

CLINICAL SIGNIFICANCE OF SIGNAL CHANGES IN THE QUADRATUS FEMORIS MUSCLE ON MR

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Objectives: To evaluate the clinical significance of quadratus femoris muscle signal changes (QFMC) on MRI.

Methods: 204 consecutive bilateral MRI hip examinations (132 female, 72 male) were reviewed in retrospect for QFMC. Inclusion imaging parameters were edema or atrophy of the quadratus femoris muscle. The presence or absence of symptoms and additional ipsilateral and/or contralateral imaging findings were used to differentiate between isolated symptomatic, co-incidental and asymptomatic QFMC.

Results: 24 (11.8%) patients and 30 (7.3%) hips demonstrated QFMC. Atrophy was present in 5 symptomatic hips. Female to male ratio was 23:1. Isolated symptomatic QFMC: 4 hips (13.3%), 1 bilateral. Clinical symptoms in this group were non-specific greater trochanter pain and stiffness of the hip. Co-incidental QFMC: 19 symptomatic hips, ipsilateral associated findings present in 18 hips (94.7%) and contralateral additional findings present in 8 hips (42.1%). Asymptomatic QFMC: 7 hips (23.3%), ipsilateral associated asymptomatic findings in 5 hips (71.4%) and contralateral associated symptomatic findings in 6 hips (85.7%). Edema around the greater trochanter and hamstring insertions were the most frequent associated findings.

Conclusion: In this study, most cases of QFMC were co-incidental or asymptomatic. In isolated symptomatic QFMC clinical complaints were non-specific. Atrophy was found only in the symptomatic hips.

Key-word: Muscles, MR.

Hip, groin and buttock pain are diagnostic challenges and an abnormal quadratus femoris muscle (QFM) has only been recognized as a possible cause of pain around the hip since the era of MRI. The QFM is a quadrilateral muscle located at the posterior side of the hip joint. It originates from the upper external border of the ischial tuberosity and inserts on the quadratus tubercle and linea quadrata of the posterior femur. It is bordered anteriorly by the obturator externus muscle, posteriorly by fat and the sciatic nerve, inferiorly by the adductor magnus muscle and cranially by the inferior gemellus muscle. The hamstring tendons are inserting just posterior to the ischial origin of the QFM (Fig. 1). The QFM acts as hip external rotator, and assists in adduction of the hip (1).

Quadratus femoris muscle signal changes (QFMC) are almost exclusively seen in female patients (84-100%) (2-7). Trauma and ischiofemoral impingement are different mechanisms thought to be responsible for the development of QFMC (2-11). Overuse, age-related degeneration, disuse, denervation and exercise-induced edema of the QFM should also be considered as a possible cause for QFMC (1, 7, 12).

There are only a limited number of reports on asymptomatic and co-incidental QFMC (1, 5-8). The incidence of QFMC in patients with symptoms that could be attributed to QFMC only (isolated symptomatic), patients with symptoms that could be attributed to multiple causes (co-incidental) and asymptomatic patients has not been studied sys-

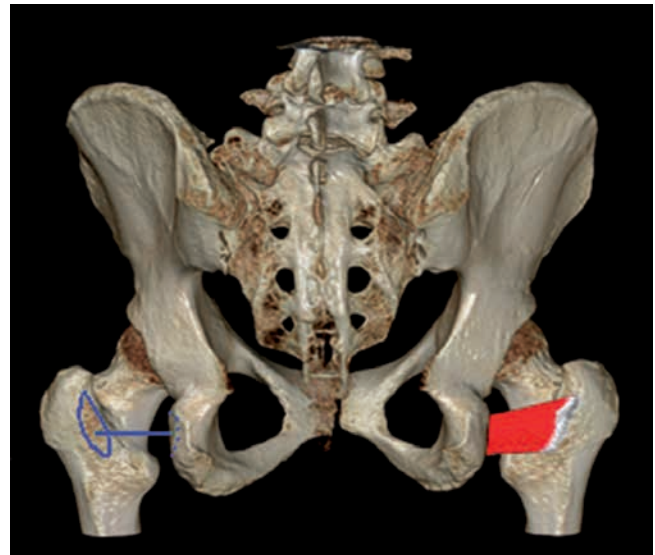


Fig. 1. — Posterior view of the pelvis and hips with course (right) and insertions (left) of the QFM.

tematically. This study also differentiates between these three groups of patients in order to identify possible specific symptoms related to QFMC.

Material and methods

Patient selection and imaging protocol

Consecutive bilateral MRI hip examinations performed in our MRI department between March 2011 and October 2012 were reviewed for the presence of QFMC. All examinations were performed on a 16 channel 1.5 Tesla MRI scanner (Intera, Philips Medical Systems, Best, The Netherlands) using a phased-array coil. The

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Table I. — Summary of the patients demonstrating QFMC in the present study.

	Sex	Age	Symptoms	Clinical findings	QMFC	Associated findings
A1	F	18	R+L	GTPS	R+L	none
A2	F	29	R+L	buttock pain for 2 years	Atrophy R+L	HSE R+L, GTE R
A3	F	64	R	pain hip	R	effusion R, AVN R, HSE R
A4	F	68	L	GTPS	Atrophy L	GTE L, HSE L
A5	F	30	L	paresis, post-epidural anaesthesia (delivery), low weight	L	sciatic nerve edema L
A6	F	44	L	pain hip	L	posterior labral tear/ edema in the superior gemellus muscle L
A7	F	4	R	pain hip	R	effusion R
A8	F	40	L	GTPS, groin pain	Atrophy L	GTE L
A9	F	58	L	GTPS	L	GTE L
A10	F	39	R	pain anterior leg	R	avascular necrosis R
A11	F	66	L	sudden groin pain	L	GTE L
A12	M	46	L	pain hip	L	HSE L
B1	F	44	R+L	GTPS, hypermobility	R	GTE R+L
B2	F	47	R+L	pain buttocks and thighs, hypermobility	L	HSE L, GTE R
B3	F	56	R+L	pain ischial tuberosity/ ischialgia R>L, low weight	L	fluid around sciatic nerve L
B4	F	58	R+L	GTPS	Atrophy L	none
B5	F	26	R+L	groin pain (R>L), inguinal hernia correction R + L	L	labral tear R
C1	F	36	L	stiffness left hip	R!+L	none
C2	F	71	R	Reduced flexion and endorotation	R+L!, Atrophy R	effusion R, OAD R, HSE R+L
C3	F	56	L	GTPS, groin pain	R!+L	GTE R+L
C4	F	69	R	GTPS	R+L!	GTE R, HSE R+L, OAD R
D1	F	57	R	GTPS	L!	GTE R+L
D2	F	50	R	GTPS, reduced abduction	L!	GTE R+L, HSE L
D3	F	59	L	pain hip	R!	GTE L

GTPS: greater trochanter pain syndrome, R: right, L: left, HSE: hamstring edema, GTE: greater trochanter edema, !: asymptomatic, OAD: osteoarthritis deformans.

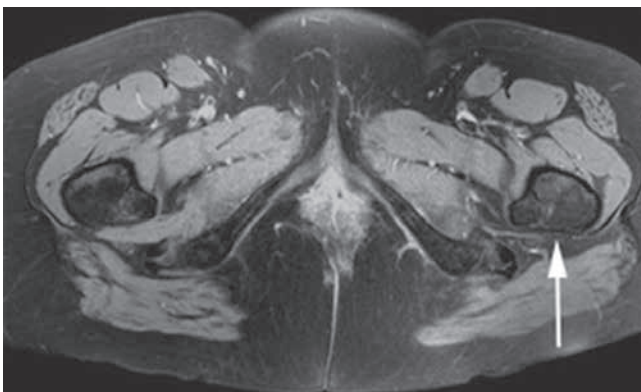


Fig. 2. — Patient B4. Axial fat-suppressed proton-density image demonstrates almost complete disappearance of the left QFM (arrow). This may represent a chronic tear with atrophy and complete fatty replacement. The QFM on the right side is normal.

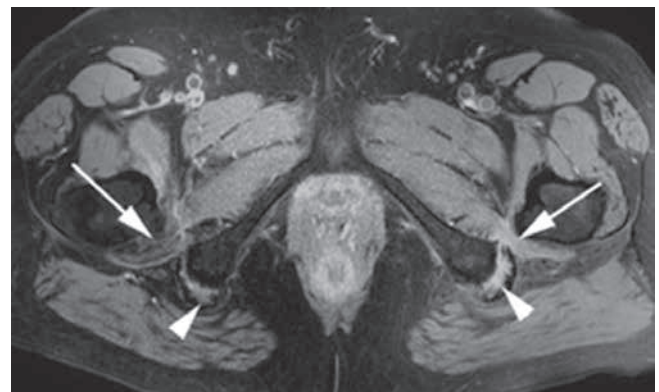


Fig. 3. — Patient C2. Axial fat-suppressed proton-density image shows an asymptomatic hyper-intense signal in the left QFM (arrow). On the symptomatic right side there is a hypo-intense signal indicating atrophy with fatty replacement of the QFM. HSE is present on both sides (arrowheads).

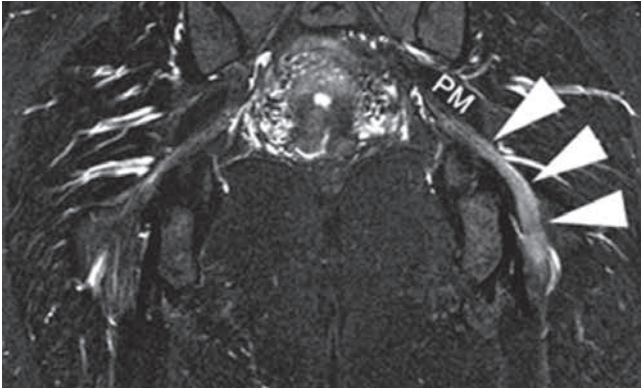


Fig. 4. — Patient A5. Coronal T2-STIR image in a patient with a left-sided QFMC shows edema of the sciatic nerve (arrowheads) after prolonged immobilisation during delivery with epidural anaesthesia. PM: Piriform muscle.

standard protocol includes : Coronal fast T1-weighted images (TR/TE: 500/18 ms, Number of excitations (NEX): 3, slice thickness: 3 mm, field of view (FOV): 360 × 371 mm, matrix: 384 × 316), transverse fat-suppressed proton-density images (TR/TE 1500/20 ms, NEX: 2, slice thickness: 5 mm, FOV: 375 × 338 mm, matrix: 400 × 288), coronal T2-STIR images (TR/TE/TI: 2500/60/160ms, NEX: 3, slice thickness: 3 mm, FOV: 395 × 395 mm, matrix: 420 × 336) and sagittal T2 gradient-echo images (TR/TE: 705/14ms, NEX: 2, slice thickness: 3 mm, FOV: 260 × 207 mm, matrix: 256 × 162). All imaging sequences include both hips examined in a neutral position which practically produces some external rotation. Review was performed on our picture archiving and communication system (Agfa HealthCare, Mortsels, Belgium) in retrospect and devoid of knowledge of the symptoms, by two radiologists (first author, experienced with musculoskeletal imaging for 21 years and second author, experienced with MRI for 9 years) on consensus.

Following patients were excluded: unilateral and bilateral total hip and resurfacing arthroplasty, infectious disease of the hip, suspected malignancy, fracture, inadequate MR examination or absent clinical record. No patients were excluded for age.

The first inclusion imaging parameter for QFMC was edema of the QFM. This was defined as an increase in signal of the muscle on fat-suppressed proton-density images or T2-STIR images. The second inclusion imaging parameter was atrophy. Atrophy can present as 1/ sim-

ple volume loss, 2/ a low fatty signal on fat-suppressed proton-density images or T2-STIR images and a high fatty signal on T1-weighted images, 3/ a combination of volume loss and fatty transformation.

After detection of the QFMC medical records were consulted to differentiate between symptomatic and asymptomatic hips. Four groups could be discerned on a symptom basis:

A: Unilateral/bilateral symptomatic hips with ipsilateral/bilateral QFMC
B: Bilateral symptomatic hips with unilateral QFMC

C: Unilateral symptomatic hips with bilateral QFMC (one side asymptomatic)

D: Unilateral symptomatic hips with contralateral asymptomatic QFMC

All included patients were evaluated for associated ipsilateral and contralateral abnormalities. Associated findings were assigned to one of following groups:

1/ Greater trochanter edema (GTE) defined as an abnormal signal around the greater trochanter as seen in bursitis, gluteus muscles tendinopathy or tear.

2/ Hamstring edema (HSE) defined as edema at the insertion of the hamstring tendons complex on the ischial tuberosity.

3/ Miscellaneous findings such as osteoarthritis deformans (OAD), avascular necrosis (AVN), labral tear, sciatic nerve abnormality, joint effusion, psoas tendon signal changes.

When combining symptoms with associated ipsilateral and contralat-

eral findings isolated symptomatic, co-incident and asymptomatic QFMC could be differentiated:

Isolated symptomatic QFMC: clinical complaints may be related directly to QFMC since no ipsilateral and/or contralateral additional imaging findings were detected.

Co-incident QFMC: clinical complaints may not be related to QFMC since ipsilateral and/or contralateral additional imaging findings were detected.

Asymptomatic QFMC: clinical complaints in the hip with QFMC were absent.

Results

The results are summarized in Table I. A total of 204 examinations (132 female, 72 male) or 408 hips were included. And 24 patients (30 hips) showed QFMC (11.8% of patients, 7.3% of hips). Mean age was 47 ± 17 year. Age-range was 4-71 years. Female to male ratio was 23:1. Female incidence was 17.4% (23/132). Male incidence was 1.3% (1/72). QFMC was observed in 11 right and 19 left hips. In 6 patients involvement was bilateral (25%). Atrophy of the QFM was present in 4 patients (5 hips) with symptomatic QFMC (Fig. 2-3). No atrophy was present in the asymptomatic hips.

Isolated symptomatic QFMC: 4 hips (13.3%)

Symptoms in these patients were greater trochanter pain syndrome (GTPS) (2 patients, 3 hips) and stiffness of the hip (1 patient, 1 hip).

Co-incident QFMC: 19 hips (63.3%)

In 18 symptomatic hips with QFMC, ipsilateral additional imaging findings were present (94.7%). GTE was present in 8, HSE in 8, OAD in 2, joint effusion in 2, AVN in 2, sciatic nerve edema in 1, edema surrounding the sciatic nerve in 1 (Fig. 4) and posterior labral tear/edema in the superior gemellus muscle in 1 hip. In 8 symptomatic hips with QFMC contralateral additional imaging findings were present (42.1%). GTE was seen in 4, HSE in 4 and a labral tear in 1 contralateral hip. In the case with QFMC and a contralateral labral tear, no ipsilateral associated findings were present (Fig. 5).

In co-incident QFMC following symptoms were present: GTPS (6 patients), groin pain (4 patients), pain not otherwise specified (4 patients), ischialgia and/or paresis (2 patients), pain at the ischial tuber-

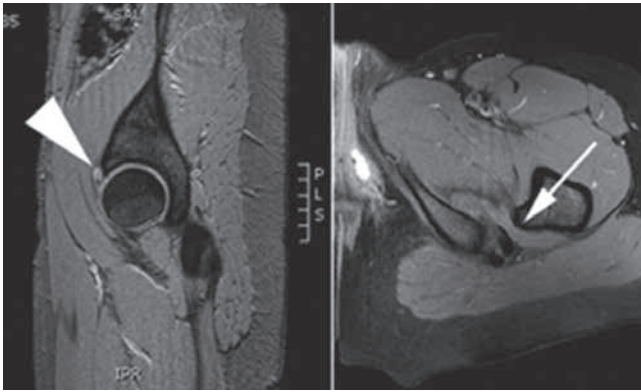


Fig. 5. — Patient B5. Axial fat-suppressed proton-density image of the left hip shows symptomatic QFMC with edema (arrow right image). The sagittal T2 gradient-echo image of the contralateral hip demonstrated a symptomatic labral tear (arrowhead left image).

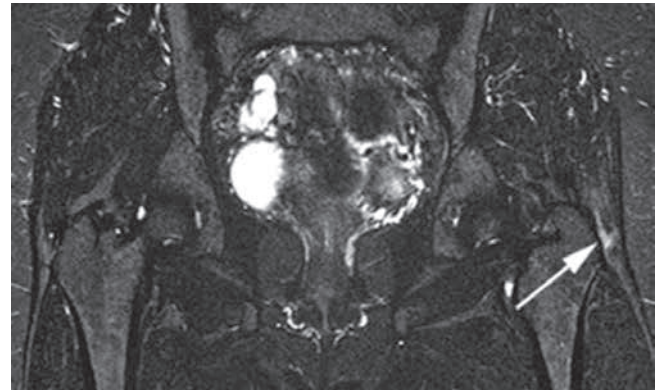


Fig. 6. — Patient A8. Coronal T2-STIR image shows edema surrounding the greater trochanter (arrowhead).

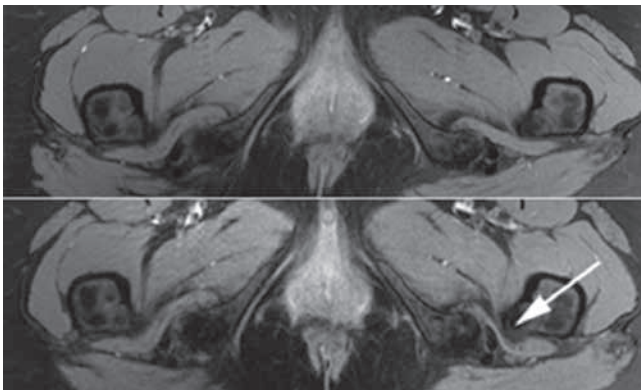


Fig. 7. — Patient A8. Axial fat-suppressed proton-density images. The top image shows bilateral normal QFM. QFMC with atrophy developed in this patient 2 years later (bottom image arrow).

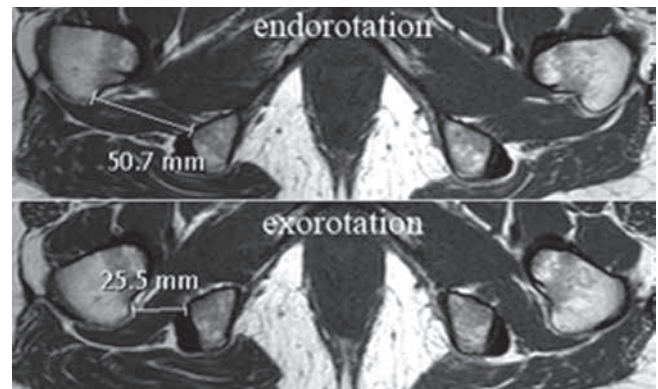


Fig. 8. — Axial T1-weighted images in a healthy volunteer with normal QFM. External rotation of the leg produces a narrowing of the space between ischium and femur and this may produce impingement of the QFM.

osity (1 patient), buttock and posterior thigh pain (2 patients), reduced flexion and endorotation (1 patient), anterior leg pain (1 patient), hypermobility (2 patients).

Asymptomatic QFMC: 7 hips (23.3%)

In case of asymptomatic QFMC, contralateral symptomatic imaging findings different from QFMC were present in 6 out of 7 cases (85.7%). GTE was present in 5 of them, HSE was present in 3 hips, OAD was present in 2 hips.

5 patients (71.4%) with asymptomatic hips with QFMC showed an ipsilateral combination with asymptomatic GTE in 3 hips and asymptomatic HSE in 3 hips.

Follow-up

1 patient (A8) had MRI 2 years before the detection of QFMC because of GTPS on the left side. No QFMC

was present at that time but a GTE was present then on the left side (Fig. 6). Ipsilateral QFMC developed 2 years later and GTE persisted (Fig. 7).

1 patient (A10) had a follow-up examination 9 months after the initial examination for AVN. Forage had been performed for AVN. QFMC evolved from ipsilateral and unilateral to bilateral.

Discussion

Incidence of QFMC

Findings of this report and previous reports found in the literature are summarized in Table II. When we only consider our symptomatic patients and hips, incidence of QFMC is 10.4% (21/201) of patients and 5.7% (23/401) of hips. However, these data may not be comparable with one larger study, since no detail on the

sex of the 805 examined patients of Tosun was mentioned (7).

Bilateral involvement has been reported to be present in 14.2-40% of patients. Bilateral QFMC is believed to be consistent with a congenital factor. The strong female predominance is also in favour for a congenital predisposition and this has been attributed to the anatomy of the female pelvis having a wider intertuberosity distance (changing the ischium angulation), and more frequent valgus hip configuration both narrowing the ischiofemoral space (6, 7, 12). Injury may be the trigger which activates a genetic predisposition for ischiofemoral impingement (13). However, a narrower intertuberosity diameter was also significantly associated with greater degenerative changes of the QFM in a cadaveric study suggesting that different mechanisms are responsible for QFMC development (12).

Table II. – Literature review of reports on quadratus femoris muscle changes.

Reference	Number of patients/hips	QFMC Female/Male (%of patients) / Hips(% of hips)	Bilateral	Asymptomatic hips	Age range (mean)	Associated findings ipsilateral	Associated findings contralateral	Mechanism of QFMC
MR studies								
Tosun (7)	805 patients/1598 hips	42F/8M (6.2%)/ 70 hips (4.4%)	20/50 (40%)	excluded	14-77 (51y)	10/70 (14.3%)	0	ischiofemoral impingement
present study	204 patients/408 hips (264F/144M)	23F/1M (11.8%)/ 30 hips (7.3%)	6/24 (25%)	7/30 (23.3%)	4-71 (47y)	23/30 (76.7%)	14/30 (46.7%)	associated findings? coexisting mechanisms
Torriani (6)	9 patients/12 hips	9F/12 hips/ Males excluded	3/9 (33%)	2/12 (16.6%)	30-71 (53y)	>50%	0	ischiofemoral impingement
Kassarjian (1, 9)	8 patients/9hips	5F/2M/1unknown/9 hips	1/8 (12.5%)	1/8 (12.5%), 1 unknown	13-73 (35y)	0	0	strain, ischiofemoral impingement, exercise-induced
O'Brien (2-5)	7	7F/8 hips	1 (14.2%)	0	17-43 (30y)	2/8 (25%)	1/8 (12.5%)	trauma/tear QFM
Ali (15)	1	1F	0	0	17y	0	0	trauma, pelvic imbalance, ischiofemoral impingement
Bano (14)	1	1F	0	0	22y	0	0	trauma, hematoma QFM
Patti (8)	1	1F	0	0	43y	1	0	ischiofemoral impingement
Viala (11)	1	1F	1	0	37y	0	0	exostosis
Tosun (13)	1	1F	0	0	11y	0	0	ischiofemoral impingement
Cadaveric study								
Sussman (12)	16 (7F/9M)/29 hips (12F/17M)	15 hips (51.7%) showed QFM degeneration			65-101 (84y)			overuse, age-related degeneration, disuse

Symptoms

When analysing symptoms in our patients with symptomatic isolated QFMC, these symptoms may only be addressed to QFMC. Non-specific GTPS and stiffness of the hip were present.

Pain symptoms related to QFMC can be acute as described in several case reports describing QFMC in young active individuals (1-3, 5, 13-15). Other patients however present with chronic non-specific complaints. Groin pain, upper posterior thigh pain, deep gluteal pain, tenderness to palpation on the ischial tuberosity, hip and groin pain radiating to the knee while walking, and snapping hip have been described (1, 6-9, 15). Sciatic nerve compression producing ischialgiform symptoms such as posterior thigh pain can be attributed due to the course of the sciatic nerve directly posterior to an edematous QFM. One of our patients had severe edema of the sciatic nerve and paresis of the ipsilateral lower limb after delivery with epidural anaesthesia. The long supine immobilization was thought to be responsible for the nerve damage and QFMC. Another of our patients with ischialgia had low body-weight and lacked protecting fat over the sciatic nerve.

Symptoms can be aggravated by extension, adduction and external rotation of the hip which may cause impingement of the QFM between the ischial tuberosity and the lesser trochanter. Internal or external rotation, sitting, prolonged hip flexion and adduction were also reported to provoke symptoms (1, 7, 10, 14).

Asymptomatic QFMC is frequent in our series (23.3%) and it has been reported in up to 16.6 % of cases in a series with a limited number of patients (6). In the large series analysed by Tosun the asymptomatic patients were excluded (7).

Associated findings

GTE and HSE were the most frequently detected associated findings in our series. Hip disorders being co-existent with QFMC make it difficult to establish an adequate clinical diagnosis. GTE and HSE were the first reported ipsilateral associated imaging findings in one patient (5). In the same report a contralateral stress fracture was observed in another patient. Iliopsoas tendon edema and bursa-like formations, OAD, AVN, joint effusion, edema in or around the sciatic nerve, and femoro-acetab-

ular impingement lesion (CAM) have also been described (6, 7, 10, 14). The greater trochanter insertion of the gluteus muscles is located lateral to the QFM femoral insertion on the quadratus tubercle. Myotendinous pathology of the gluteus tendons and bursitis around the posterior greater trochanter may produce symptoms difficult to differentiate clinically from QFM pathology since tearing of the QFM is located at the femoral insertion in the majority of cases (1). HSE can be responsible for ischiofemoral narrowing and ischiofemoral impingement (7). OAD can result in superior and medial displacement of the proximal femur with subsequent narrowing of the ischiofemoral space and development of QFMC due to impingement (10). A contralateral acetabular labral tear has not been associated with QFMC previously. This is however difficult to demonstrate without arthrography. Hypermobility was present in 2 of our patients and hypothetically a greater range of motion in these patients might also have led to QFMC (12, 16).

Other often asymptomatic lesions such as GTE, HSE and labral lesions are common on hip MRI especially in older patients (17-19). Therefore the presence of certain symptoms or specific other lesions in combination with QFMC may be truly co-incident.

Follow-up

Follow up MRI examination has been mentioned in two reports (9, 15). Resolution of QFMC demonstrated by MRI was reported in case of a QFM muscle tear (9). Ali hypothesized, in a case report with progressive IFS narrowing, that a minor injury not detectable on an initial MRI led to an abnormal gait (with adduction) and this altered walking pattern or pelvic imbalance may have resulted in ischiofemoral narrowing, impingement and QFMC (15). The follow-up MRI in 2 of our patients demonstrating the appearance of QFMC in one patient and the evolution from unilateral to bilateral QFMC might raise the speculative question whether pre-existing hip disorders may induce ipsilateral or contralateral symptomatic and/or asymptomatic QFMC. A reduced range of motion induced by ipsilateral additional findings causing pain may in some cases be responsible for the development of QFMC by a mechanism of ischiofemoral impingement. On the

other hand a greater range of motion compensating for the contralateral associated pathology may be needed on the side in which asymptomatic or symptomatic QFMC develops (12, 15).

Mechanisms responsible for QFMC

The first MRI report dates from 1997 and focused on a traumatic cause (2). Subsequent MRI case studies also focused on the traumatic origin of QFMC (3-5). This QFMC was interpreted as the result of muscle strain or tearing of the QFM. Strain and tearing injury is not the result of muscle contraction alone. They are the result of excessive stretch or stretch while the muscle is being activated (20). When the QFM contracts in an elongated or stretched status trying to control internal hip rotation this may trigger damage to the QFM (5).

Patti and Kassarian were the first to introduce ischiofemoral impingement on MRI (8, 9). In this concept QFMC develop due to a significant narrowing of the distance between the ischial tuberosity and the lesser trochanter with subsequent impingement of the QFM. An ischiofemoral space smaller than 17 mm can be used as a cut-off value indicative for ischiofemoral impingement with an 83% sensitivity and 82% specificity (6, 7). However, measurements have to be executed in an internally rotated hip position since external rotation narrows the ischiofemoral space significantly (Fig. 8). Ischiofemoral narrowing had already been recognized by Johnson in 1977 following hip arthroplasty and valgus intertrochanteric osteotomy. Acquired ischiofemoral space narrowing can also be the result of intertrochanteric fracture, osteochondroma, and OAD (10, 11).

A recent cadaveric study approximating QFM attachments sites scored the degree of QFM degeneration in an elderly population (12). Degenerative QFM was observed in 51.7% of hips. The closer together the two QF attachment sites could be approached one to another (by extension, adduction, not external rotation) the greater the degenerative changes of the QFM. A narrower intertuberosity diameter was significantly associated with greater degenerative changes of the QFM. This narrow intertuberosity diameter may allow greater motion of the hip and may put the QFM under excessive stress with subsequent degeneration

as can be seen in overuse syndrome injuries of the rotator cuff (21). Because of the advanced age of the subjects in this study, age-related QFM degeneration or disuse atrophy might have been responsible for loss of dynamic joint control. This loss of dynamic joint control could also increase the range of motion of the hip.

Mechanisms thought to be responsible for QFMC development may coexist and MR images should be scrutinized for all possible causes of hip, groin or buttock pain.

Treatment

No definitive treatment has been recommended other than excision of the lesser trochanter. This resulted in relief of symptoms and supported the hypothesis of a bony conflict between the ischial tuberosity and the lesser trochanter. A progressive post-traumatic ischiofemoral space narrowing and QFMC with the development of a snapping hip was treated by successful resection of the lesser trochanter and reinsertion of the psoas muscle tendon on the proximal femur (10, 15). In a case report a QFM tear resulted in a massive hematoma compressing the sciatic nerve. This had to be treated by surgical decompression due to persistent sciatica (14). Associated morbidity would be too high if resection of the lesser trochanter was to be used as the routine treatment resulting in weakness of hip flexion (22). Treatment with corticosteroid injection in or around the hip, non-steroidal anti-inflammatory drugs, transcutaneous neurostimulation, ultrasound therapy, and proper stretching technique have been shown to be effective with return to normal activity in the majority of reports describing treatment (2-4, 6, 8, 13). In case of multiple hereditary exostoses, resection of the exostoses in case of demonstrated ischiofemoral impingement was performed (11). Periarticular endoscopic decompression around the hip joint is a more recent treatment technique used in snapping psoas, gluteus medius and minimus tears and sciatic nerve compression. Decompression of the QFM is an option in case of MRI proven ischiofemoral impingement not responding to conservative therapy (14, 15, 23).

Conclusion

To conclude we cannot exclude the fortuitous or co-incidental character of QFMC in asymptomatic patients and when associated findings are present in symptomatic cases. The high incidence of associated findings may be related to QFMC but it may simply be selection bias as all patients had some pain to justify hip imaging. The retrospective character of our study did not allow follow-up examinations in all but 2 patients. Systematic follow-up and dynamic MRI examination of patients with QFMC can be next steps to continue this line of research.

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