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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2022;11(3):1166-71

The evaluation of hip joint pathologies in pediatric age group with MRI

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Received 16 January 2022; Accepted 13 June 2022
Available online 25.07.2022 with doi: 10.5455/medscience.2022.01.07

Abstract

Diagnosis of hip pathologies in the pediatric age group has difficulties. This study aimed to evaluate the hip diseases and prevalences detected by magnetic resonance imaging (MRI) in patients presenting with a preliminary diagnosis of hip pain. The MRI scans of pediatric patients who underwent hip MRI were re-evaluated retrospectively. Clinical and laboratory findings, pathology reports, operation and follow-up notes from the hospital information system, and MRI findings were re-evaluated as a whole and noted. It was examined whether there was a correlation between the prevalence of pathologies and the demographic data, such as age and gender. A total of 101 pediatric patients with hip pain were included in the study. The mean age was 12.29±3.35. Of these patients, 36 (35.6%) were female, and 65 (64.4%) were male. There was right hip involvement in 29 (28.7%), left hip in 47 (46.5%), and bilateral hip involvement in 25 (24.8%) patients. Legg-Calvé Perthes (LCP) disease was the most common final diagnosis seen significantly more frequently in males (p=0.016). Ischiofemoral impingement was significantly more common in girls (p=0.004). Avulsion fractures were significantly more commonly detected by patients over 10 years of age (p=0.019). Similarly, ischiofemoral impingement was more common in patients over 10 years of age (p=0.040). On the contrary, LCP disease was significantly more common in patients under 10 years of age (p<0.001). We observed that hip pathologies in children show significant differences between different age groups and genders. Because wrong and delayed diagnosis can cause irreversible joint destruction and early development of osteoarthritis, a fast and accurate diagnosis of hip pathologies in children is critical. Therefore, MRI plays a crucial role in the differential diagnosis of hip diseases, determining the correct treatment methods, and postoperative follow-up.

Keywords: Pediatric hip, pediatric hip pain, Legg-Calvé Perthes disease, femoral head epiphyseal slippage, ischiofemoral impingement, avulsion fracture, magnetic resonance imaging

Introduction

Hip pain in children is often accompanied by a protective limp and reduced mobility and is sometimes concomitant with groin pain, thigh pain, and gait disturbances [1]. Clinical evaluation is complex, and radiological imaging methods usually play an essential role in the diagnosis. Although radiography is the primary imaging method, ultrasonography (USG) and MRI are frequently used in imaging the hip joint and related structures [2]. Due to its high soft-tissue resolution, MRI provides detailed information about cartilage, synovium, bone marrow, and soft tissues around the hip [3].

Pediatric hip diseases vary according to the age of the patients. While transient synovitis, septic arthritis, or LCP disease are common in young children, slipped femoral epiphysis and apophyseal avulsion fractures are more common in older children [4]. Therefore, the patient's age should be considered to reach a provisional diagnosis.

In this study, we aimed to evaluate the frequencies of traumatic and non-traumatic diseases in pediatric patients who underwent hip MRI for hip pain. We also aimed to review the distribution of these pathologies according to gender and age groups.

Materials and Methods

Patient population

This retrospective study was approved by the hospital's institutional ethics board (Approval Date:03.05.2021, No:110/05), and informed consent was not required. Pediatric patients who underwent standard hip MRI examination were evaluated retrospectively from the picture archiving and communication system (PACS). Between January 2016 and December 2020, 158 patients with a preliminary diagnosis of hip pain were evaluated. No abnormality was detected in MRI examination in 49 patients. Due to technical reasons and motion artifacts of the MRI examinations, 9 cases

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were not included in the study. A total of 101 pediatric patients were included in the study.

MRI protocol

All patients underwent MRI examination in the supine position with an 18-channel body coil using a 1.5 Tesla (MAGNETOM Aera; Siemens, Erlangen, Germany) MRI system.

Standard MRI protocol included; transverse T1-turbo spin-echo (TSE) weighted image (WI) (TR=434 ms, TE=10 ms, slice thickness=3.0 mm, NEX=2, FOV=250 mm, flip angle=180°), transverse fat-suppressed TSE T2 WI (TR=4650 ms, TE=60 ms, slice thickness=3.0 mm, NEX=1, FOV=250 mm, flip angle=150°), coronal TSE T1 WI (TR=561 ms, TE=12 ms, slice thickness=3.0 mm, NEX=2, FOV=280 mm, flip angle=180°), fat-suppressed coronal TSE T2 WI (TR=4650 ms, TE=60 ms, slice thickness=3.0 mm, NEX=1, FOV=280 mm, flip angle=150°). All sequences were performed involving both two hips.

In addition, two planes (transverse and fat-suppressed coronal) T1 WIs were performed in patients using contrast media after a 0.1 mmol/kg dose of gadolinium-based contrast material was administered. Intravenous Gadolinium-based contrast material was used in 7 patients (6.9%).

Evaluation of MRI examinations

All MRI images were re-evaluated by a radiologist with 20 years of experience in musculoskeletal radiology. Hip joint space, joint effusion, synovitis, bone marrow edema, soft-tissue edema, cartilage structures, subchondral bone structure, epiphyseal structure, acetabular labrum, foreign bodies, joint dysplasia, trochanteric bursitis, tendinitis, femoroacetebular impingement, ischiofemoral impingement, snapping hip disease, fracture, avascular necrosis, coxa magna, femoral neck morphology, mass, presence of sacroiliitis, osteitis and enthesitis were investigated in MRI examination. It was evaluated whether the lesions were unilateral or bilateral. The presence and pattern of contrast enhancement were recorded in patients given contrast material. The relationship of pathologies detected by MRI examination with age and gender was investigated.

In addition, radiography and USG findings of the patients were evaluated. Basic demographic data (age and gender), the clinical and laboratory findings of the patients, pathology results, follow-up, and operation findings through the hospital information system were searched. The patients were divided into two groups over and under 10 years of age, and evaluation and comparison were made.

Statistical analysis

Statistical analysis was performed using SPSS 21 (IBM, Chicago, IL, USA) software. Categorical variables were given as numbers and percentages, and continuous variables were represented as mean ± standard deviation (SD). The Chi-square test was used to compare categorical variables between groups. A p-value of <0.05 was considered statistically significant in all analyses.

Results

The mean age of 101 patients was 12.29 ± 3.35. Of these patients, 36 (35.6%) were female, and 65 (64.4%) were male. There was right hip involvement in 29 (28.7%), left hip in 47 (46.5%), and bilateral hip involvement in 25 (24.8%) patients.

Bone marrow edema was seen in 67 patients (66.3%). Soft-tissue edema in 43 (42.5%) patients, joint effusion in 42 (41.6%), fracture line in 28 (27.7%), sclerosis of the epiphysis in 16 (15.8%), flattening of the epiphysis in 12 (12.9%), coxa magna in 5 (5%), synovitis in 5 (5%), shortening and thickening of the femoral neck in 4 (4%), subchondral cysts in 3 (3%) patients were noted, respectively.

Stress fracture was seen in 11 of the patients. The stress fracture was in the inferior pubic ramus in 3 (3%) of these patients, in the sacral area in 4 (4%) and, the femoral neck in 4 (4%) patients (Figure 1a, b, c). Avulsion fractures had detected in 11 patients. 6 (5.9%) of these patients had in the tuber ischiadicum, and 5 (5%) of them in the anterior inferior iliac spine (Figure 2a, b). Femoral neck fracture was observed in 2 patients. In one of these, the fracture was at the intertrochanteric level and avascular necrosis developed at the femoral head (Figure 3a, b).

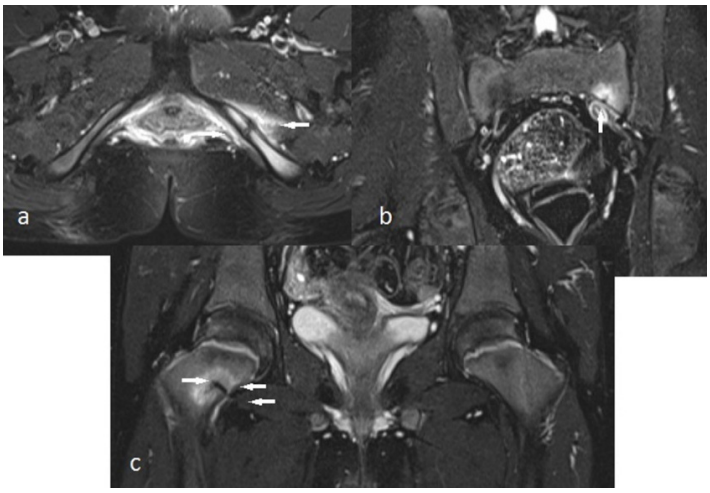

Figure 1. In different patients, a hypointense line compatible with insufficiency fractures and accompanying hyperintense bone marrow edema are seen in a) left inferior pubic ramus, b) left sacral region, and c) right femoral neck in fat-suppressed T2 WIs

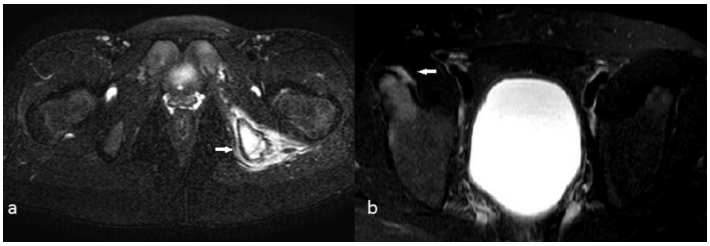

Figure 2. In different patients, linear hypointense avulsion fractures and accompanying hyperintense bone marrow edema are seen in a) left tuber ischiadicum and b) right anterior inferior iliac spine in fat-suppressed T2 WIs

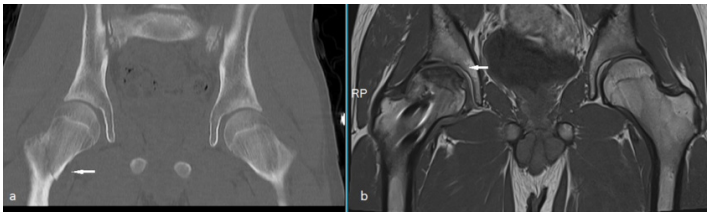

Figure 3. a) On the coronal CT image, the intertrochanteric fracture is seen on the right b) No fracture line is observed in the coronal T1 WI one year later. Irregularity, volume loss, sclerosis, and edema are seen in proximal femoral epiphysis compatible with avascular necrosis

Muscle strain was seen in one patients in the rectus femoris. Leukemic infiltration was found in 2 patients. One of them was chronic myeloid leukemia (CML), and the other was acute lymphoblastic leukemia (ALL).

Developmental dysplasia of the hip (DDH) was observed in one patient. Coxa vara and coxa valga were seen in 2 patients each (Figure 4a, b). 2 of 7 patients with sacroiliitis had osteitis in the proximal femur, and enthesitis was accompanied in one patient (Figure 5). The overall diagnoses of the patients are summarized in Table 1.

Table 1. Distribution of diagnoses and bilaterality rates in patients who underwent hip MRI

Diagnosis	n	%	Bilaterality (n)	%
Transient synovitis	9	8.9	2	22.22
Legg-Calvé Perthes	16	15.9	3	18.75
Slipped femoral head epiphysis	11	10.9	1	9.09
Stress fracture	11	10.9	0	0
Avulsion fracture	11	10.9	1	9.09
Ischio femoral impingement	9	8.9	5	55.55
Snapping hip syndrome	2	2	1	50
Muscle strain	1	1	0	0
Femoral neck fracture	2	2	0	0
Morel-Lavallee lesion	1	1	0	0
Sacroiliitis	7	6.9	3	42.85
Developmental hip dysplasia	1	1	1	100
Coxa vara	2	2	1	50
Coxavalga	2	2	2	100
Epiphysealedema	4	4	2	50
Trochanteric bursitis	1	1	1	100
Osteoid osteoma	2	2	0	0
Fibrous displasia	2	2	0	0
Eosinophilic granuloma	1	1	0	0
Fibrous cortical defect	1	1	0	0
Simple bone cyst	2	2	0	0
Chondroblastoma	1	1	0	0
Leukemia	2	2	2	100

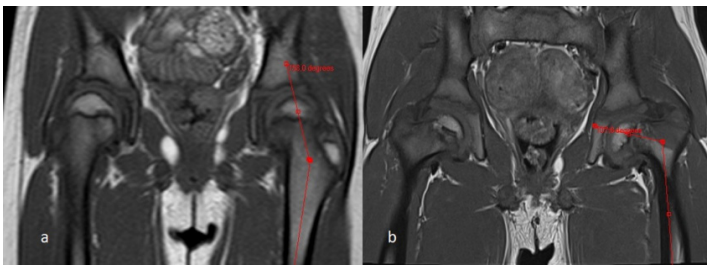

Figure 4. a) Bilateral coxa valga b) bilateral coxa vara appearances in two different patients in coronal T1 WI

LCP disease was seen statistically significantly more frequently in males (p=0.017) (Figure 6a, b). Ischiofemoral impingement was significantly more common in girls (p=0.001) (Figure 7a, b). When the patients were grouped as over and under 10 years of age, avulsion fractures were seen significantly more frequent in the over 10 years of age group (p=0.016). Similarly, ischiofemoral impingement was more common in patients over 10 years of age (p=0.036). LCP disease was significantly more common in the patient group under 10 years of age (p<0.001). Although the incidence of slipped capital femoral epiphysis was higher over the age of 10, it was not statistically significant (p=0.103) (Figure 8) (Table 2).

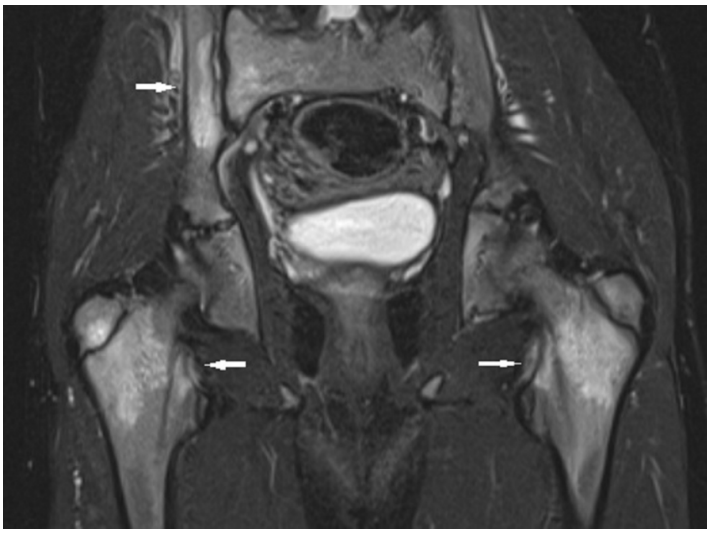

Figure 5. In a 14-year-old male patient with fat-suppressed coronal T2 WI, edema compatible with sacroiliitis on the right (white arrow). Intertrochanteric edema concomitant great trochanteric edema on the right is consistent with osteitis. There is soft tissue edema medially compatible with osteitis (white arrows)

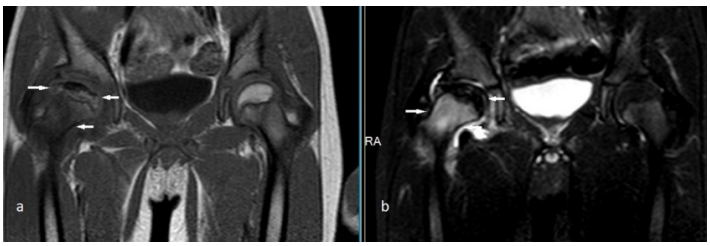

Figure 6. In a 9-year-old male patient, on coronal T1 WI (a) and fat-suppressed T2 WI (b), irregularity in the right femoral proximal epiphysis, volume loss, sclerosis, and marked edema in the femoral neck are consistent with Legg-Calvé Perthes disease

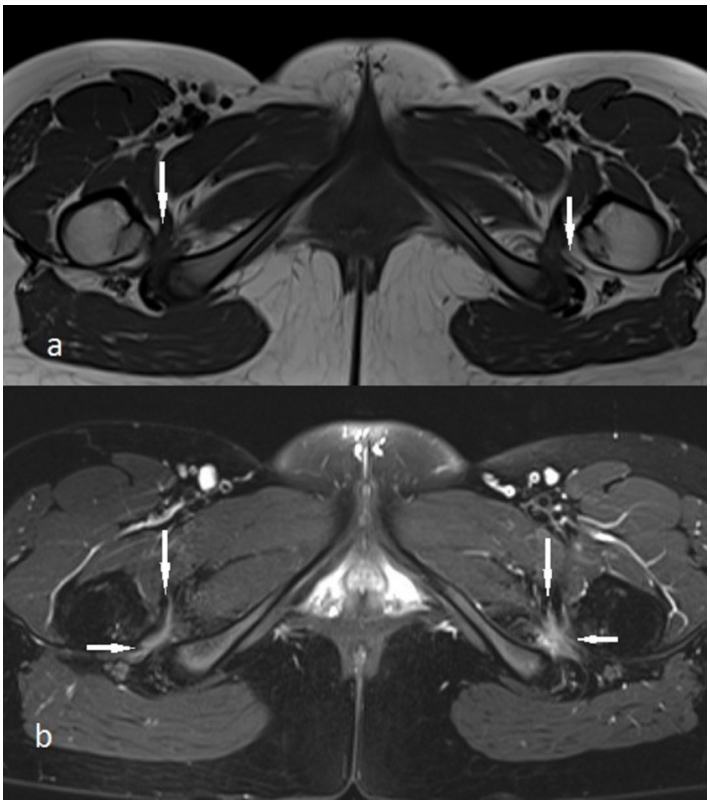

Figure 7. In a 15-year-old girl, bilateral ischiofemoral impingement is seen on axial T1 WI (a) and fat-suppressed T2 WI (b). Edema in bilateral quadratus femoris muscle and fatty atrophy on the left is seen

Table 2. Distribution of diagnoses according to gender and age

	Gender			Age		
Diagnosis	**Girl**	**Boy**	**p value**	**≤10 year**	**> 10 year**	**p value**
Transient synovitis	2	7	0.312	5	4	0.085
Legg-Calvé Perthes	1	15	0.017	13	3	<0.001
Slipped femoral head epiphy-sis	1	10	0.046	1	10	0.103
Stress fracture	6	5	0.146	3	8	0.579
Avulsion fracture	2	9	0.173	0	11	0.016
Ischio femoral impingement	8	1	0.001	0	9	0.036
Snapping hip syndrome	0	2	-	1	1	-
Muscle strain	0	2	-	0	2	-
Femoral neck fracture	1	1	-	0	2	-
Morel-Lavallee lesion	0	1	-	0	1	-
Sacroiliitis	1	6	0.484	3	4	0.327
Developmental hip dysplasia	1	0	-	0	1	-
Coxa vara	0	2	-	1	1	-
Coxa valga	1	1	-	1	1	-
Epiphyseal edema	4	0	-	1	3	-
Trochanteric bursitis	1	0	-	0	1	-
Osteoid osteoma	2	0	-	2	0	-
Fibrous displasia	1	1	-	0	2	-
Eosinophilic granuloma	0	1	-	1	0	-
Fibrous cortical defect	1	0	-	0	1	-
Simple bone cyst	1	1	-	1	1	-
Chondroblastoma	0	1	-	0	1	-
Leukemia	1	1	-	1	1	-

Figure 8. In a 13-year-old male patient, inferior displacement of the femoral head and the enlargement of the physis line are consistent with the shift of the epiphysis of the left femoral head on coronal T1 WI

Discussion

The hip joint carries all the individual's weight throughout life and must withstand heavy stresses. Morphology must be normal to maintain its function throughout life. Disturbances in the development of the hip joint and different diseases in childhood cause deterioration in joint morphology, leading to the development of osteoarthritis in the early period. MRI has a critical role in diagnosing pre-and post-ossification diseases and evaluating them in the pre-and post-treatment period during hip joint development [5].

In our study, the most common disease was LCP disease. Joint effusion, volume loss in the femoral epiphysis, sclerosis, and fragmentation were observed in the patients. Although LCP disease can be seen in all childhood periods, it usually occurs between the ages of 4 to 7. It is about 4-5 times more common in boys. In 10-15% of LCP patients, the involvement is asynchronous bilateral [6,7]. In our study, 3 (20%) of the LCP cases had bilateral asynchronous hip involvement, and it was significantly more common in boys under 10 years of age, similar to the literature. The primary pathology in LCP disease is idiopathic osteonecrosis of the immature femoral head epiphysis. The disease presents clinically with limitations of movement and pain. While radiographs are normal in the early period, MRI is the gold standard in demonstrating ischemic changes in the epiphysis. In MRI, the epiphysis is seen in the early avascular phase, hypointense in T1 WI, and hyperintense in T2 WI due to edema. In the late avascular stage, the necrotic epiphysis appears hypointense on all sequences, with a crescent sign secondary to a subchondral fracture. Dynamic contrast-enhanced MRI does not show enhancement in the epiphysis of the femoral head in the avascular phase [5,6]. Joint effusion and synovial hypertrophy accompany, and lateral subluxation of the femoral head occurs. Although the femoral head is reshaped in the following period, various degrees of deformation occurs in the femoral head [8].

Other common lesions in our study were slipped capital femoral epiphysis, stress fractures, and avulsion fractures. The slipped capital femoral epiphysis is a Salter-Harris type I fracture of the proximal femoral physis, and the femoral neck is displaced anterosuperiorly. Hence, the epiphysis appears to be displaced posteriorly [9]. It is common in adolescent males. Obesity, trauma, and endocrinopathy are the most critical risk factors. MRI findings are based on morphological changes at the head-neck junction and abnormal signal changes at the physis level. The simultaneous bilateral presentation has been reported in approximately 20-50%

of the patients [5]. In our study, it was more common in the group over 10 years of age. In this study, it was observed bilaterally in only one case.

Stress fractures occur secondary to repetitive microtraumas. Playing new sports or suddenly increasing the intensity of sports activity are risk factors. Its diagnosis is crucial because it causes delayed union, malunion, or nonunion if activity continues without treatment and recovery. It most commonly affects the inferior pubic ramus, sacrum, and femoral neck in the pelvic region. It is not easy to diagnose on radiographs, but MRI has a sensitivity ranging from 86-100% [10].

Avulsion fractures occur secondary to the immature skeleton being forced by the muscles. Trauma or overusing is a risk factor. It is common in adolescents who play sports, where the apophysis is weaker than the tendon. It is most commonly seen in the tuber ischiadicum but can be seen in the pelvic region, in bone structures such as the anterior inferior iliac spine, and the symphysis pubis. In our study, it was common in the adolescent group and tuber ischiadicum. MRI is the most appropriate tool for evaluating avulsion fractures and accompanying muscle injuries and guides treatment planning [11].

There are different impingement syndromes, such as femoroacetabular, anterior inferior iliac spine, ischiofemoral, and iliopsoas impingement [10]. However, the only impingement syndrome observed in our study was ischiofemoral impingement. It was seen significantly more frequently, especially in female patients over 10 years of age, and was not uncommon compared with other hip pathologies. In ischiofemoral impingement, there is narrowing between the trochanter minor of the femur and the ischial tuberosity. When this gap narrows, edema, tearing, and fatty atrophy occur in the quadratus femoris muscle [12].

Transient synovitis is the most common cause of non-traumatic hip pain among children. It is a self-limiting acute inflammatory disorder of the hip. Although its etiology is unknown, it is suggested that viral infections may be the cause, and it is the most common cause of limping in children. It is usually seen in children aged 4-8 years. The male/female ratio is 2:1, and approximately 5% of cases have bilateral involvement. Diagnosis is based on clinical findings; the most critical finding is effusion in the joint, which is almost non-specific. It can occur in many infectious and non-infectious pathologies. Laboratory findings help distinguish it from septic arthritis. MRI can be performed to evaluate other possible lesions if clinical findings persist [4]. In our study, it was seen in approximately 8.9% of the cases, and 22% of the transient synovitis cases were bilateral.

Septic arthritis, which can be confused with transient synovitis, is an emergency condition and usually occurs within 2 years. Delayed diagnosis causes joint destruction and permanent damage. It may accompany osteomyelitis. The absence of effusion in the joint usually excludes the disease. In a patient with joint effusion and high inflammatory markers, the probability of septic arthritis is relatively high. MRI is generally not needed for diagnosis, but it is used to evaluate accompanying osteomyelitis [13]. We did not detect septic arthritis in any of the cases in our study. The reason may be that the diagnosis was made in patients without the need for MRI.

Juvenile inflammatory arthritis can affect the hip or sacroiliac joints. It may be unilateral but is often bilateral. It usually affects children older than 4-5 years. Radiographs can show erosions in the bone structure and narrowing of the joint space, but MRI shows soft tissue changes, synovitis, and bone marrow changes, allowing early diagnosis [13,14]. In this study, sacroiliitis was present in 6.9% of the cases. None of the cases had hip joint involvement.

The diagnosis of snapping hip syndrome is based on clinical examination findings. As a clinical sign, there is a sound or sensation during repetitive hip flexion or adduction. It is common in adolescent athletes who do a lot of flexion and adduction. There are different types. It is formed by the friction of the gluteal tendons or the iliotibial band against the greater trochanter during movement. Tendon thickening and increased signal in fluid-sensitive sequences can be seen in MRI [12].

Benign or malignant tumoral lesions can be seen in the hip joint and surrounding soft tissues. Benign lesions include osteoid osteoma, aneurysmal bone cyst, simple bone cyst, chondroblastoma, exocytosis, and osteoblastoma [13]. Among the malignant lesions, osteosarcoma and Ewing's sarcoma are the most common primary malignant tumors in children [15]. Metastases, lymphoma, and leukemia can also be seen in children. In addition, Langerhans cell histiocytosis, which can affect children of all ages, can be seen in different ways from solitary bone lesions (eosinophilic granuloma) to widespread skeletal involvement. MRI is a preferred technique for diagnosis and local staging by evaluating tumor size, bone destruction, bone marrow, and soft tissue involvement [13]. In this study, fibrous dysplasia, eosinophilic granuloma, fibrous cortical defect, and chondroblastoma were found, with osteoid osteoma and simple bone cyst being the most common in the benign group. There was one case of ALL and one CML but not primary sarcoma in the malignant group.

Conclusion

In conclusion, hip pathologies in children show significant differences between different age groups and genders. Early and accurate diagnosis of traumatic or non-traumatic hip pathologies is of critical importance. MRI is a very effective diagnostic tool in the diagnosis of pediatric hip pathologies. It should be used as a problem solver, especially in pediatric cases without abnormal findings on radiography but persistent clinical findings.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
The study was approved by the University of Health Sciences Diskapi Yildirim Beyazit Health Application and Research Center Ethical Committee (2021/110-05)

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