myositis and neoplastic disorders. Detailed analysis of the oedema pattern and the configuration of muscular fibers matched with clinical findings can lead to precise diagnosis.

KEY WORDS
impingement syndromes/ischiofemoral; quadratus femoris muscle/disorders; MR imaging/diagnosis; hip pain

1. Introduction

Owing to its multifactorial nature, causative depiction of hip and groin pain presents a diagnostic challenge [1]. Recent advances in MR imaging provide superb characterisation of soft-tissue pathology and elegant depiction of deeply located structures. These features, combined with the progress in our understanding of hip joint pathology, allow for a comprehensive assessment of hip pain and improved diagnosis. Lesions of the quadratus femoris muscle (QFm) have been infrequently reported in the literature [2-6]: these include partial tears and exercise-induced oedema and impingement, a condition known as ischiofemoral impingement syndrome (IFIs). MR imaging findings of these conditions do not differ significantly and are usually subtle; thus careful analysis of the pattern of muscular and myotendinous involvement, as well as detailed assessment of the surrounding structures, are essential for accurate differential diagnosis [5]. Additionally, abnormal signal intensity of the QFm can be observed in asymptomatic individuals, including elite athletes [7, 8].

Clinical tests are non-specific regarding the diagnosis of QFm pathology, which may be difficult to differentiate from intra-articular or other extra-articular causes of hip pain, solely on clinical grounds. It has been suggested that symptoms of impingement can be reproduced during a combination of hip extension, adduction and external rotation [7] or during flexion, abduction and internal rotation [8].

Herein, we provide a holistic overview on the MR imaging findings related to pathological conditions affecting the QFm in patients with a painful hip. This study provides the first comprehensive assessment of secondary causes affecting the QFm with respect to regional anatomy and the pattern of QFm involvement.

2. Material and Methods

2.1 Patients

This is a case control study conducted according to the principles of the Helsinki Declaration. Ethical committee approval was obtained together with the written informed consent of all patients prior to each MR examination. Patients were recruited retrospectively within a two-year period, in two tertiary health care centers and three major private practice centers, in three countries (Greece, Cyprus and South Africa). Inclusion criteria comprised: (i) hip pain, (ii) presence of QFm abnormal signal intensity and (iii) identification of other pathology in the anatomical area of QFm on MR imaging studies potentially related to pain. Exclusion criteria included: (i) evidence of other hip/pelvic and/or lumbar spine pathology on MR imaging related to pain and (ii) incomplete MR imaging examination (regarding the protocols described in paragraph 2.2 as a reference). According to the above criteria the study group comprised 51 patients (13 males, 38 females; age range 13-73 years; mean age 44.3 years; standard deviation (SD) 17.6).

Anonymised demographic information such as age, sex, level of physical activity and history of previous trauma were collected from the medical database. The MR imaging findings were correlated with the clinical diagnosis, as indicated on the medical report. Follow-up MR imaging studies and other imaging investigations which were available for 4 and 9 patients respectively were evaluated. Regarding the detected osseous and soft-tissue neoplastic lesions, final diagnosis was achieved by image guided needle biopsy or open incisional or excisional biopsy in cases where imaging findings were not pathognomonic.

2.2 Imaging technique

MR imaging examinations were performed on two 3 T and three 1.5 T MR scanners (Siemens Vision 1.5 T, Siemens Avanto 1.5 T, Siemens Aera 1.5 T, and Philips Achieva 3.0 T) using a phased array pelvic coil. All patients were scanned in the supine position. No specific precaution was applied regarding rotation of the lower limbs. The pelvic/hip MR protocol consisted of axial and coronal T1-weighted (w) turbo spin-echo (TSE), coronal T1-w turbo inversion recovery (STIR), axial fat suppressed (FS) proton density (PD)-w/T2-w TSE or STIR and small field of view FS PD-w sequences for the symptomatic side. Contrast-enhanced FS T1-w TSE images in multiple planes were obtained in selected cases, based on the findings on conventional sequences. Fat suppression was achieved with spectral presaturation.

2.3 Image analysis

MR images were reviewed by five experienced musculoskeletal radiologists and the diagnosis was based on well established criteria [5, 8-11]. Oedema of the QFm was defined as increased signal intensity on fluid sensitive (FS PD-w/T2-w or STIR) sequences and its extent was categorised according to a previously published classification system [9, 11]: (i) mild, when affecting <50% of the muscle; (ii), moderate, when involving ≥50% of the muscle and (iii) severe, when extending to surrounding soft tissues. In patients with mild or moderate QFm oedema, its location was further categorised as (i) within muscle belly or (ii) at the myotendinous junction. The configuration of QF muscular fibers was assessed on axial T1-w and secondarily on axial FS PD-w/T2-w images [4] and was categorised as (i) normal; (ii) partially disrupted; (iii) completely disrupted or (iv) crowded. QFm fatty replacement was indicated by the presence of linear or globular fat signal intensity on T1-w images between muscle fibers. Hamstring tendon attachment was also evaluated for the presence of tendinosis/chronic avulsion which was defined as increased signal intensity on fat suppressed PD/T2-w or STIR sequences, or tear/avulsion indicated by fluid-like increased signal within the tendon or at its ischial insertion. In addition, the QFm region was examined in detail for the presence of space-occupying lesions, or other symptoms-related pathology. Axial T1-w images were used to obtain the ischiofemoral space (IFS) and quadratus femoris space (QFS) dimensions. IFS was defined as the minimum distance between the lateral cortex of the ischial tuberosity and the medial cortex of the lesser trochanter, whereas QFS represented the minimum distance between the superolateral surface of the hamstring tendons and the posteromedial aspect of the iliopsoas tendon or lesser trochanter (**Fig. 1**). A cut-off value of ≤17 mm and ≤8 mm, regarding IFS and QFS distance respectively, was considered abnormal [11]. Bone marrow oedema was categorised as present or absent and its location was recorded.

IFIs was suggested by the presence of QFm oedema together with abnormally narrowed IFS and/or QFS matched with ipsilateral hip pain [9, 11]. Partial QF tears represented focal fluid-like increased signal intensity within the muscle or its tendon with partial disruption of the muscular or tendinous fibers, while complete tears were defined as fluid-like increased signal areas with complete disruption of the muscular or tendinous fibers [11]. Special attention was given to patients with oedema located at the QF myotendinous junction in order to differentiate between impingement and muscular strain, by correlating the configuration of QF muscular fibers on axial T1-w and a positive history of recent trauma [6]. Chronic tears were indicated by the inability to identify QFm. In patients with unilateral symptoms, imaging findings of the asymptomatic, contralateral side were recorded.

2.4 Statistical analysis

For the statistical analysis, SPSS v22 was utilised. Standard descriptive results were expressed as mean ± SD. The significance of the relationship between parameters was assessed with Fisher's exact test and a p-value less than 0.05 was considered statistically significant.

3. Results

3.1 Patient data

Unilateral symptoms were reported in 37 patients (14 left

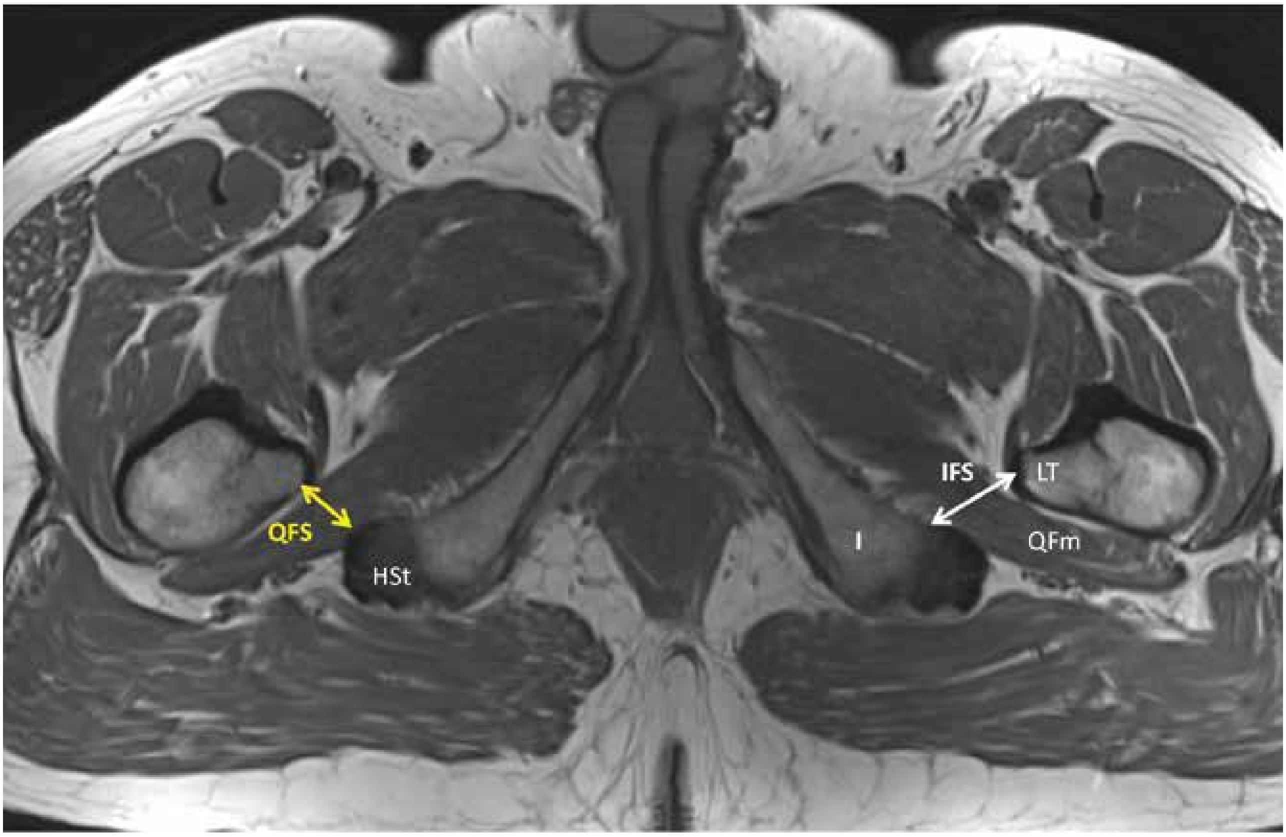

Fig. 1. Axial T1-w MR image showing how the measurements are performed. IFS, ischiofemoral space measuring 25 mm; QFS, quadratus femoris space measuring 19 mm; LT, lesser trochanter; I, ischium; HSt, hamstring tendon.

sided, 23 right sided) and bilateral symptoms in 14. Twelve patients were scanned on 3T and 39 on 1.5 T MR scanners.

3.2 MR imaging findings

Imaging findings related to IFIs were identified in 39 patients (9 males, 30 females; age range 13-73 years; mean age 44.1 years; SD 17.7). Sixteen patients exhibited right and 9 left sided pain, while 14 patients complained of bilateral symptoms. No patient reported a history of recent trauma and all had an ordinary level of physical activity, with the exception of 1 track athlete, 2 ballet dancers and 1 elite long jump athlete. MR imaging revealed oedema within the muscle belly, which was categorised as mild (n=31), moderate (n=4) or severe (n=4) (**Fig. 2**) and abnormally narrowed IFS (n=39) and/or QFS (n=23). The absence of severe QFm oedema correlated significantly with the diagnosis of IFIs ($p<0.05$). The configuration of QF muscular fibers was categorised as normal (n=10) or crowded (n=29). The latter correlated significantly with the diagnosis of IFIs over an alternative QFm pathology ($p<0.05$) (**Figs. 1-3**). The site where the major disorganisation of muscular fibers on T1-w images matched the site of the most pronounced oedema indicated the point of maximum impingement (**Figs. 2, 3**). Fatty degeneration of the QFm with superimposed mild oedema was observed in one case. A wide spectrum of underlying processes implicated in the pathogenesis of IFIs was detected (**Figs. 4, 5**). In 18/39 (46.2%) patients restriction of the IFS and/or QFS was related to an acquired aetiology. The imaging findings, related aetiologies and demographic data in patients with IFIs are demonstrated in **Table 1**. In 7 patients with unilateral symptoms, MR imaging revealed restriction of the IFS/QFS with (n=4) or without QFm oedema (n=2) and a QFm lipoma (n=1) on the contralateral, asymptomatic side.

A diagnosis of QFm tear was suggested in 5 patients (2 males, 3 females; age range 16-67 years; mean age 39.4 years; SD 20.9). All patients complained of unilateral symptoms (1 left sided, 4 right sided) and 4/5 indicated a history of recent trauma (up to 6 months). One patient had a grade I injury, 3 were diagnosed with grade II partial tears, while in 1 patient with chronic hamstring tendinopathy and restricted IFS and QFS, a chronic QFm tear was suggested (**Fig.**

Patient No	Diagnosis	Age (years)	Sex (M/F)	Side (R/L)	Physical activity	Asymptomatic side	QFm fibers configuration					QFm edema classification		QFm edema location		QFm fatty degeneration	Hamstrings		IFS/QFS distance		BME (location)
							Crowded	PD	CD	Chronic tear	Normal	Mild/ Moderate	Severe	QFm belly	MTJ (I/F)		Tendinosis/ apophysitis	Tear/ avulsion	IFS narrowing	QFS narrowing	
1	Hamstring tendinopathy, IFI	70	F	R		Hamstring tendinopathy, IFS/QFS restriction. No QFm edema					✓	✓		✓			✓		✓	✓	
2	Hamstring tendinopathy, IFI	66	M	B			✓					✓		✓				✓	✓	✓	
3	Hamstring tendinopathy, IFI	14	F	B	✓(track athlete)		✓					✓		✓				✓	✓	✓	
4	Hamstring tendinopathy, IFI	70	F	B			✓					✓		✓			✓		✓	✓	
5	Huge ischial bone avulsion fracture, IFI	28	M	R	✓(long jump)		✓						✓	✓					✓	✓	✓(ischial bone)
6	Hamstring tendinopathy, IFI	50	F	R		Hamstring tendinopathy, IFS/QFS restriction. No QFm edema					✓	✓		✓			✓		✓	✓	
7	Hamstring tendinopathy, IFI	17	F	R	✓(ballet dancer)		✓					✓		✓			✓		✓	✓	
8	Ischial bone metatsasis (prostate carcinoma) IFI	68	M	L			✓					✓		✓					✓	✓	✓(ischial bone)
9	Proximal femur MFH, IFI	37	M	L			✓					✓		✓					✓	✓	✓(proximal femur)
10	Proximal femur parosteal chondroma, IFI	28	M	R			✓						✓	✓					✓	✓	✓(proximal femur)
11	DDH-THR, IFI	63	F	R			✓					✓		✓					✓	✓	
12	Proximal femur fracture-pseudarthrosis, IFI	60	M	L		QFm lipoma	✓						✓	✓					✓	✓	
13	THR, IFI	57	M	R			✓					✓		✓		✓			✓	✓	
14	Hamstrings' avulsion, IFI	13	F	B	✓(ballet dancer)		✓					✓		✓				✓	✓	✓	
15	IFI	59	M	L							✓	✓		✓					✓	✓	
16	IFI	67	F	R							✓	✓		✓					✓		
17	Hematocolpos, IFI	15	F	B			✓					✓		✓					✓	✓	
18	IFI	45	F	L			✓					✓		✓					✓	✓	
19	Hamstring tendinopathy, IFI	67	F	B			✓					✓		✓			✓		✓	✓	
20	IFI	73	F	B			✓					✓		✓					✓	✓	
21	IFI	32	F	B			✓					✓		✓					✓		
22	IFI	60	F	B			✓					✓		✓					✓		
23	IFI	45	F	R			✓					✓		✓					✓		
24	IFI	48	F	R							✓	✓		✓					✓	✓	
25	IFI	45	F	R			✓					✓		✓					✓		
26	IFI	54	M	B							✓	✓		✓					✓		
27	IFI	45	F	R							✓	✓		✓					✓	✓	
28	IFI	37	F	L		IFS/QFS restriction. QFm edema	✓					✓		✓					✓		
29	IFI	21	F	R			✓					✓		✓					✓	✓	✓(proximal femur)
30	IFI	51	F	B			✓					✓		✓					✓		
31	IFI	53	F	R		IFS/QFS restriction. QFm edema	✓					✓		✓					✓		
32	IFI	28	F	B			✓					✓		✓					✓		
33	IFI	43	F	L			✓					✓		✓					✓		
34	IFI	28	F	B			✓					✓		✓					✓		
35	IFI	45	F	R		IFS/QFS restriction. QFm edema	✓					✓		✓					✓		
36	IFI	35	F	L		IFS/QFS restriction. QFm edema					✓	✓		✓					✓		
37	IFI	44	F	B							✓	✓		✓					✓		
38	Proximal femur sessile osteochondroma, IFI	26	F	R			✓					✓		✓					✓		✓(lesser trochanter)
39	Ischial bone ABC, IFI	25	F	L							✓		✓	✓					✓		✓(ischial bone)

Table 1. *Description of imaging findings, related aetiologies and demographic data in patients with ischiofemoral impingement syndrome. IFIs, ischiofemoral impingement syndrome; DDH, developmental hip dysplasia; THR, total hip replacement, ABC, aneurysmal bone cyst; M/F, male/female; R/L, right/left; QFm, quadratus femoris muscle; IFS, ischiofemoral space; QFS, quadratus femoris space; PD, partial disruption; CD, complete disruption; MTJ, myotendinous junction; I/F, ischial/femoral; BME, bone marrow oedema.*

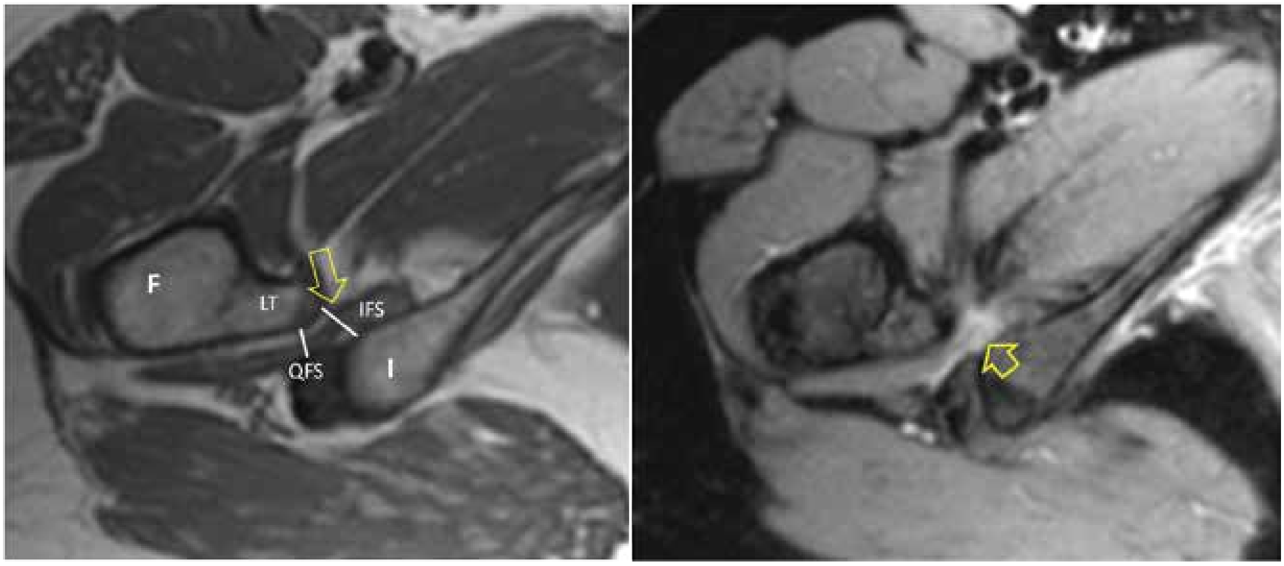

__Fig. 2.__ A 45-year-old female with right posterior hip pain. Axial T1-w (left) and fat suppressed PD-w (right) MR images show narrowing of the ischiofemoral and quadratus femoris space together with crowding and oedema of quadratus femoris fibres (arrows). Oedema indicates the site of maximum impingement. IFS, ischiofemoral space; QFS, quadratus femosis space. F, femur; LT, lesser trochanter; I, ischium.

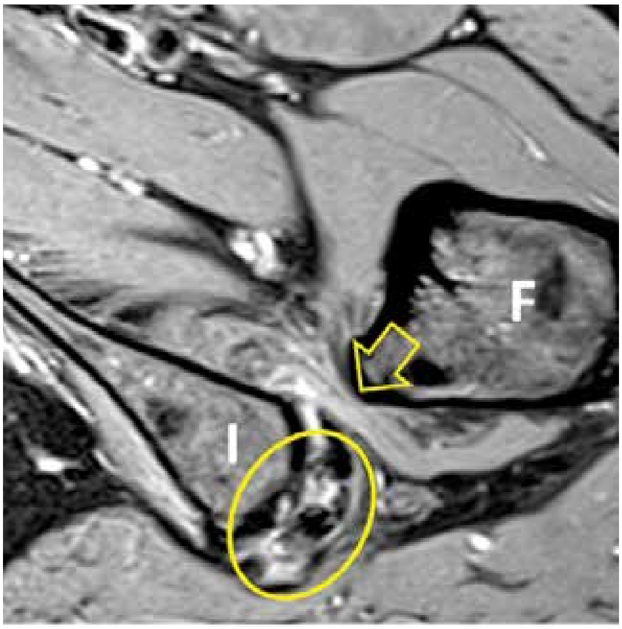

__Fig. 3.__ A 43-year old woman with left hip pain. Axial fat suppressed PD-w MR image depicts derangement and oedema (arrow) of the fibers of the left quadratus femoris muscle. Also note tendinosis involving the hamstrings' ischial insertion (oval). F, femur; I, ischium.

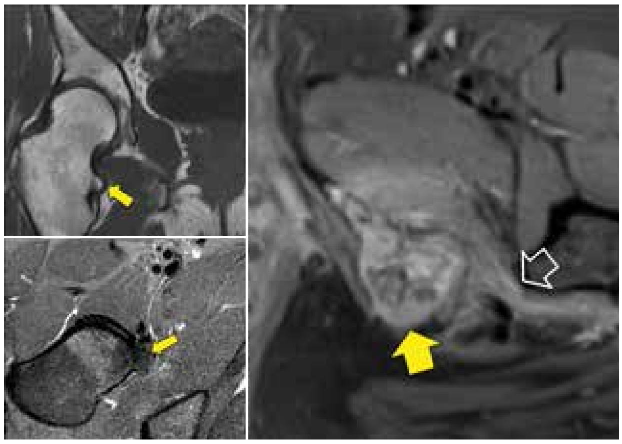

__Fig. 4.__ Various causes of quadratus femoris muscle pathology. A 26-year-old male with right hip and groin pain (upper and lower left). Coronal T1-w (upper left) and axial STIR (lower left) MR images show an osteochondroma (arrows) just cranial to the lesser trochanter. A 25-year-old female with left posterior hip pain and an aneurysmal bone cyst of the ischial bone (right). Axial fat suppressed PD-w MR image showing the expansile lesion of ischial bone (arrow) causing narrowing of the ischiofemoral and quadratus femoris spaces and severe quadrates femoris muscle oedema (open arrow).

6). MR imaging revealed QFm oedema in 4/5 patients, classified as mild (n=3) or severe (n=1). In patients with mild oedema, it was located at the myotendinous junction, either at the ischial (n=1) or femoral (n=2) attachment, while in the patient with partial tear and diffuse oedema, disruption of the femoral insertion fibers was identified. The 1-year fol-

Patient No	Diagnosis	Age (years)	Sex (M/F)	Side (R/L)	Physical activity	Trauma	F/U	QFm fibers' configuration				QFm edema classification				QFm edema location		Hamstrings		IFS/QFS distance		
								Crowded	PD	CD	Chronic tear	Normal	Mild	Moderate	Severe	QFm belly	MTJ (I/F)	Tendinosis/ apophysitis	Tear/ avulsion	IFS/QFS narrowing	QFS narrowing	Normal IFS/QFS
1	QFm, obturator muscle strain (grade I)	16	M	L	Y (football)	✓			✓				✓				✓ (I)					✓
2	QFm partial tear (grade II)	22	F	R		✓	1-year F/U MRI-resolution		✓						✓	✓						✓
3	QFm partial tear (grade II)	51	F	R		✓			✓				✓				✓ (F)					✓
4	QFm partial tear (grade II)	41	M	R	Y (football)	✓			✓				✓				✓ (F)					✓
5	QFm chronic, complete tear	67	F	R							✓							✓		✓	✓	

Table 2. *Description of imaging findings and demographic data in patients with quadratus femoris muscle tears. M/F, male/female; R/L, right/left; QFm, quadratus femoris muscle; IFS, ischiofemoral space; QFS, quadratus femoris space; F/U, follow-up; PD, partial disruption; CD, complete disruption; MTJ, myotendinous junction; I/F, ischial/femoral.*

Patient No	Diagnosis	Age (years)	Sex (M/F)	Side (R/L)	Physical activity	Trauma	F/U	QFm fibers' configuration				QFm edema classification				QFm edema location		BME (location)
								Crowded	PD	CD	Chronic tear	Normal	Mild	Moderate	Severe	QFm belly	MTJ (I/F)	
1	Fibroblastic osteosarcoma, proximal femur	28	F	L								✓	✓			✓		✓ (proximal femur)
2	QFm, gluteus maximus muscle mucoid sarcoma	48	M	L		✓						✓	✓			✓		
3	Undifferentiated pelvic sarcoma	57	F	R								✓			✓	✓		
4	QFm myositis ossificans	20	M	L	✓ football	✓	9-month F/U MRI-resolution					✓			✓	✓		
5	QFm post-radiation myositis, anal carcinoma	67	F	L								✓			✓	✓		
6	QFm hemangioma	56	F	R								✓			✓	✓		
7	Lesser trochanteric bursitis	53	F	R			1-year F/U MRI-undifferentiated					✓	✓			✓		

Table 3. *Description of imaging findings and demographic data in patients with various pathologies related to quadratus femoris muscle. M/F, male/female; R/L, right/left; QFm, quadrates femoris muscle; IFS, ischiofemoral space; QFS, quadratus femoris space; F/U, follow-up; PD, partial disruption; CD, complete disruption; MTJ, myotendinous junction; I/F, ischial/femoral; BME, bone marrow oedema.*

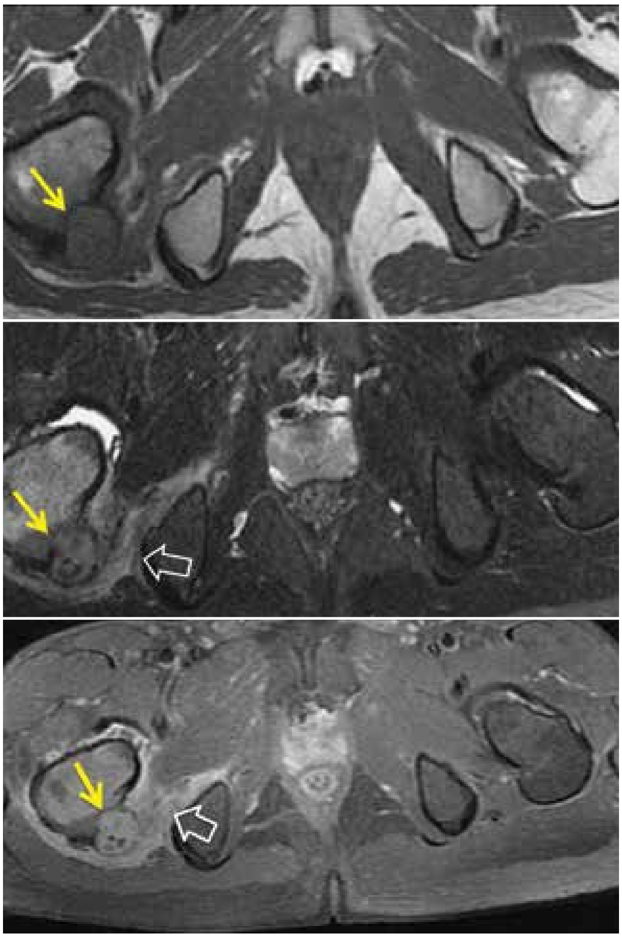

Fig. 5. A 28-year-old male with right hip pain. Axial T1-w (upper), fat suppressed T2-w (middle) and fat suppressed contrast enhanced T1-w (lower) MR images showing a parosteal chondroma (arrows) and diffuse oedema and enhancement within the quadratus femoris muscle (open arrows).

low up MR imaging study in 1 patient with partial QFm tear demonstrated complete resolution. Imaging findings and demographics in patients with QFm tears are depicted in **Table 2**.

In the remaining 7 patients (2 males, 5 females; age range 20-67 years; mean age 47 years; SD 16.9) with unilateral symptoms (4 left sided, 3 right sided) various pathologies related to the QFm were disclosed with MR imaging. One patient was involved in high level physical activity (football player) and 2/7 indicated a history of recent (up to 6 months) trauma. MR imaging revealed QFm oedema in all cases, either mild located in the muscle belly (n=3) or severe (n=4). Narrowing of the IFS/QFS was not identified in any of these patients. Pathologies broadly included neoplastic disorders, myositis ossificans and bursitis (**Fig. 7**). The 9-month follow up MR imaging study in a patient with QF muscle myositis ossificans documented complete resolution of abnormal findings while the 1-year follow up MR imaging study in a woman with lesser trochanteric bursitis and a history of breast cancer documented stability. The various pathologies related to QFm, imaging findings and demographics are shown in **Table 3**.

4. Discussion

The present study describes the MR imaging findings in pathological conditions affecting the QFm, in patients with hip pain. The most common pathologies included IFIs followed by QFm tears and various conditions affecting the QF muscle. In all patients with IFIs, QFm oedema was located in the muscle belly and crowding of the muscular fibers

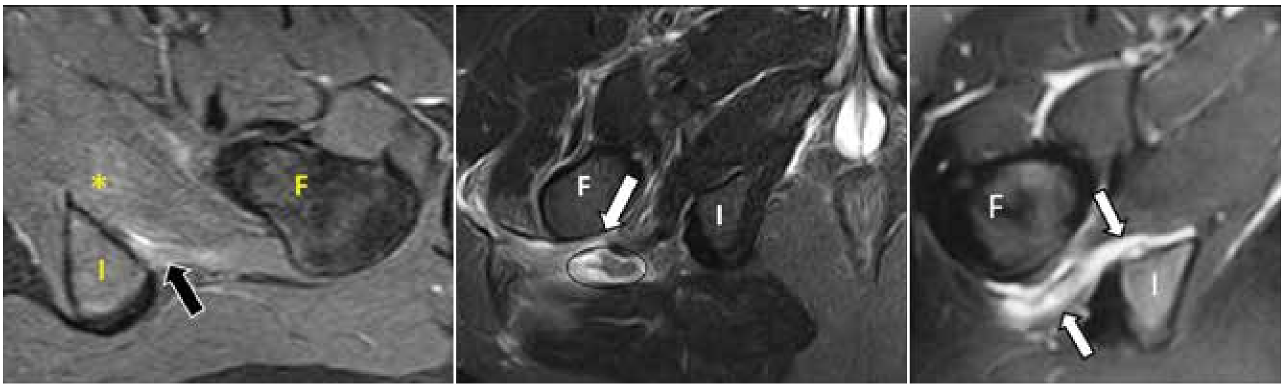

Fig. 6. Axial fat suppressed PD-w MR images in a 16-year-old male with a recent football injury (left), in a 41-year-old male with right hip pain and sciatica following trauma (middle) and axial fat suppressed T2-w image in a 22-year-old female with right hip pain following trauma (right) show quadratus femoris muscle strain grade I (left, arrow) with minor focal oedema within obturator externus muscle (*), grade II (middle) quadratus femoris muscle tear (arrow) with fluid surrounding the sciatic nerve (oval), and grade II (right) quadratus femoris muscle tear (arrows). F, femur; I, ischium.

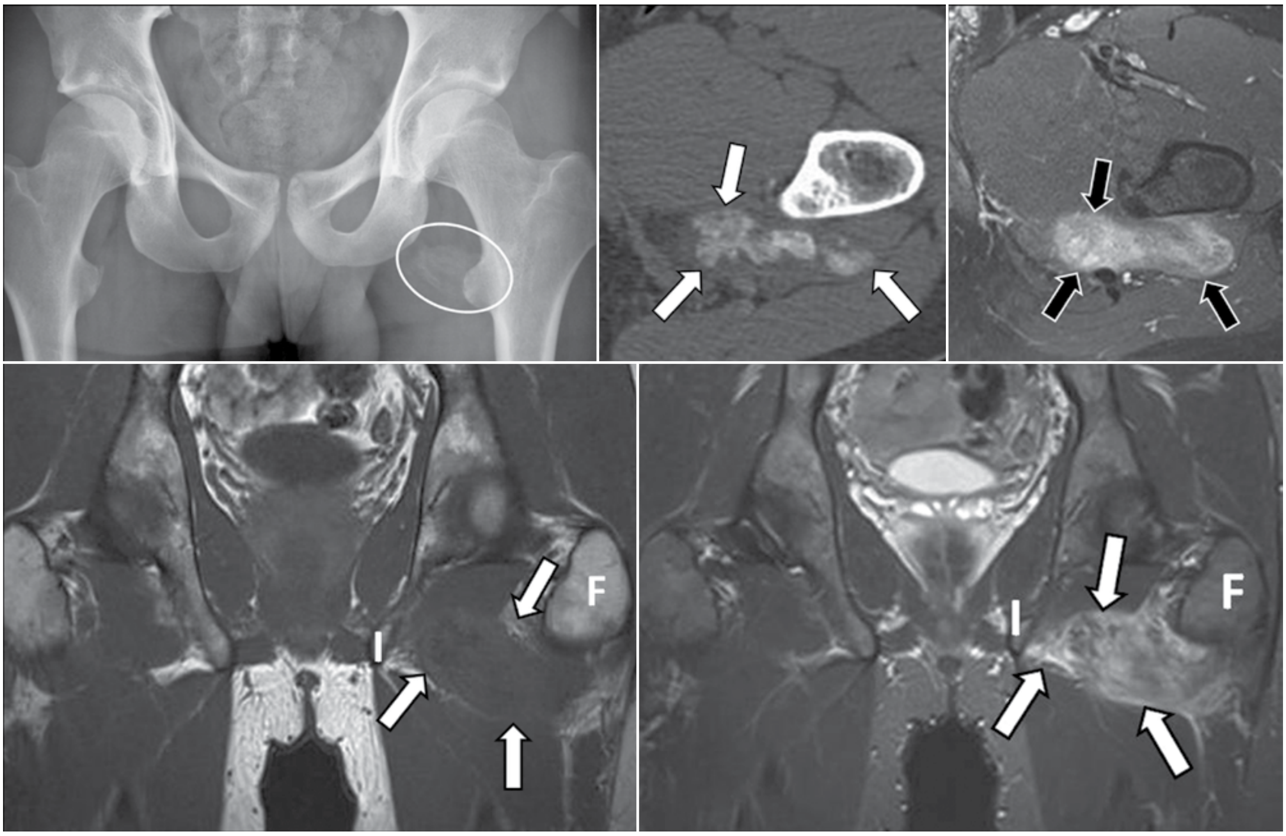

Fig. 7. *A 20-year-old male with persistent left posterior hip pain following trauma 2 months prior to imaging. The anteroposterior pelvic radiograph (upper left) shows soft tissue ossification (oval). Corresponding axial CT image (upper middle) shows multiple intramuscular foci of new bone formation (arrows). Axial fat suppressed T1-w post contrast (upper right), coronal T1-w (lower left) and STIR (lower right) images show diffuse enhancement, enlargement and inhomogeneous oedema of the left quadratus femoris muscle (arrows). Overall appearance and reduction of size and symptoms resolution on follow up are diagnostic of myositis ossificans.*

was depicted. The absence of severe QFm oedema and the crowded configuration of muscular fibers correlated significantly with the diagnosis of IFIs. QFm tears were characterised by the presence of oedema, either diffuse or located at the myotendinous junction together with fluid collections replacing the torn muscular fibers. Finally, various pathologies affecting the QF anatomic area were disclosed in 13.7% of the study population, associated with QFm oedema, which was severe in most of the cases, without restriction of the IFS/QFS.

QFm belongs to the small muscles of the pelvis and it primarily serves as one of the external hip rotators [12]. Owing to its location between closely opposed bony structures and involvement in a wide spectrum of ordinary and high level physical activities, it is particularly prone to entrapment-impingement and injury [5, 8, 13]. In addition, various lesions stemming from the osseous or soft-tissue surrounding structures may extend to the QF anatomic region, resembling primary pathology. Despite its vulnerability to impingement, injury or secondary involvement, pathological conditions affecting the QFm have been infrequently reported [2-6].

Compared to other modalities, MR imaging represents the method of choice regarding the evaluation of QFm, mainly due to its deep location and small size. Due to the regional anatomy, axial images provide better assessment while coronal and sagittal planes may offer additional information depending on the underlying pathology [5, 14]. In accordance, we found axial FS PD-w/T2-w and STIR images particularly helpful for targeting the pathology whereas axial T1-w images were ideal for the evaluation of crowding of the muscular fibers, a finding that served as a differential diagnostic clue, favouring the diagnosis of impingement [5].

IFIs has been mainly related to congenital narrowing of the IFS and/or QFS [3, 5, 9, 11, 13, 15] and it is held that a cut-off value of ≤ 17 mm and ≤ 8 mm, regarding IFS and QFS dimension respectively, can differentiate patients with IFIs from normal subjects with a sensitivity of 83% and a specificity of 82% [11]. Conversely, IFS narrowing may occur in several acquired conditions, which have been described mainly in case reports [16-20]. Herein, in 46.2% of patients with IFIs, restriction of the IFS and/or QFS was related to an acquired aetiology, with hamstring tendinosis and/or avulsion representing the leading cause.

IFS/QFS narrowing with or without QFm oedema and a QFm lipoma were depicted on the contralateral, asymptomatic side of 7 patients with unilateral symptoms. This is in accordance with previous studies, suggesting that imaging findings indicative of IFIs may be detected in asymptomatic individuals [7, 8]. As in all impingement conditions, it is recommended that the imaging findings indicative of IFIs should be correlated clinically in order to avoid over-diagnosis.

As hip joint movements induce alterations in the IFS diameter, there is debate regarding the optimal patient positioning that will ensure accurate and reproducible evaluation of this space during MR imaging investigations [5, 9, 11]. Moreover, evaluation of IFS in the prone versus supine position with hip flexion as well as supine position with hip flexion versus neutral supine position differ significantly [21]. Alterations can also occur when assessing the space in the supine versus standing position [15]. In the present study all patients were scanned in the supine position, with an attempt for internal rotation which was not the same for all imaging centers involved in this study.

MR imaging findings of QFm tear range from oedema located at the myotendinous junction, usually at the femoral insertion, to complete fiber disruption [2, 4, 5, 22, 23]. Similarly, in 60% of patients with clinically confirmed QFm tears presented herein, oedema was located at the myotendinous junction while in a patient with partial tear and diffuse QFm oedema, disrupted fibers were located at the femoral attachment. Regarding one patient with chronic QFm tear and no history of trauma, MR imaging revealed chronic hamstring tendinopathy and/or ischial apophysitis causing IFS/QFS narrowing. This may imply that the presence of conditions predisposing to IFIs may be related with chronic QFm impingement and subsequent tear.

Strengths of the study include the large number of patients, the availability of clinical correlation and the variable origin of the cohort. This study has specific limitations including: (1) utilisation of various MR units; (2) retrospective nature, with inclusion only of the patients with hip pain and MR imaging findings in the ischiofemoral area. With this limitation, inherent to case control studies, the incidence rate (rate of new cases) cannot be calculated. Therefore, a bias may exist and thus no attempt was made to depict the prevalence of QFm abnormalities; (3) lack of control group is the second limitation of the study, taking into account that asymptomatic subjects, particularly athletes, may show QFm oedema with or without IFS and or QFS narrowing [8]. In addition, patients with IFS/QFS narrowing but normal QFm were likely missed and therefore not included in the analysis. Thus, no firm conclusion can be arrived in the present study regarding the cause and effect relation between narrowing and symptomatology; (4) surgical confirmation or follow up with clinical examination or imaging did not exist in all patients. However, there is currently no surgical procedure reported in the literature for correction of IFIs; (5) although internal hip rotation is routinely performed as part of the MR protocol, it was not possible to prospectively ensure identical positioning in all patients included in the study. This could lead to a degree of IFS/QFS narrowing overestimation in cases with some degree of external rotation; (6) The performance of MR neurography for assessing the presence of sciatic neuritis as cause of pain in patients with QFm pathologies would be of interest, however due to the retrospective collection of data such an application was not feasible. The latter may be regarded as a topic for future research.

In conclusion, the QFm is yet another input in the long list of causes of hip pain. MR imaging can accurately depict related pathologic conditions. This work highlights the fact that beyond congenital IFIs, acquired aetiologies of impingement, traumatic lesions, myositis ossificans and a spectrum of neoplastic disorders should be considered. Detailed analysis of the pattern of oedema and the configuration of muscular fibers matched with the clinical presentation can lead to precise diagnosis. **R**

Conflict of interest

The authors declared no conflicts of interest.

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