134/ Acta Chir Orthop Traumatol Cech. 89, 2022, No. 2
p. 134–138

The MRI Effect in Clinical Decision Process in Perthes' Disease: "More Complex Imaging, More Complicated Surgeries"

Vliv vyšetření MR na klinické rozhodování u Perthesovy choroby: čím komplexnější zobrazení, tím komplikovanější operace

O. KALENDERER[1], S. ERKUS[2], I. A. SARIKAYA[3], A. TURGUT[4], M. INAN[3]

[1] Izmir Tınaztepe University, Department of Orthopaedics and Traumatology, Izmir, Turkey
[2] Van Training and Research Hospital, Department of Orthopaedics and Traumatology, Van, Turkey
[3] Ortopediatri, Pediatric Orthopedic Academy, Istanbul, Turkey
[4] Tepecik Training and Research Hospital, Department of Orthopaedics and Traumatology, Izmir, Turkey

ABSTRACT

PURPOSE OF THE STUDY

Radiographs are preferred for understanding the deformity and containment in Legg-Calvé-Perthes disease (LCPD), as well as for treatment planning, but plain radiographs provide only static information and are inadequate for dynamic assessment of the joint. Magnetic resonance imaging (MRI) has been shown to be superior to other diagnostic modalities. The aim of this study was to determine the importance of hip MRI in LCPD treatment decision-making processes between pediatric orthopedic surgeons and orthopedic surgery residents.

MATERIAL AND METHODS

Eight orthopedic surgery residents and eight pediatric orthopedic surgeons were invited to retrospectively evaluate hip radiography images and MRI sections of 34 patients with LCPD. The treatment choices were divided into two groups as conservative and surgical. Gwet's AC1 analysis was used to establish the relative level of intra-observer agreements. The correlation between the professional experience and the agreement parameters was also evaluated using the Pearson correlation coefficient. ANOVA was used to compare multiple groups. $p \leq 0.05$ was statistically significant.

RESULTS

For both groups most preferred treatment method was conservative approaches based on plain radiography and MRI. The resident group showed a significant shift from conservative treatment to surgical treatment choices after MRI evaluation. The difference between the frequencies of each treatment choice for pediatric orthopedic surgeons was not statistically significant among different imaging modalities, but a comparison of the changes in surgical treatment revealed a significant difference between the imaging modalities, with a trend towards more complicated treatment choices.

DISCUSSION

Conservative methods were the most preferred treatment choice in the study, as it is common. It was observed that treatment choices changed when patients were evaluated together with MRI. Compared to plain radiographs, MRI provides sufficient and particular information for evaluating the structures of the hip joint components.

CONCLUSIONS

We found that consideration of MRI data in LCPD patients changed treatment recommendations substantially towards more complicated surgical procedures. We consider this to be an 'MRI effect' where using a more complex imaging modality leads surgeons to more complicated treatment modalities in LCPD.

Key words: imagnetic resonance imaging, reliability, MRI effect, Perthes disease, children.

INTRODUCTION

Evaluation of femoral head deformity and determination of appropriate treatment strategy is crucial for decision making in Legg-Calvé-Perthes disease (LCPD) (1, 2, 7). Based on the radiographic findings, surgical procedures (proximal femoral osteotomies, pelvic osteotomies, etc.) are used to improve containment in the early stages of the disease (9, 19, 30). Since plain radiographs provide only static information and they are an inadequate tool for assessment of the deformity and containment through the arc of motion in the advanced disease (12, 21, 26, 27, 29). Arthrography can be used as a dynamic diagnostic tool in LCPD, but it provides only an indirect evaluation of the femoral head and the other intraarticular structures (12, 18, 24). However magnetic resonance imaging (MRI) was shown to be superior to other diagnostic modalities for assessment of joint fluid amount, cartilage thickening, and labral damage, as well as for depicting the femoral head deformity and containment (16, 28). Therefore, MRI is a widely accepted tool for the diagnosis and treatment of LCPD, but the need for sedation or general anesthesia and high cost limits its use (5, 6, 11, 15).

To the best of our knowledge, there is no study regarding the influence of MRI over the decision making in LCPD treatment. Therefore, the aim of this descriptive study was to determine whether the hip MRI has an impact of on pediatric orthopedic surgeons and orthopedic surgery residents' decision-making processes of LCPD treatment.

MATERIALS AND METHODS

Study groups

An invitation letter explaining the study protocol was sent to orthopedic surgery residents and pediatric orthopedic surgeons. A total of 16 physicians were allocated into two separate groups based on their experience and training levels. The first group comprised eight senior orthopedic surgery residents who were in their final year of their training and had completed two pediatric orthopedic rotations previously. The second group comprised eight pediatric orthopedic surgeons who had at least five years of experience in management of pediatric hip diseases and currently practicing as a consultant in a training hospital.

Study method

After obtaining IRB approval, patient records were reviewed retrospectively. Out of 65 patients with unilateral LCPD, hip radiographies (antero-posterior and frog-leg position) and hip MRI (T1 and T2 sections) of 34 patients were chosen as the cases for review by the study participants. The both of MRI and radiographies were obtained a two-day interval. Using these data, three consecutive slide decks, without any patient identifiers, were prepared using Microsoft Windows PowerPoint 2016 (Microsoft Corporation, Seattle, WA.). The first slide deck contained only the radiography images, demographic data (age and gender), and physical examination findings, such as pain and hip range of motion (ROM). The second and third decks contained different T1 and T2 sections from the MRIs, as well as the same demographic data and physical examination findings as the first deck. Reviewers were blinded by changing the presentation order of the cases in the review deck and the order of each round was determined by drawing lots. The slide decks were sent to the reviewers via e-mail and at least a one-month interval was left between each review.

The reviewers were given and were asked to choose the one they thought would be best for the case. The treatment choices were divided into two groups: conservative and surgical. The surgical treatment choices were further divided into two groups: soft tissue and bone procedures (proximal femoral osteotomies, acetabular osteotomies, combined femur and acetabular osteotomies, arthrodiastasis and/or shelf osteotomy, and surgical hip dislocation and/or femoral head and neck reconstruction). The conservative methods included observation alone, activity restriction, and physical therapy. The responses for the first slide deck were taken as the gold standard for each reviewer and their answers for the second and the third deck were analyzed on this basis.

Statistical analysis

The percent agreement between the first and the second slide decks and Gwet's AC1 were first calculated, followed by similar calculations between the first and the third decks. Averages were calculated using the data from two sets. The percent agreement and Gwet's AC1 were subsequently recalculated for inter-observer measurements for each group in each slide deck.

Gwet's AC1 analysis was used to establish the relative level of intra-observer agreements for the assessment (4). Data interpretation was performed according to Landis and Koch (14). An agreement was graded as poor (<0), slight (0–0.2), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), or almost perfect (0.81–1).

The correlation between the professional experience and the agreement parameters was also evaluated using the Pearson correlation coefficient, since data showed a normal distribution. ANOVA was used to compare multiple groups, followed by Tukey's post-hoc test for comparison of each group. $p \leq 0.05$ was considered statistically significant. Data were analyzed using open source software package R (version 2.10.1; The R Foundation for Statistical Computing, Vienna, Austria). Graphs were sketched using Graphpad Prism (Version 7.00 for Mac, GraphPad Software, La Jolla California USA).

RESULTS

In total, records of 34 male patients were used. The mean age of the patients was 6.5 years (range: 3–10 years). In 16 patients (47%) right hip was affected and in 18 patients (53%) left hip was affected. All patients were in Group B in according the lateral pillar (Herring) classification system, and also there was a consensus among the authors on this issue. Likewise, all patients were in fragmentation stages with respect to Waldenström classification of Perthes disease. Regardless of patients' age, it was observed that at least one observer in each of the patients changed their treatment choice.

Based on the plain radiography and MRI, most preferred treatment method for both resident and experienced surgeon groups were conservative approaches (Fig.1). There was a significant shift towards surgical treatment choices from conservative treatment in the resident group after MRI sections was considered (p=0.0036) (Table 1). The difference between the frequency of conservative and surgical treatment choices for pediatric orthopedic surgeons among the different imaging modalities was not statistically significant (p=0.3875), (Table 2).

When changes in surgical treatment choice frequencies were compared in detail (Fig. 2), there was no significant difference between the imaging modalities for

Table 1. Resident choice frequencies

Approach	Imaging modality		
	X-ray	MRI-1	MRI-2
Conservative	188	179	168
Surgical	84	93	104

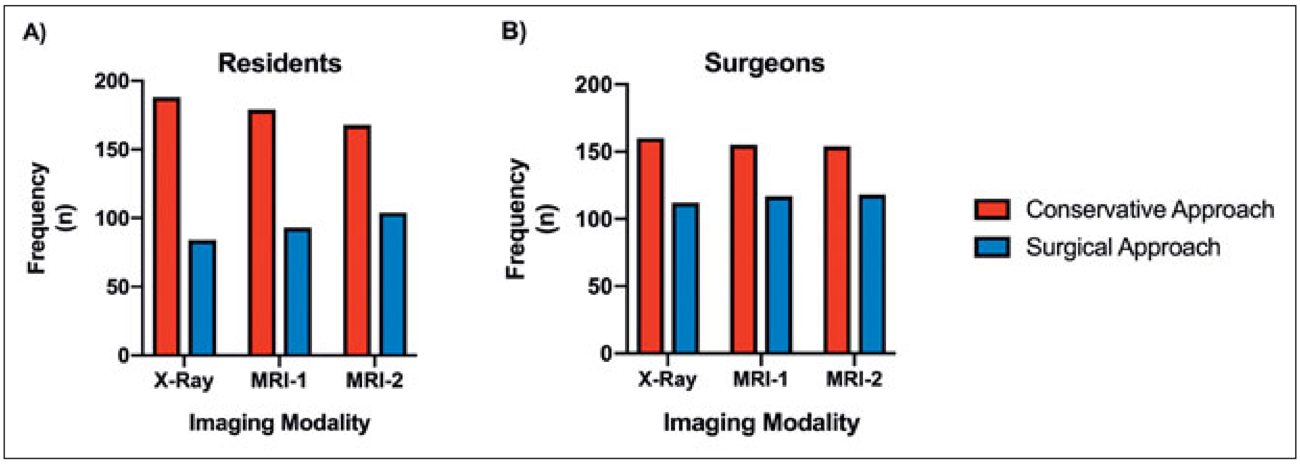

Fig. 1. Conservative vs. surgical choice frequencies
Comparison between frequencies of conservative vs. surgical choices are shown for residents (A) and pediatric orthopedic surgeons (B). There was a significant shift towards surgical treatments for residents after MRI images were considered (p= 0.0036), however the shift between choices was not significant for pediatric orthopedic surgeons. Frequencies are shown in detail in Table 1 and Table 2 for each group respectively.

residents (p=0.9952) (Table 3). However, there was a significant difference for the pediatric orthopaedic surgeons (p<0.001), with a trend towards combination of treatment choices (Table 4). Distribution of surgical treatment choices for each group is shown in Fig. 2.

The mean percent agreement for the residents' intra-observer reliabilities was 66.7%, and Gwet's AC1 statistics showed a substantial reliability (0.64). The mean percent agreement for the pediatric orthopedic surgeons' intra-observer reliability was 70.25% and Gwet's AC1 statistics again showed a substantial reliability (0.67) (Figure 3, 4).

Evaluations based on plain radiographs revealed an inter-observer reliability of 57.9% with a moderate Gwet's AC1 of 0.52 for senior residents and an inter-observer reliability of 54.1% with a moderate Gwet's AC1 of 0.46 for the pediatric orthopedic surgeons. The mean values corresponding to the slide decks including MRI were 53.2% (Gwet's AC1=0.46; moderate) and 47.2% (Gwet's AC1=0.38; fair).

No statistically significant correlation was noted between the professional experience and the level of agreement (Pearson correlation coefficient=0.144, p = 0.596).

Table 2. Consultant choice frequencies

Approach	Imaging modality		
	X-ray	MRI-1	MRI-2
Conservative	160	155	154
Surgical	112	117	118

DISCUSSION

Plain radiographs are used as the primary choice of imaging for the treatment decision making in LCPD, but this modality can be associated with certain shortcomings and errors (8, 10, 17, 20). By contrast, MRI, as a diagnostic imaging tool in routine use, has been shown to provide sufficient information for the assessment of deformity of the epiphysis, joint surfaces, labrum, and femoral head (2, 3, 13, 16, 21, 22, 23, 25). In the present study, we assessed how availability of MRI images affects the decision-making process in LCPD treatment, and we determined that MRI could direct surgeons to combination of the LCPD procedures. On the other hand, the in-

Table 3. Resident's surgical choice frequencies

Approach	Imaging modality n (%)		
	X-Ray (n:112)	MRI-1 (n:117)	MRI-2 (n:118)
Soft tissue release	15 (13%)	9 (8%)	17 (14%)
Proximal femoral osteotomies	49 (44%)	55 (47%)	49 (41%)
Acetabular osteotomies	4 (3%)	2 (2%)	0
Combined femoral and acetabular osteotomies	0	0	0
Arthrodiasthasis and/or shelf osteotomy	23 (21%)	23 (20%)	23 (19%)
Safe dislocation and/or femoral head - neck reconstruction	21 (19%)	28 (23%)	29 (26%)

Table 4. Consultant's surgical choice frequencies

Approach	Imaging modality n (%)		
	X-Ray (n:84)	MRI-1 (n:93)	MRI-2 (n:104)
Soft tissue release	31 (37%)	40 (43%)	40 (38%)
Proximal femoral osteotomies	40 (48%)	37 (40%)	34 (33%)
Acetabular osteotomies	7 (8%)	5 (5%)	8 (8%)
Combined femoral and acetabular osteotomies	4 (5%)	0	4 (4%)
Arthrodiasthasis and/or shelf osteotomy	1 (1%)	2 (2%)	4 (4%)
Safe dislocation and/or femoral head - neck reconstruction	1 (1%)	9 (10%)	14 (13%)

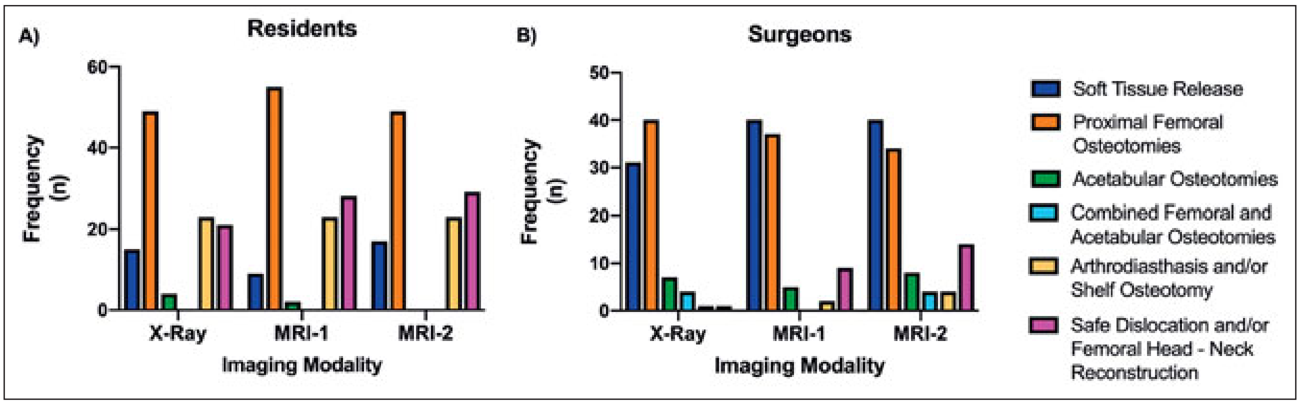

Fig. 2. Changes in surgical treatment choices
For each group, changes in surgical treatment choices is shown in detail for each frequency for residents (A) and pediatric orthopedic surgeons (B) separately. There was no significant difference between the imaging modalities for residents (p=0.9952), but there was a significant difference for the pediatric orthopaedic surgeons (p<0.001), with a trend towards more complex treatment choices Frequencies are shown in detail in Table 3 and Table 4 for each group respectively.

ter-observer reliability decreased among the groups with the use of MRI. This could be an important finding, since these pediatric orthopedic surgeons are highly experienced in the management of LCPD and this decreased agreement regarding the treatment procedure can reflect the complexity of the surgical procedure decision such as the addition of another bone or soft tissue procedure.

In our study, the most preferred treatment method was conservative treatment by both the pediatric orthopedic surgeons and the orthopedic surgery residents. However, MRI changed their treatment choices toward complicated treatments such as combined procedures or addition of them. The resident group showed an increased tendency toward surgical methods after evaluation of MRI images. Likewise, the pediatric orthopedic surgeons showed a similar trend toward combined surgeries after MRI evaluations. Our findings suggest that hence MRI provides more information about the femoral head and other soft tissues, this then leads the residents, who have limited experience regarding the surgical treatment of LCPD, toward surgical treatments, while the pediatric orthopedic surgeons with more surgical LCPD experience tend to choose complicated surgeries to address the deformity.

The decision to operate and the choice of surgery depend heavily on the hip involvement observed in the radiographs; however, no globally accepted imaging algorithm has been established for LCPD (1, 7). The present study was performed to assess the intra observer reliability and agreement for plain radiographs and MRI in determining the treatment choices for LCPD between orthopedic surgeons with different educational and experience levels. Agreement with regards to the different imaging modalities was similar between the pediatric orthopedic surgeons and the senior residents. Even though it was not shown statistically, it could be expected that the probability of reaching a consensus in LCPD treatment increases with experience; thus, the probability of making the appropriate decision.

We could describe the impact of MRI evaluation in LCPD treatment decision making as an 'MRI effect'. This MRI effect could lead to the choice of surgical procedure requiring more dexterity, like arthrodiastasis and safe dislocation, by both senior residents and pediatric

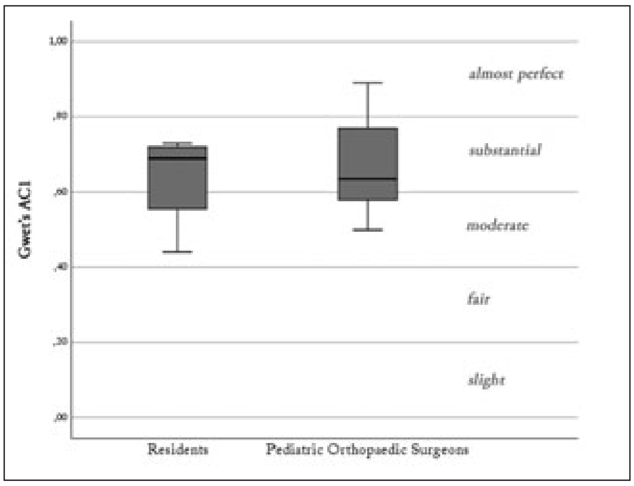

Fig. 3. The distribution of Gwet's AC1 values for subgroups' intra-observer reliabilities.

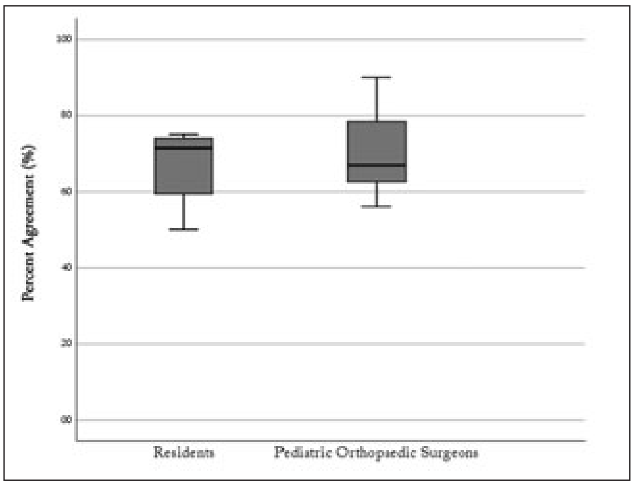

Fig. 4. The distribution of percent agreement for subgroups' intra-observer reliabilities.

orthopedic surgeons. This effect would not lead to more reliable decisions in LCPD treatment using MRI, as indicated by the decreased agreement between the highly experienced surgeons in this study. Briefly, the MRI effect could lead to more complicated surgeries, and an MRI-based treatment algorithm regarding this MRI effect could be developed for LCPD treatment decisions to increase the consensus between surgeons.

Our study had some limitations, including the retrospective sampling of patients. We are also aware that MRI needs sedation or anesthesia for high-quality images, and these methods involve some risk and expense (23). We do not know the prospective data regarding which surgical decision was better for these patients; therefore, we have tried to raise awareness of the effect of MRI in the clinical decision process for LCPD. On the other hand, there is not a gold standard treatment to help reliable guide treatment choice even with MRI information, so the treatment strategies were planned based on surgeon's experience. Furthermore, why observers changed their choices could not be questioned in this study. For this, it is considered that multicenter, multiparticipant, prospective studies are needed.

CONCLUSIONS

We found that consideration of MRI data in LCPD patients did not result in a statistically significant change in the percentage agreement for treatment choices by experienced surgeons, but their treatment recommendations changed substantially toward more complicated surgical procedures. Also, MRI helps residents or less experienced surgeons, better understand the complexity of the hip findings, leading them to more aggressive treatment in line with more experienced pediatric orthopedic surgeons. We consider this to be an 'MRI effect' whereby more complex imaging leads to more complicated treatment modalities in LCPD.

References

1. Catterall A. Legg-Calvé-Perthes syndrome. Clin Orthop Relat Res. 1981;158:41–52.
2. Cheng JC, Lam TP, Ng BK. Prognosis and prognostic factors of Legg-Calve-Perthes disease. J Pediatr Orthop. 2011;31:147–151.
3 Edwards AD, Arthurs OJ. Pediatric MRI under sedation:is it necessary? What is the evidence for the alternatives? Pediatr Radiol. 2011;41:1353–1364.
4 Gwet KL. Computing inter-rater reliability and its variance in the presence of high agreement. Br J Math Stat Psychol. 2008;61:29–48.
5 Hefti F, Clarke NM. The management of Legg-Calvé-Perthes' disease:is there a consensus?:a study of clinical practice preferred by the members of the European Pediatric Orthopedic Society. J Child Orthop. 2007;1:19–25.
6 Henderson RC, Renner JB, Sturdivant MC, Greene WB. Evaluation of magnetic resonance imaging in Legg-Perthes disease: a prospective, blinded study. J Pediatr Orthop. 1990;10:289–297.
7 Herring JA. Tachdjian's Pediatric Orthopedics:From the Texas Scottish Rite Hospital for Children. New York:Elsevier Health Sciences, New York, 2013.
8 Ibrahim T, Little DG. The pathogenesis and treatment of Legg-Calvé-Perthes disease. JBJS Rev. 2016;4:e4.
9 Joseph B, Rao N, Mulpuri K, Varghese G, Nair S. How does a femoral varus osteotomy alter the natural evolution of Perthes' disease? J Pediatr Orthop B. 2005;14:10–15.
10 Karkenny AJ, Tauberg BM, Otsuka NY. Pediatric hip disorders:slipped capital femoral epiphysis and Legg-Calvé-Perthes disease. Pediatr Rev. 2018;39:454–463.
11 Kimiya T, Sekiguchi S, Yagihashi T, Arai M, Takahashi H, Takahashi T. Sedation protocol with fasting and shorter sleep leads to magnetic resonance imaging success. Pediatr Int. 2017;59:1087–1090.
12 Laine JC, Martin BD, Novotny SA, Kelly DM. Role of advanced imaging in the diagnosis and management of active Legg-Calvé-Perthes disease. J Am Acad Orthop Surg. 2018;26:526–536.
13 Lamer S, Dorgeret S, Khairouni A, Mazda K, Brillet P-Y, Bacheville E, Bloch J, Penneçot GF, Hassan M, Sebag GH. Femoral head vascularisation in Legg-Calvé-Perthes disease:comparison of dynamic gadolinium-enhanced subtraction MRI with bone scintigraphy. Pediatr Radiol. 2002;32:580–585.
14 Landis JR, Koch GG. The measurement of observer agreement for categorial data. Biometrics. 1977;33:159–174.
15 Mahmoud M, Gunter J, Donnelly LF, Wang Y, Nick TG, Sadhasivam S. A comparison of dexmedetomidine with propofol for magnetic resonance imaging sleep studies in children. Anesth Analg. 2009;109:745–753.
16 Maranho DA, Nogueira-Barbosa MH, Zamarioli A, Volpon JB. MRI abnormalities of the acetabular labrum and articular cartilage are common in healed Legg-Calvé-Perthes disease with residual deformities of the hip. J Bone Joint Surg Am. 2013;95:256–265.
17 McAndrew MP, Weinstein SL. A long-term follow-up of Legg-Calvé-Perthes disease. J Bone Joint Surg Am. 1984;66:860–869.
18 Newberg AH, Munn CS, Robbins AH. Complications of arthrography, Radiology. 1985;155:605–606.
19 Paterson DC, Leitch JM, Foster BK. Results of innominate osteotomy in the treatment of Legg-Calvé-Perthes disease. Clin Orthop Relat Res. 1991;266:96–103.
20 Perry DC, Hall AJ. The epidemiology and etiology of Perthes disease. Orthop Clin North Am. 2011;42:279–283.
21 Pienkowski D, Resig J, Talwalkar V, Tylkowski C. Novel three-dimensional MRI technique for study of cartilaginous hip surfaces in Legg-Calvé-Perthes disease. J Orthop Res. 2009;27:981–988.
22 Rampal V, Clément JL, Solla F. Legg-Calvé-Perthes disease:classifications and prognostic factors. Clin Cases Miner Bone Metab. 2017;14:74–82.
23 Sales de Gauzy J, Kerdiles N, Baunin C, Kany J, Darodes P, Cahuzac JP. Imaging evaluation of subluxation in Legg-Calvé-Perthes disease:magnetic resonance imaging compared with the plain radiograph. J Pediatr Orthop B. 1997;6:235–238.
24 Saupe N, Zanetti M, Pfirrmann CW, Wels T, Schwenke C, Hodler J. Pain and other side effects after MR arthrography:prospective evaluation in 1085 patients, Radiology. 2009;250:830–838.
25 Schulte-Uentrop L, Goepfert MS. Anaesthesia or sedation for MRI in children. Curr Opin Anaesthesiol. 2010;23:513–517.
26 Shah H. Perthes disease:evaluation and management. Orthop Clin North Am. 2014;45:87–97.
27 Standefer KD, Dempsey M, Jo C, Kim HKW. 3D MRI quantification of femoral head deformity in Legg-Calvé-Perthes disease. J Orthop Res. 2017;35:2051–2058.
28 Tiwari V, Gamanagatti S, Mittal R, Nag H, Khan SA. Correlation between MRI and hip arthroscopy in children with Legg-Calvé-Perthes disease. Musculoskelet Surg. 2018;102:153–157.
29 Tsao AK, Dias LS, Conway JJ, Straka P. The prognostic value and significance of serial bone scintigraphy in Legg-Calvé-Perthes disease. J Pediatr Orthop. 1997;17:230–239.
30 Wichlacz W, Sotirow B, Sionek A, Czop A. The surgical treatment of children with Perthes' disease:26 years of experience. Orthop Traumatol Rehabil. 2004;6:718–727.

Corresponding author:
Serkan Erkus, MD
Van Training and Research Hospital
Department of Orthopaedics and Traumatology
Van, TURKEY
E-mail: s.erkus@ymail.com