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Iliopsoas Disorder in Athletes with Groin Pain

Prevalence in 638 Consecutive Patients Assessed with MRI and Clinical Results in 134 Patients with Signal Intensity Changes in the Iliopsoas

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Background: Although iliopsoas disorder is one of the most frequent causes of groin pain in athletes, little is known about its prevalence and clinical impact.

Methods: We retrospectively reviewed the cases of 638 consecutive athletes who had groin pain. Each athlete was assessed with magnetic resonance imaging (MRI). First, we identified the prevalence of changes in signal intensity in the iliopsoas. Then we classified the changes in signal intensity in the iliopsoas, as visualized on short tau inversion recovery MRI, into 2 types: the muscle-strain type (characterized by a massive high-signal area in the muscle belly, with a clear border) and the peritendinitis type (characterized by a long and thin high-signal area extending proximally along the iliopsoas tendon from the lesser trochanter, without a clear border). Finally, we compared the time to return to play for the athletes who had these signal intensity changes.

Results: Changes in signal intensity in the iliopsoas were detected in 134 (21.0%) of the 638 athletes. According to our MRI classification, 66 athletes had peritendinitis changes and 68 had muscle-strain changes. The time from the onset of groin pain to return to play was significantly shorter for the patients with muscle-strain changes on MRI than for those with peritendinitis changes (8.6 ± 8.3 versus 20.1 ± 13.9 weeks, respectively; $p < 0.0001$).

Conclusions: Changes in MRI signal intensity in the iliopsoas were observed in 21.0% of 638 athletes who had groin pain. Distinguishing between muscle-strain changes and peritendinitis changes could help to determine the time to return to play.

Pain in the groin is a common problem in athletes[1,2]. There are often coexisting pathologies in an injured athlete, and the athletic groin pain has been reported to be derived from multiple causes rather than a single etiology[3,4]. Iliopsoas disorder is recognized as one of the most important entities causing groin pain in athletes[5].

As there has been some confusion in the terminology regarding groin pain in athletes, a meeting of international investigators was held to resolve it[5]. The investigators suggested categorization based on the results of physical examination[5]. For example, groin pain on resisted flexion of the hip and/or on stretching of the hip flexors was categorized as iliopsoas-related[4,5]. Iliopsoas-related pain has been reported to account for 12% to 36% of all cases of groin pain in athletes[3,4,6] on the basis of physical examination alone. Little information is available regarding the prevalence of iliopsoas disorder as identified with magnetic resonance imaging (MRI). In addition, it remains unclear whether iliopsoas lesions seen on MRI would impact the clinical outcome and whether there is a clinically useful classification for these lesions.

We reviewed the cases of consecutive athletes in whom groin pain was evaluated with MRI. The purposes of the present study were (1) to investigate the prevalence of MRI signal intensity changes in the iliopsoas in athletes who had groin pain and (2) to determine the clinical usefulness of classification of iliopsoas signal-intensity changes into 2 types (the muscle-strain type and the peritendinitis type).

Materials and Methods

The study was performed at a single orthopaedic clinic (JIN Orthopaedic and Sports Clinic) specializing in sports medicine, especially groin pain in athletes, located in the urban area of Saitama City, Japan. The study protocol and publication were approved by the ethics committee.

Disclosure: There was no source of external funding for this study. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A33).

Inclusion and Exclusion Criteria

Athletes with groin pain who were seen between June 2013 and February 2016 were included in the study. During the study period, patients in whom groin pain was diagnosed on the basis of history and physical examination were routinely evaluated with use of MRI. Patients who had non-sports-related pain in the groin were excluded.

Clinical and Imaging Evaluation of Athletes with Groin Pain

History-taking and standardized physical examination around the groin were performed by an experienced sports-medicine physician (S.N.). After these evaluations, all patients who had groin pain were also evaluated with MRI. The same sports-medicine physician was present during the MRI sessions and provided instruction to the radiation technologist, including field of view, slice thickness, and scan planes for oblique sequences.

We obtained axial and coronal T1-weighted sequences and axial, coronal, and oblique sagittal short tau inversion recovery (STIR) sequences for athletes who had iliopsoas-related groin pain. The oblique sagittal view was the slice parallel to the iliopsoas (Fig. 1). For patients in whom we detected a lesion other than the iliopsoas disorder, suitable sequences were added. For example, the STIR sequence parallel to the external obturator muscle was added for patients who had a change in the signal intensity of the external obturator muscle. The STIR sequence, one of the fluid-sensitive techniques, has been reported to be excellent for detecting changes in signal intensity around the groin[7,8]. STIR has been recommended for the initial MRI assessment of patients who have groin pain of undetermined origin[7].

The MRI scanner used in this study operates at 1.5 T (Echelon-1.5T RX; Hitachi Medical).

Outcome Measures

We performed a retrospective review of MRI scans to investigate whether there were changes in signal intensity in the iliopsoas and then identified the prevalence of such changes among athletes with groin pain. We reviewed medical records to assess demographic data, including age, sex, height, weight, body mass index, sports activity, and the duration of groin pain at the time of MRI study. We also evaluated whether the patient had a clear history of trauma (defined as sudden onset of groin pain during a particular activity) and speculated on possible causes of iliopsoas lesions other than trauma. As a clinical outcome, we assessed the time from the onset of groin pain to the return to sports activity.

MRI Evaluation of Signal Intensity Change in the Iliopsoas

All lesions detectable on MRI were recorded for each patient because previous reports have indicated that >1 lesion may be detected on the MRI scans of athletes who have groin pain[6,9].

Based on the results of STIR MRI, changes in signal intensity in the iliopsoas were classified as either the muscle-strain type or the peritendinitis type (Fig. 2). The muscle-strain type was indicated by a massive high-signal area in the iliopsoas muscle belly, with a clear border (Fig. 2-A). The peritendinitis

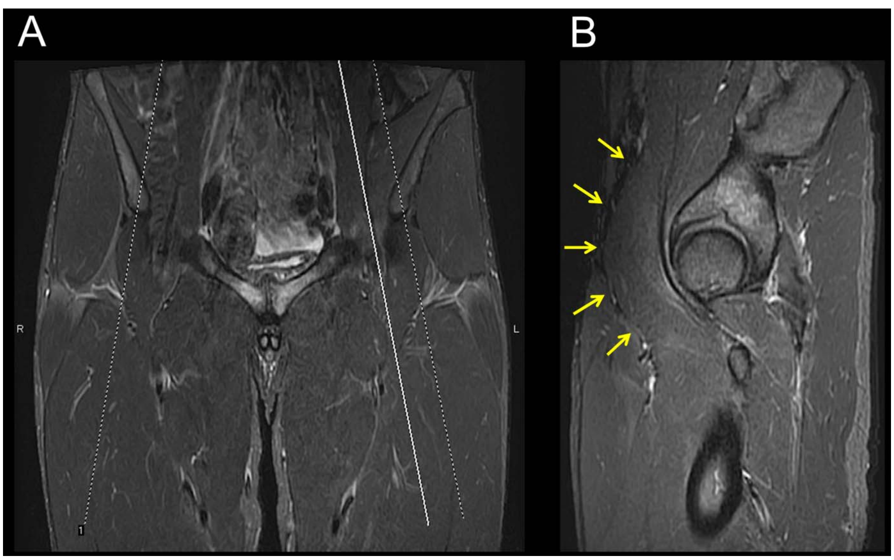

Fig. 1

Figs. 1-A and 1-B A 20-year-old man was diagnosed with iliopsoas-related groin pain on the basis of physical examination. We obtained axial and coronal T1-weighted sequences and axial, coronal, and oblique sagittal STIR sequences. To assess the iliopsoas, the oblique sagittal plane was imaged parallel to the iliopsoas. **Fig. 1-A** Coronal view. The solid white line indicates a slice cut for the oblique sagittal view, and the 2 white dotted lines indicate the edge of the field of view for oblique sagittal slices. Note that this athlete had degenerative changes at the symphysis pubis with edema in addition to the iliopsoas disorder. **Fig. 1-B** Oblique sagittal view. The arrows indicate the anterior margin of the iliopsoas. The high-signal area around the iliopsoas tendon is indicative of peritendinitis.

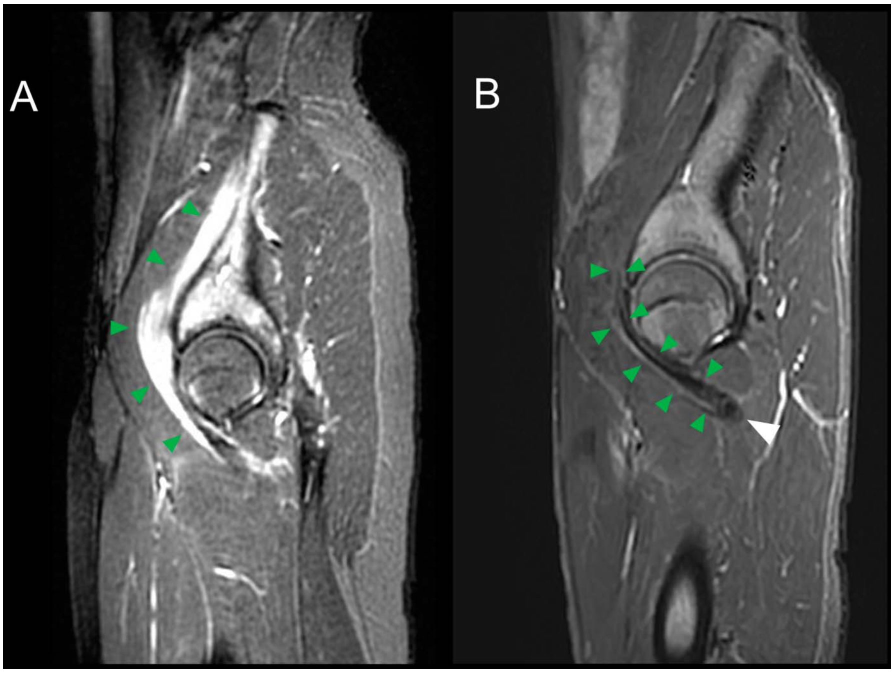

Fig. 2

Figs. 2-A and 2-B Classification of changes in signal intensity in the iliopsoas on STIR oblique sagittal MRI scans. **Fig 2-A** The muscle-strain type is characterized by a massive high-signal area in the belly of the iliopsoas muscle with a distinct border (green arrowheads). **Fig. 2-B** The peritendinitis type is characterized by a long and thin high-signal area (green arrowheads) extending proximally along the iliopsoas tendon from the lesser trochanter (white arrowhead). The contrast is lower than that seen with muscle-strain changes.

type was indicated by a long, thin, high-signal area extending proximally along the iliopsoas tendon from the lesser trochanter, without a clear border (Fig. 2-B). To monitor the course of the signal changes on MRI, follow-up scans were obtained at an interval of at least 4 weeks.

Statistical Analysis

One fellow in sports medicine (M.S.), without access to patient data, independently reviewed the STIR MRI scans showing high signal intensity in the iliopsoas and classified the changes as muscle-strain type or peritendinitis type. The agreement

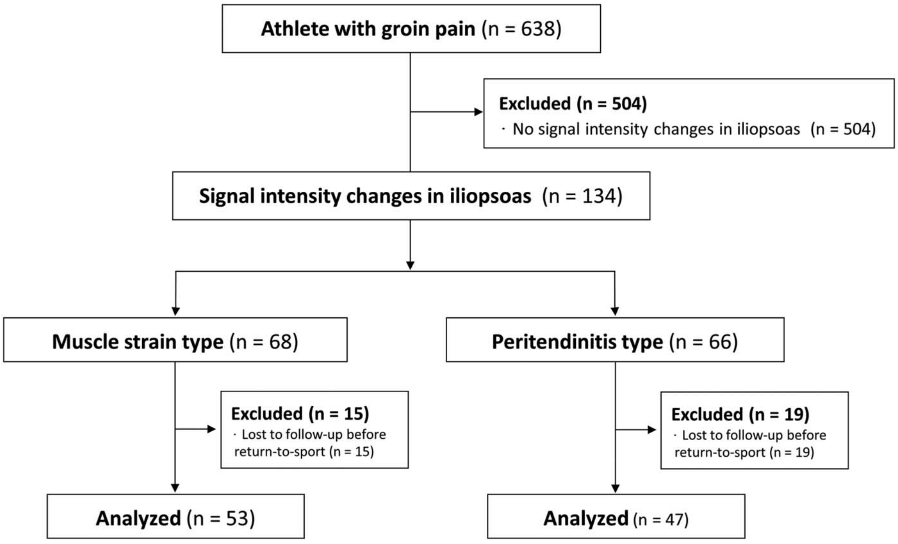

Fig. 3

Patient flow diagram. The time from onset of groin pain to return to play was compared between patients who had the muscle-strain type of changes in MRI signal intensity and those who had peritendinitis changes.

TABLE I Imaging Diagnoses for Patients with No Changes in MRI Signal Intensity in the Iliopsoas

Diagnosis	No. of Patients
1. Pubic BME on superior ramus	
1A. Pubic BME on superior ramus alone	104
1B. Pubic BME on superior ramus combined with fracture	7
Avulsion fracture of ASIS	1
Avulsion fracture of ischial tuberosity	1
Fatigue fracture of inferior pubic ramus	3
Fatigue fracture of inferior pubic ramus, and obturator and rectus femoris injury	1
Fatigue fracture of femur	1
1C. Pubic BME on superior ramus combined with muscle injury	15
Adductor injury	9
Obturator muscle injury	3
Adductor and rectus femoris injury	1
Adductor, obturator muscle, and pectineal muscle injury	1
Avulsion of semimembranosus footprint and conjoined tendon footprint	1
1D. Pubic BME on superior ramus combined with other lesions	1
Trochanteric bursitis	1
2. Fracture	
2A. Fracture alone	92
Avulsion fracture of anterior inferior iliac spine	21
Avulsion fracture of ASIS	11
Avulsion fracture of ischial tuberosity	9
Fatigue fracture of inferior pubic ramus	21
Fatigue fracture of ischium	4
Fatigue fracture of ilium	1
Fatigue fracture of acetabulum	1
Bone bruise of the acetabulum	1
Fatigue fracture of sacrum	1
Fatigue fracture of both sacrum and ilium at sacroiliac joint	2
Articular cartilage injury of femoral head	1
Fatigue fracture of femoral shaft	12
Fatigue fracture of femoral shaft, avulsion fracture of ASIS, and rectus femoris injury	1
Fatigue fracture of femoral neck	2
Fatigue fracture of greater trochanter	1
Avulsion fracture of anterior inferior iliac spine combined with fatigue fracture of femoral shaft	1
Avulsion fracture of anterior inferior iliac spine combined with avulsion fracture of ischial tuberosity	1
Avulsion fracture of ASIS combined with fatigue fracture of inferior pubic ramus	1
2B. Fracture combined with muscle injury	3
Fatigue fracture of inferior pubic ramus combined with obturator muscle injury	1
Fatigue fracture of inferior pubic ramus combined with rectus femoris injury	1
Fatigue fracture of ischium combined with incomplete avulsion of proximal hamstring tendon footprint	1
2C. Fracture combined with other lesions	3
Fatigue fracture of inferior pubic ramus combined with coxitis simplex	2
Fatigue fracture of femoral shaft combined with varicocele testis	1
3. Muscle injury	
3A. Muscle injury alone	102
Abdominal oblique injury	2
Rectus abdominis injury	8
Adductor injury	40

continued

TABLE I (*continued*)

Diagnosis	No. of Patients
Rupture of proximal adductor longus tendon	2
Gluteus maximus injury	1
Gluteus medius injury	5
Pectineus injury	2
Gemellus injury	1
Obturator injury	25
Rectus femoris injury	2
Vastus lateralis injury	1
Vastus intermedius injury	1
Hamstrings injury	2
Sartorius injury	1
Rectus femoris injury combined with adductor injury	1
Rectus femoris injury combined with gluteus maximus injury	1
Rupture of proximal adductor longus tendon combined with pectineus and external oblique injury	1
Adductor injury combined with vastus lateralis injury	1
Adductor injury combined with vastus lateralis and vastus intermedius injury	1
Adductor injury combined with vastus lateralis, vastus intermedius, and rectus femoris injury	1
Obturator injury combined with rectus femoris injury	1
Obturator injury combined with adductor injury	2
3B. Muscle injury combined with other lesions	4
Rectus femoris injury combined with coxitis simplex	1
Gluteus medius injury combined with labral tear and femoroacetabular impingement*	1
Gluteus medius injury combined with labral tear and femoroacetabular impingement* and vastus intermedius injury	1
Gluteus minimus injury combined with labral tear and femoroacetabular impingement*	1
4. Other	
Labral tear and femoroacetabular impingement* alone	47
Osteoarthritis of hip	7
Bone bruise of femoral head	1
Articular cartilage injury of femoral head combined with labral tear and femoroacetabular impingement*	1
Coxitis simplex alone	12
Coxitis of hip	3
No detectable lesions	102

*Labral tear and femoroacetabular impingement were diagnosed on the basis of history and physical examination, radiographs, and sometimes computed tomography, as well as MRI.

between that fellow and the experienced sports-medicine physician (S.N.) was assessed with use of the weighted Cohen kappa coefficient. The data are presented as estimates and accompanying 95% confidence intervals (CIs). The level of agreement was classified as poor (kappa = 0), slight (>0 to 0.20), fair (0.21 to 0.40), moderate (0.41 to 0.60), substantial (0.61 to 0.80), or almost perfect (0.81 to 1.0)[10].

The difference in time to return to play for athletes who had each of the 2 types of MRI changes was compared with use of the Student t test as well as the Mann-Whitney U test. Other comparisons were performed with use of the chi-square test for categorical variables and the Student t test for continuous variables. All tests were 2-sided, and $p < 0.05$ was considered significant.

All statistical analyses were performed by an investigator (S.T.) using R (R Foundation for Statistical Computing).

Results

Patients and Prevalence of Signal Intensity Change in the Iliopsoas

A total of 638 athletes who had groin pain were included in this study. The study group included 118 women and 520 men with a mean age (and standard deviation) of 20.6 ± 9.9 years. The most common activities were soccer (395 patients, 61.9%), track and field (38 patients, 6.0%), baseball (38 patients, 6.0%), tennis (19 patients, 3.0%), badminton (11 patients, 1.7%), volleyball (11 patients, 1.7%), and basketball (11 patients, 1.7%).

TABLE II Demographic and Baseline Clinical Characteristics*

	Iliopsoas Peritendinitis (N = 66)	Iliopsoas Muscle Strain (N = 68)	P Value
Age *(yr)*	18.7 ± 5.0	16.3 ± 3.0	0.0014†
Female:male ratio *(no. of patients)*	12:54	16:52	0.53‡
Height *(cm)*	169.0 ± 8.8	167.1 ± 9.4	0.23†
Weight *(kg)*	61.1 ± 10.8	57.8 ± 10.5	0.073†
Body mass index *(kg/m²)*	21.3 ± 2.4	20.5 ± 2.6	0.091†
Time from onset of groin pain to MRI *(wk)*	10.4 ± 19.5	2.2 ± 6.7	0.0015†
Type of sport *(no. of patients)*			0.68‡
Soccer	45	43	
Track and field	6	5	
Badminton	3	0	
Volleyball	2	3	
Basketball	2	2	
Tennis	2	2	
Baseball	1	7	
Other	5	6	

*The results are expressed as the mean and standard deviation unless otherwise indicated. †Determined with the Student t test. ‡Determined with the chi-square test.

Changes in signal intensity in the iliopsoas were seen in 134 (21.0%) of the 638 athletes who had groin pain. One hundred (74.6%) of these 134 athletes were followed until their return to sports activity (Fig. 3). Table I shows the diagnosis based on physical examination and MRI for the remaining 504 athletes who did not have a change in signal intensity in the iliopsoas.

MRI Classification of Signal Intensity Change in the Iliopsoas

On the basis of the MRI scans, 66 athletes were classified as having peritendinitis changes in signal intensity and 68 were classified as having muscle-strain changes. The demographic data for these patients are shown in Table II. The agreement between 2 observers was almost perfect (kappa = 0.96; 95% CI, 0.91 to 1.00). No clear history of trauma was noted for 45 (68.2%) of the 66 patients who had peritendinitis changes and 53 (77.9%) of the 68 patients who had muscle-strain changes. This difference was not significant (p = 0.28). Excluding trauma, the predominant suspected cause of the iliopsoas disorder was inappropriate training, including excessive abdominal-muscle exercise (42 patients), excessive

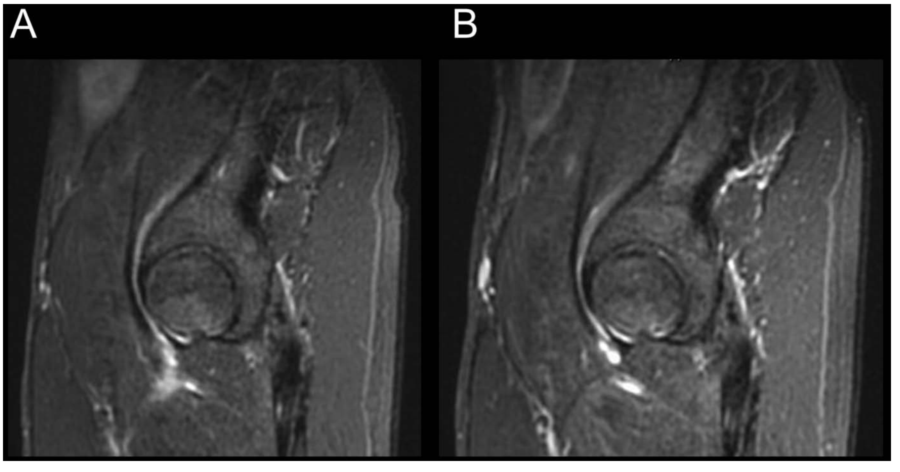

Fig. 4

Figs. 4-A and 4-B Follow-up STIR oblique sagittal MRI scans showing the peritendinitis type of changes in an 18-year-old male soccer player. **Fig. 4-A** Scan obtained 4 days after the onset of groin pain. A long, thin high-signal area was observed along the iliopsoas tendon. **Fig. 4-B** Scan obtained 4 weeks after the onset of groin pain. The high-signal area remained.

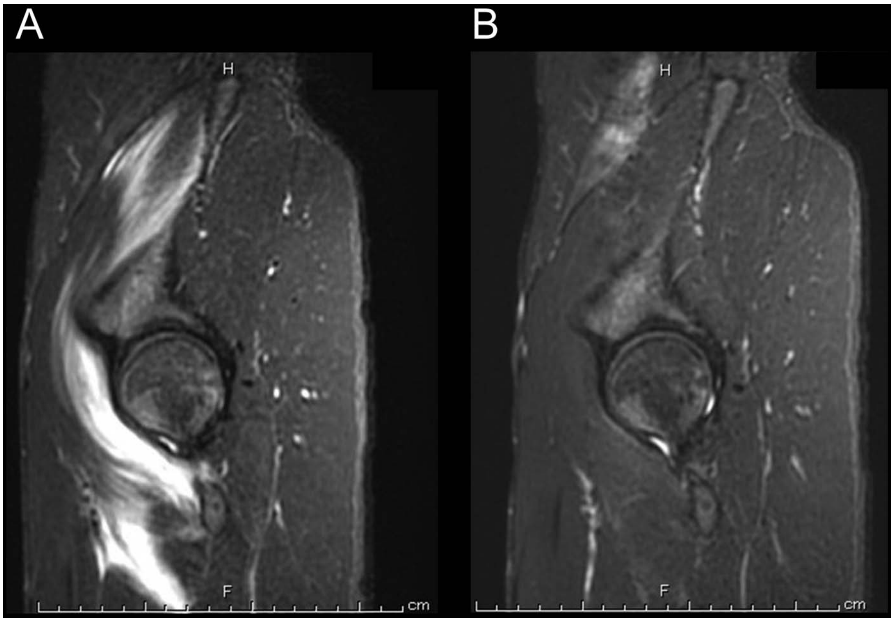

Fig. 5

Figs. 5-A and 5-B Follow-up STIR oblique sagittal MRI scans showing the muscle-strain type of changes in a 22-year-old male soccer player. **Fig. 5-A** Scan obtained 2 days after the onset of groin pain, showing a massive high-signal area in the iliopsoas muscle belly. **Fig. 5-B** Scan obtained 6 weeks after the onset of groin pain. The size of the high-signal area had decreased.

stair-running exercise (33 patients), and training for long kicking (21 patients).

The time from the onset of groin pain to return to play was significantly shorter for patients with muscle-strain changes than for those with peritendinitis changes (8.6 ± 8.3 compared with 20.1 ± 13.9 weeks; $p < 0.0001$, Student t test). The significance of the difference was also confirmed with nonparametric statistics (median, 7.1 compared with 17.4 weeks; $p < 0.0001$, Mann-Whitney U test).

We performed follow-up MRI scans to monitor the changes in signal intensity for 6 (9.1%) of the 66 athletes who had peritendinitis changes and 11 (16.2%) of the 68 athletes who had muscle-strain changes. Although the changes in signal intensity improved in 3 of 6 athletes who had peritendinitis changes, there were no improvements in the signal intensity changes in the other 3 athletes (Fig. 4). In contrast, the changes in signal intensity improved in all 11 athletes who had muscle-strain changes (Fig. 5).

Changes in signal intensity in areas other than the iliopsoas were detected in 35 (53.0%) of the 66 athletes who had peritendinitis changes and 19 (27.9%) of the 68 athletes who had muscle-strain changes. Multiple lesions were seen more frequently in patients who had peritendinitis changes than in those who had muscle-strain changes ($p = 0.0054$). In patients who had peritendinitis changes, the changes in intensity in areas other than the iliopsoas revealed injuries including pubic bone marrow edema (BME) of the superior ramus (24 patients), adductor muscle injury (3 patients), obturator muscle injury (1 patient), avulsion fracture of the anterior inferior iliac spine (1 patient), avulsion fracture of the anterior superior iliac spine (ASIS) (1 patient), avulsion fracture of the ASIS combined with pubic BME of the superior ramus (1 patient), avulsion fracture of the ASIS combined with iliopsoas muscle strain of the contralateral (not painful) side (1 patient), avulsion fracture of the inferior superior iliac spine (1 patient), fatigue fracture of the femur (1 patient), and inguinal hernia (1 patient). In patients who had the muscle-strain type of signal changes, the changes in intensity other than the iliopsoas included pubic BME of the superior ramus (6 patients), adductor muscle injury (4 patients), abdominal oblique muscle injury (1 patient), vastus lateralis injury (1 patient), adductor muscle injury combined with rectus femoris and semitendinosus injury (1 patient), and iliopsoas peritendinitis of the contralateral (not painful) side (6 patients).

Discussion

We found changes in signal intensity in the iliopsoas in 21.0% of 638 consecutive athletes with groin pain who were evaluated with MRI. The time to return to play was significantly shorter for patients who had muscle-strain changes on MRI than for those who had peritendinitis changes. No clear history of trauma was identified in 68.2% of the patients who had peritendinitis changes and 77.9% of those who had muscle-strain changes.

The prevalence of iliopsoas-related groin pain based on physical examination has been reported to be 12% to 36% among athletes who have pain in the groin[3,4,6]. However, in studies on the detectability of iliopsoas lesions on MRI scans, very low rates of abnormal iliopsoas-related findings have been reported for athletes with groin pain[11]. The 21.0% prevalence of changes in signal intensity in the iliopsoas on MRI that was observed in our study was similar to the prevalence based on physical examination. Obtaining the oblique sagittal view parallel to the iliopsoas in addition to the standard axial and coronal views may help to detect signal intensity changes in the iliopsoas.

The time to return to play was significantly shorter for the athletes who had muscle-strain changes in signal intensity than for those who had peritendinitis changes. Although muscle-strain changes in signal intensity in the iliopsoas have been reported by many investigators[11,12], we are aware of only 1 report that has described peritendinitis changes in the iliopsoas[13]. Coexisting issues other than muscle strain and peritendinitis may affect the time to return to play because groin pain in athletes has multiple causes rather than a single etiology[3,4]. In the present study, the frequency of coexisting issues was significantly higher in association with peritendinitis-type changes. The high frequency of coexisting issues may be associated with a longer time to return to play. Recognizing the difference between iliopsoas peritendinitis and iliopsoas muscle strain is important for both medical staff and athletes.

As only approximately a quarter of athletes in our study had a clear history of trauma, a diagnosis of iliopsoas injury could not be excluded by history-taking alone. While history and physical examination are important for determining the causes of groin pain in athletes, MRI could play an important role in the diagnostic work-up[14]. Our study supports the usefulness of MRI for diagnosis in athletes who have groin pain.

This study had some limitations, the most important of which was its nonrandomized case-series design. However, the sample size was relatively large compared with previous MRI studies of groin pain in athletes, which allowed statistical analysis of the difference in time to return to play between the athletes who had muscle-strain changes in signal intensity and those who had peritendinitis changes.

It should be noted that MRI was performed under the instruction of the sports-medicine physician who had performed the history-taking and physical examination, which may have resulted in bias in image acquisition.

There is concern regarding whether iliopsoas peritendinitis can be separated completely from iliopsoas muscle strain. Iliopsoas peritendinitis may be a consequence of muscle strain or may overlap with it. However, we believe that it is an independent lesion because, if iliopsoas peritendinitis were the final stage of muscle strain, the time to return to sports would be longer for patients who had muscle-strain signal changes than for those who had peritendinitis signal changes. Nevertheless, it should be noted that the number of patients undergoing follow-up MRI in the present investigation was small and therefore the study was underpowered to conclude that the 2 MRI classifications did not overlap.

We did not include reported outcomes such as the Hip And Groin Outcome Score (HAGOS); we focused only on the time to return to play as a clinical outcome. However, time to return to play is one of the primary concerns for both medical staff and athletes.

In conclusion, changes in MRI signal intensity in the iliopsoas were observed in 21.0% of athletes who had groin pain. We advocate classification of changes in MRI signal intensity in the iliopsoas to distinguish between the muscle-strain type and the peritendinitis type of iliopsoas injury. The time to return to play was significantly shorter for athletes who had muscle-strain changes in MRI signal intensity. ■

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References

1. Slavotinek JP, Verrall GM, Fon GT, Sage MR. Groin pain in footballers: the association between preseason clinical and pubic bone magnetic resonance imaging findings and athlete outcome. Am J Sports Med. 2005 Jun;33(6):894-9. Epub 2005 Apr 12.

2. Schilders E, Talbot JC, Robinson P, Dimitrakopoulou A, Gibbon WW, Bismil Q. Adductor-related groin pain in recreational athletes: role of the adductor enthesis, magnetic resonance imaging, and entheseal pubic cleft injections. J Bone Joint Surg Am. 2009 Oct;91(10):2455-60.

3. Hölmich P. Long-standing groin pain in sportspeople falls into three primary patterns, a "clinical entity" approach: a prospective study of 207 patients. Br J Sports Med. 2007 Apr;41(4):247-52; discussion 252. Epub 2007 Jan 29.

4. Rankin AT, Bleakley CM, Cullen M. Hip joint pathology as a leading cause of groin pain in the sporting population: a 6-year review of 894 cases. Am J Sports Med. 2015 Jul;43(7):1698-703. Epub 2015 May 11.

5. Weir A, Brukner P, Delahunt E, Ekstrand J, Griffin D, Khan KM, Lovell G, Meyers WC, Muschaweck U, Orchard J, Paajanen H, Philippon M, Reboul G, Robinson P, Schache AG, Schilders E, Serner A, Silvers H, Thorborg K, Tyler T, Verrall G, de Vos RJ, Vuckovic Z, Hölmich P. Doha agreement meeting on terminology and definitions in groin pain in athletes. Br J Sports Med. 2015 Jun;49(12):768-74.

6. Serner A, Tol JL, Jomaah N, Weir A, Whiteley R, Thorborg K, Robinson M, Hölmich P. Diagnosis of acute groin injuries: a prospective study of 110 athletes. Am J Sports Med. 2015 Aug;43(8):1857-64. Epub 2015 May 14.

7. Khoury NJ, Birjawi GA, Chaaya M, Hourani MH. Use of limited MR protocol (coronal STIR) in the evaluation of patients with hip pain. Skeletal Radiol. 2003 Oct;32(10):567-74. Epub 2003 Aug 27.

8. Guermazi A, Roemer FW, Robinson P, Tol JL, Regatte RR, Crema MD. Imaging of muscle injuries in sports medicine: sports imaging series. Radiology. 2017 Mar;282(3):646-63.

9. Serner A, Weir A, Tol JL, Thorborg K, Roemer F, Guermazi A, Hölmich P. Can standardised clinical examination of athletes with acute groin injuries predict the presence and location of MRI findings? Br J Sports Med. 2016 Dec;50(24):1541-7. Epub 2016 Aug 16.

10. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977 Mar;33(1):159-74.

11. Bui KL, Ilaslan H, Recht M, Sundaram M. Iliopsoas injury: an MRI study of patterns and prevalence correlated with clinical findings. Skeletal Radiol. 2008 Mar;37(3):245-9. Epub 2007 Nov 20.

12. Shabshin N, Rosenberg ZS, Cavalcanti CF. MR imaging of iliopsoas musculotendinous injuries. Magn Reson Imaging Clin N Am. 2005 Nov;13(4):705-16.

13. Serner A, Roemer FW, Hölmich P, Thorborg K, Niu J, Weir A, Tol JL, Guermazi A. Reliability of MRI assessment of acute musculotendinous groin injuries in athletes. Eur Radiol. 2017 Apr;27(4):1486-95. Epub 2016 Jul 6.

14. Falvey ÉC, King E, Kinsella S, Franklyn-Miller A. Athletic groin pain (part 1): a prospective anatomical diagnosis of 382 patients—clinical findings, MRI findings and patient-reported outcome measures at baseline. Br J Sports Med. 2016 Apr;50(7):423-30. Epub 2015 Nov 30.