Initial Plain Radiographs versus MR Imaging: Comparison of Prognostic Efficacy in Legg-Calve-Perthes Disease

Sun-Jin Lee[1], Won-Hee Jee[1], Song-Mee Cho[1], Chang-Hoon Jeong[2], In-Young Ok[2]

Purpose : To evaluate if at the time of diagnosis of Legg-Calve-Perthes disease, MR imaging is superior to radiographs for identifying patients with a favorable long term prognosis as determined by maintenance of a spherical configuration of the femoral head epiphysis on follow-up radiographs.

Materials and Methods : We retrospectively analyzed plain radiographs and MR images of 48 femoral heads in 41 patients with Legg-Calve-Perthes disease at time of diagnosis. Femoral head involvement was estimated on initial plain radiographs and MR images using the Catterall classification. Prognosis as determined by maximum femoral head deformity was determined on follow-up radiographs evaluated according to Stulberg classification.

Results : Catterall classification of greater than 1 at MR imaging had 100% sensitivity (14/14) for detecting patients with a poor prognosis as indicated by deformity of the femoral head on follow-up radiographs (Stulberg class > 2). Initial radiographs had a lower sensitivity of 57% (8/14) for detecting patients with poor prognosis. Specificity for MR imaging was 21% (7/34) which was not significantly different from 32% (11/34) specificity for initial radiographs.

Conclusion : Catterall group 1 at initial MR imaging indicates favorable prognosis for Legg-Calve-Perthes disease. Patients with more extensive involvement of the femoral head can have a good outcome, however they are at risk for loss of spherical configuration of the femoral head and subsequent osteoarthritis in adulthood. MR imaging may be superior to radiographs for identifying a subgroup of patients with favorable prognosis.

Index words : Hip, radiographs
Magnetic resonance (MR)
Legg-Calve-Perthes disease

JKSMRM 12:153-160(2008)

[1]Department of Radiology, Kangnam St. Mary's Hospital, The Catholic University of Korea
[2]Department of Orthopedic Surgery, Kangnam St. Mary's Hospital, The Catholic University of Korea
Received; August 6, 2008, accepted; September 20, 2008
Corresponding author : Won-Hee Jee, M.D., Department of Radiology, Kangnam St. Mary's Hospital,
The Catholic University of Korea, 505 Banpo-dong, Seocho-gu, Seoul 137-701, Korea
Tel. 82-2-590-2784 Fax. 82-2-599-6771 E-mail: whjee@catholic.ac.kr

Introduction

Legg-Calve-Perthes disease is idiopathic avascular necrosis of the femoral head epiphysis. Since in Legg-Calve-Perthes disease patients who need active treatment should be identified at an early stage, it is important to establish the prognosis as early as possible, preferably at the time of initial diagnosis (3, 10, 13). One of the most important prognostic factors in determining the end result in Legg-Calve-Perthes disease is the loss of spherical configuration of the femoral head epiphysis (14, 15). Deformity of the femoral head epiphysis can progress with the maximum radiographic resorption of the femoral head epiphysis often occurring many months after the appearance of the first radiographic signs of the disease (12). Thus radiographs obtained at the time of diagnosis may not accurately reflect the prognosis of Legg-Calve-Perthes disease. Previous studies have indicated that MR imaging may provide a method to predict the prognosis earlier than is possible with radiographs because of increased sensitivity for detection of the extent of necrosis of the femoral head epiphysis (5).

The purpose of this study was to evaluate that MR imaging would be superior to radiographs for predicting the prognosis of Legg-Calve-Perthes disease at the time of diagnosis.

Materials and Methods

Radiographs and MR images of 41 patients with Legg-Calve-Perthes disease (36 boys and 5 girls, age range 3–10, mean 6 years, at time of diagnosis) were included in this study. Only patients with radiographs and MR imaging within one month of the time of diagnosis and with follow-up radiographs obtained greater than 24 months after diagnosis were included. Seven patients had bilateral involvement. The average time between the first symptoms and MR imaging was 3.5 months (range, 1–11 months). The interval between initial radiographs and MR imaging was ten days (range, 0–23 days). All patients had standard anteroposterior and Lauenstein (frog-position) lateral radiographs. MR imaging was performed with 1.5-T (Signa Advantage, GE Medical Systems, Milwaukee, Wis), with the body coil. Coronal and axial T1-weighted MR imaging (TR/TE, 450–650/11–30) was performed in all cases. Coronal intermediate-weighted (1800–2700/19–40) and T2-weighted MR (1800–2700/60–100) imaging were performed. MR imaging parameters included the following: field of view, 20-26 cm; two signals acquired; matrix size, 256x192; section thickness, 3 mm; intersection gap, 1 mm.

Initial and follow-up plain radiographs and MR images were retrospectively reviewed by the consensus of three reviewers (one experienced musculoskeletal radiologist, one third year radiology resident, and one

Table 1. Results of Stulberg Classification on Follow-up (FU) Radiographs According to Catterall Groups on Initial Radiographs and MR Imaging in 48 Femoral Head (41 patients)

Classification by Catterall Group*		Stulberg Classification on FU Radiographs**			
		1	2	3	4
		(n = 13)	(n = 21)	(n = 12)	(n = 2)
Initial Radiographs	1	1	1	0	1
	2	3	3	3	0
	3	6	9	6	0
	4	3	8	3	1
Initial MR Imaging	1	3	0	0	0
	2	2	1	0	0
	3	8	13	9	1
	4	0	7	3	1

n = Number of patients.

* Catterall classification determined by extent of involvement of femoral head epiphysis at the time of initial diagnosis based on radiographs and MR imaging: Catterall group 1–4

** Prognostic results of Stulberg classification on follow-up radiographs obtained at least 24 months after diagnosis: Stulberg class 1–4

orthopedic surgeon) blinded to the clinical data.

The Catterall classification was used to determine the extent of involvement of the femoral head epiphysis at the time of diagnosis based on the radiographs and separately based on the MR images (3). The Catterall classification was retrospectively determined by consensus of three reviewers who were blinded to the results of the follow-up radiographs. Catterall Group 1. No Subchondral fracture line, No metaphyseal reaction, No sequestrum; Group 2. Subchondral fracture line-anterior half, Sequestrum present, Metaphyseal reaction present; Group3. Subchondral fracture line-posterior half, Large sequestrum, Metaphyseal reaction present; Group 4. Whole head involvement, Metaphyseal reaction present, Posterior remodelling.

Prognosis as determined by femoral head deformity was determined on follow-up radiographs obtained at least 24 months after diagnosis evaluated according to the Stulberg classification (15). The interval between the initial and follow-up radiographs was 50 months (range, 25-91 months). The three reviewers determined the Stulberg classification by consensus using the following criteria: Class 1 reveals a completely normal hip joint. In class 2, a spherical head is present. One or more of the following abnormal characteristics of the

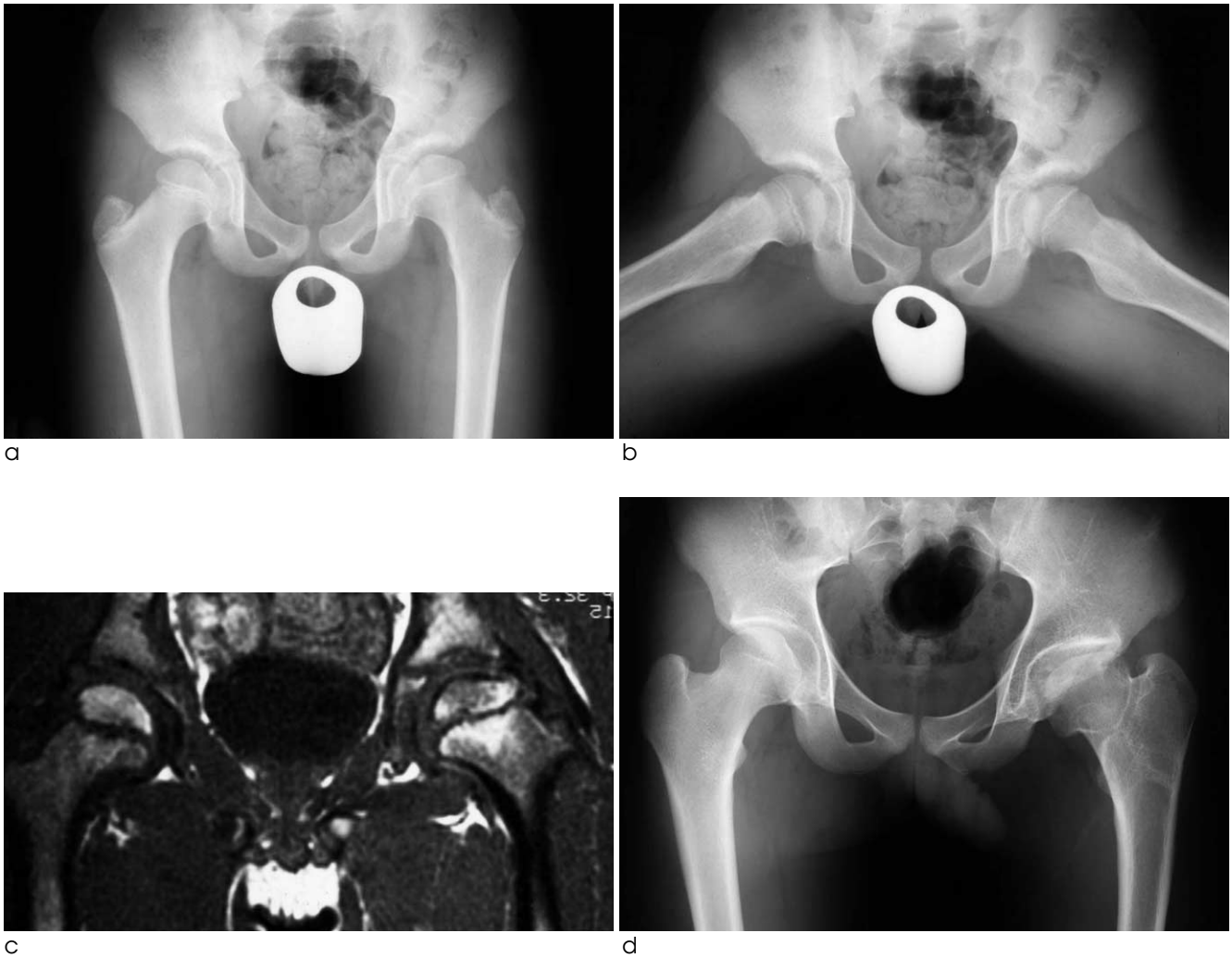

Fig. 1. Legg-Calve-Perthes disease of left femoral head in a ten-year-old boy. Initial anteroposterior (a) and lateral (b) radiographs show involvement of anterior epiphysis of left femoral head with subchondral fracture (arrows), consistent with Catterall group 2. (c) Coronal T1-weighted MR image (TR 566/TE 11) shows Catteral group 3 involvement (arrows) of left femoral head. (d) Follow-up anteroposterior radiograph 68 months after initial radiographs shows an ovoid left femoral head, short femoral neck, and trochanteric overgrowth, consistent with Stulberg class 3.

femoral head, neck, or acetabulum is present: larger than normal femoral head; shorter than normal femoral neck; or abnormally steep acetabulum. In class 3, a non-spherical (ovoid, mushroom-shaped, or umbrella-shaped) but not flat femoral head is present. Abnormal characteristics of the femoral head, neck, and acetabulum are present also. Class 4 shows a flat femoral head with abnormalities of the femoral head, femoral neck and acetabulum. In class 4, the femoral head is congruent with an equally deformed acetabulum (aspherical congruency). Class 5 demonstrates a flat femoral head with a normal femoral neck and acetabulum. The acetabulum has not accommodated to the flattened femoral head (aspherical incongruity) in this class.

Bivariate correlation was used to determine the strength of correlation between Catterall group at diagnosis based either on radiographs or MR imaging compared with Stulberg classification on follow-up radiographs. Correlation between patient age at diagnosis and Stulberg classification was also determined.

Results

Initial radiographs were classified as Catterall group 1 in three, group 2 (Fig. 1) in nine, group 3 (Fig. 2) in 21, and group 4 in 15. MR images were classified as

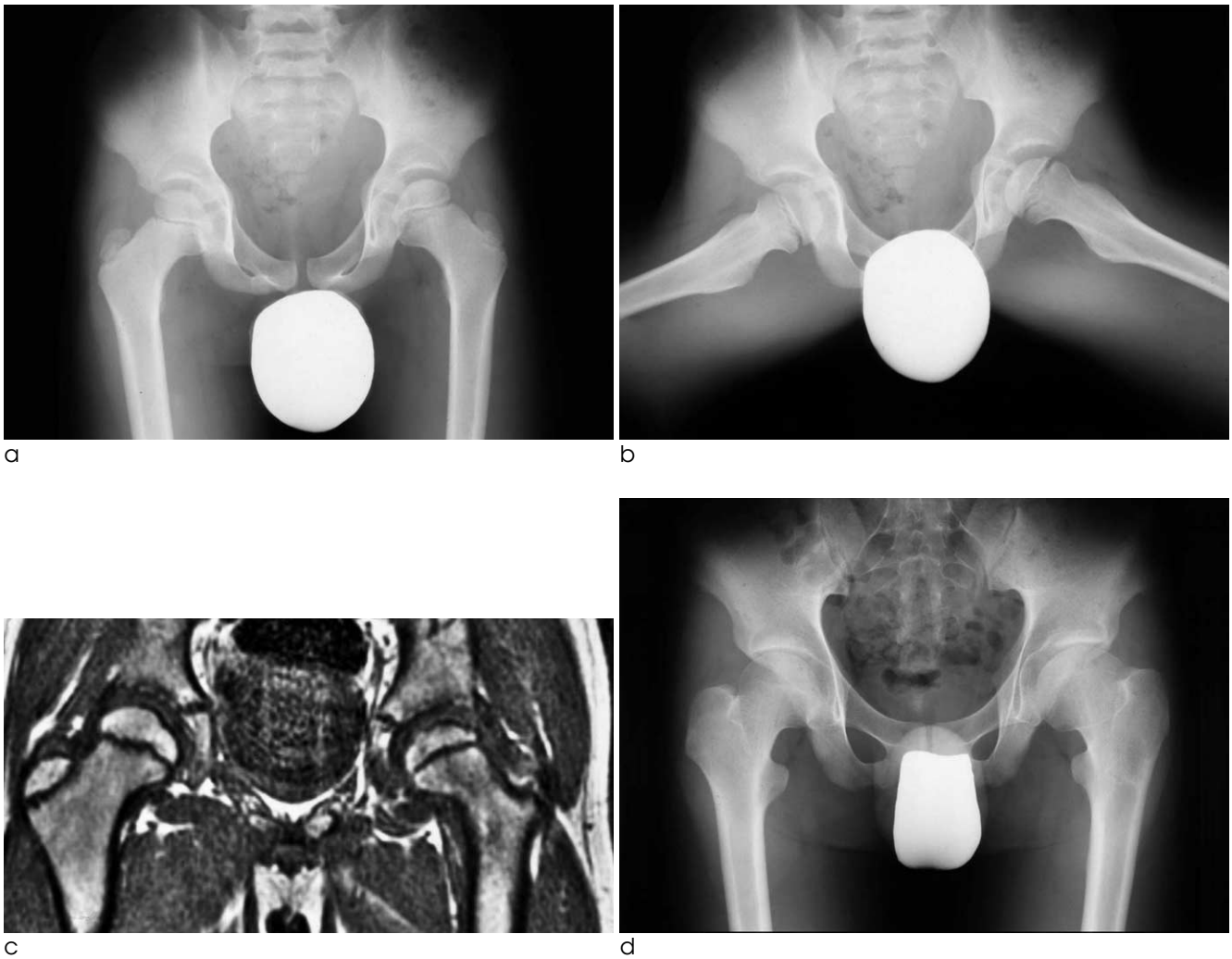

Fig. 2. Legg-Calve-Perthes disease of left femoral head in a nine-year-old boy. Initial anteroposterior (a) and lateral (b) radiographs show a subchondral fracture (arrows) extending more than 50% around left femoral head, consistent with Catterall group 3. (c) Coronal T1-weighted MR image (TR 600/TE 13) shows Catterall group 3 involvement (arrows) with sparing the medial and lateral aspects of the epiphysis. (d) Follow-up anteroposterior radiograph 80 months after initial radiographs shows a spherical left femoral head and short femoral neck, consistent with Stulberg class 2.

Catterall group 1 in three, group 2 in three, group 3 (Figs. 1, 2) in 31, and group 4 in 11. Follow-up radiographs were classified as Stulberg class 1 in 13, class 2 (Fig. 2) in 21, class 3 (Fig. 1) in 12, and class 4 in two (Table 1).

Catterall classification at initial MR imaging showed a

Table 2. MR Imaging and Radiographic Classification in 41 Patients with Legg-Calve-Perthes Disease

Patients	Sex	Age	Catterall Groups on Initial Radiographs	Catterall Groups on Initial MR Imaging	Stulberg Classes on Follow-up Radiographs
1	Boy	6	2	3	3
			4	2	1
2	Boy	6	2	3	1
3	Boy	9	3	3	2
4	Boy	6	4	4	2
5	Boy	7	4	3	2
			4	4	3
6	Boy	4	3	3	2
			2	3	2
7	Boy	10	2	3	3
8	Boy	3	4	3	1
			3	1	1
9	Boy	6	3	3	3
10	Boy	10	4	3	2
11	Boy	9	4	3	1
12	Boy	6	4	4	4
13	Girl	4	3	3	1
14	Boy	4	3	1	1
15	Boy	5	1	2	2
16	Boy	5	4	4	2
17	Boy	7	4	4	3
18	Boy	9	2	4	2
19	Boy	4	3	3	1
			3	3	2
20	Boy	6	4	4	2
21	Boy	7	3	3	2
22	Boy	6	3	3	1
23	Boy	7	3	3	2
24	Boy	4	2	3	2
25	Boy	3	2	2	1
			4	4	2
26	Girl	3	3	3	2
27	Boy	5	3	3	3
28	Boy	8	3	3	3
29	Boy	7	3	3	2
30	Boy	8	2	3	1
31	Boy	6	1	1	1
32	Boy	8	3	3	3
33	Boy	6	3	3	1
34	Boy	8	2	3	3
35	Girl	10	1	3	4
36	Boy	5	3	3	2
37	Girl	6	3	3	3
38	Boy	7	4	4	2
39	Boy	6	4	4	2
40	Boy	6	4	4	3
			3	3	3
41	Girl	4	3	3	2

moderate correlation with Stulberg classification at follow-up radiographs ($r = 0.39$, $p < 0.01$), however there was no significant correlation between Catterall classification at initial radiographs and Stulberg classification at follow-up radiographs ($r = 0.001$, $p = 0.995$). There was a moderate correlation between Catterall classification at plain radiographs and MR imaging ($r = 0.55$, $p < 0.001$). A majority of our patients had a good outcome as determined by maintenance of a spherical configuration of the femoral head (Stulberg class 1 or 2).

Among three cases with group 1 on plain radiographs, there were group 1 (n = 1), group 2 (n = 1), and group 3 (n = 1) on MR imaging. Among nine cases with group 2 on plain radiographs, there were group 2 (n = 1), group 3 (n = 7), and group 4 (n = 1) on MR imaging. Among 21 cases with group 3 on plain radiographs, there were group 1 (n = 2), and group 3 (n = 19) on MR imaging. Among 15 cases with group 4 on plain radiographs, there were group 2 (n = 1), group 3 (n = 4), and group 4 (n = 10) on MR imaging (Table 2). Catteral groups of MR imaging were lower (15%), equal (64%) or greater(21%) than those of plain radiographs.

Discussion

Legg-Calve-Perthes disease can lead to painful and disabling osteoarthritis in adulthood. Identification of patients who are at risk for this complication has been the purpose of a number of studies and imaging grading systems (3, 6, 8–10, 12–15). The Catterall and Stulberg classification systems have been used to evaluate radiographs to predict the likelihood of a poor prognosis and the need for early intervention. The Catterall classification of the extent of involvement has been shown to predict outcome at the time of the maximum radiographic resorption of the femoral head epiphysis often occurring many months after the appearance of the first radiographic signs of the disease (3, 4, 6, 10, 14, 15). Early treatment offers the possibility of favorable outcome, particularly in the early phases of Catteral group 4 involvement (9, 10, 13). The Stulberg classification has been used to describe the presence and severity of deformity of the femoral head with Stulberg classification of greater than 2 indicative of loss of spherical configuration of the femoral head and increased likelihood of disability due to osteoarthritis in adulthood. Unfortunately the degree of involvement or deformity of the femoral head is best determined months to years after the diagnosis at the end of the fragmentation phase because radiographic deformity often progresses after diagnosis (12). Thus, classification based on radiographs is of more prognostic significance in a relatively late phase of the disease. It would be helpful in the management of the patients to determine prognosis earlier in the disease process.

In our study, Catterall classification at time of diagnosis at MR imaging fairly correlated with the Stulberg classification on follow-up radiographs, whereas there was no correlation between Catterall classification at initial radiographs and Stulberg classification at follow-up radiographs. Thus at the time of diagnosis of Legg Calve Perthes disesase, we could predict prognosis with MR imaging. Catteral groups of MR imaging were equal or greater than those of plain radiographs in 85% of our cases. Our results are consistent with prior reports (1, 2, 5, 7, 8) that MR imaging showed the total extent of necrosis more sensitively than radiographs. In contrast to a previous report (7) that MR imaging failed to indicate necrosis detected on radiographs among 22 patients, early in the course of the disease, there were no false negative cases in our study.

This study had several limitations. The ultimate outcome of patients was not measured in this study. Long term follow up into adulthood would be needed. A second limitation was the use of consensus reading for determining Catterall group and Stulberg classification. Consensus was used because interobserver variance has been described as high in classifying Catterall groups and Stulberg classes (6, 11). Observer variability could result in a poorer outcome when only one observer interprets images. A third limitation was the relatively small patient population.

In conclusion, MR imaging was more helpful in predicting prognosis of Legg-Calve-Perthes disease than plain radiography at the time of diagnosis.

References

1. Bluemm RG, Falke TH, Ziedses des Plantes BG Jr, Steiner RM. Early Legg-Perthes disease (ischemic necrosis of the

femoral head) demonstrated by magnetic resonance imaging. Skeletal Radiol 1985;14:95-98
2. Bos CF, Bloem JL, Bloem RM. Sequential magnetic resonance imaging in Perthes' disease. J Bone Joint Surg Br 1991;73:219-224
3. Catterall A. The natural history of Perthes' disease. J Bone Joint Surg Br 1971;53:37-53
4. Catterall A, Pringle J, Byers PD. et al. A review of the morphology of Perthes' disease. J Bone Joint Surg Br 1982;64:269-275
5. Dwyer AJ. Matchmaking and McNemar in the comparison of diagnostic modalities. Radiology 1991;178:328-330
6. Hardcastle PH, Ross R, Hamalainen M, Mata A. Catterall grouping of Perthes' disease: as assessment of observer error and prognosis using the Catterall classification. J Bone Joint Surg Br 1980;62:428-431
7. 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
8. Lahdes-Vasama T, Lamminen A, Merikanto J, Marttinen E. The value of MRI in early Perthes' disease: an MRI study with a 2-year follow-up. Pediatr Radiol 1997;27:517-522
9. Lloyd-Roberts GC, Catterall A, Salamon PB. A controlled study of the indications for and the results of femoral osteotomy in Perthes' disease. J Bone Joint Surg Br 1976;58:31-36
10. Muirhead-Allwood W, Catterall A. The treatment of Perthes' disease. The results of a trial of management. J Bone Joint Surg Br 1982;64:282-285
11. Neyt JG, Weinstein SL, Spratt KF. et al. Stulberg classification system for evaluation of Legg-Calve-perthes disease: intra-rater and inter-rater reliability. J Bone Joint Surg Am 1999;81:1209-1216
12. Oshima M, Yoshihasi Y, Ito K, Asai H, Fukatsu H, Sakuma S. Initial stage of Legg-Calve-Perthes disease: comparison of three-phase bone scintigraphy and SPECT with MR imaging. Eur J Radiol 1992;15:107-112
13. Salter RB, Thompson GH. Legg-Calve-Perthes disease. The prognostic significance of the subchondral fracture and a two-group classification of the femoral head involvement. J Bone Joint Surg Am 1984;66:479-489
14. Stulberg SD, Cooperman DR, Wallensten R. The natural history of Legg-Calve-Perthes disease. J Bone Joint Surg Am 1981;63:1095-1108
15. Van Dam BE, Crider RJ, Noyes JD, Larsen LJ. Determination of the Catterall classification in Legg-Calve-Perthes disease. J Bone Joint Surg Am 1981;63:906-914

대한자기공명의과학회지 12:153-160(2008)

초기의 단순 X선 촬영술 대 자기공명영상: 소아성 대퇴골두 무혈성 괴사증에서 예후 예측성 비교

[1]가톨릭대학교 강남성모병원 영상의학과
[2]가톨릭대학교 강남성모병원 정형외과

이선진[1] · 지원희[1] · 조송미[1] · 정창훈[2] · 옥인영[2]

목적: 소아성 대퇴골두 무혈성 괴사증의 추적 단순 X선 촬영술에서 대퇴 골단의 구형 모양을 유지하는 것을 기준으로 좋은 예후를 기대할 수 있는 환자를 찾는데에 자기공명영상이 진단당시 단순 X선 촬영술보다 우월한지 여부를 알아보기 위함이 목적이다.

대상 및 방법: 소아성 대퇴골두 무혈성 괴사증을 가진 41명의 환자에서 48예의 대퇴 골두의 진단 당시 단순 X선 촬영술과 자기공명영상을 후향적으로 분석하였다. 대퇴 골두 침범은 초기 단순 X선 촬영술과 자기공명영상을 Catterall 분류를 이용하여 평가하였다. 최대 대퇴 골두 변형으로 결정되는 예후는 추적 단순 X선 촬영술에서 Stulberg 분류에 의해 평가되었다.

결과: 자기공명영상에서 Catterall 분류가 1보다 큰 경우에는 추적 단순 X선 촬영술에서 대퇴 골두 기형의 나쁜 예후 (Stulberg class〉2) 를 보이는 환자를 발견하는 데에 100% 민감도 (14/14) 을 보였다. 단순 X선 촬영술에서는 57% (8/14) 의 낮은 민감도를 보였다. 자기공명영상의 특이도는 21% (7/34) 였고, 단순 X선 촬영술의 특이도인 32%(11/34) 와 유의한 차이를 보이지 않았다.

결론: 자기공명영상에서 Catterall 분류1은 소아성 대퇴골두 무혈성 괴사증의 좋은 예후를 시사한다. 대퇴 골두의 더욱 광범위한 침범을 가진 환자들도 좋은 결과를 보일 수 있으나, 그들은 대퇴 골두의 구형 모양을 소실하고 수반되는 골관절염을 성인에서 보일 위험성이 있다. 자기공명영상은 좋은 예후를 가진 환자 집단을 파악하는데 단순 X선 촬영술보다 우월하다.

통신저자 : 지원희, (137-701) 서울시 서초구 반포동 505, 가톨릭대학교 강남성모병원 영상의학과
Tel. 82-2-590-2784 Fax. 82-2-599-6771 E-mail: whjee@catholic.ac.kr