Case Reports

Anteroinferior Acetabular Rim Damage Due to Femoroacetabular Impingement

Lisa M. Tibor MD, Reinhold Ganz MD,
Michael Leunig MD

Published online: 19 March 2013
© The Association of Bone and Joint Surgeons® 2013

Abstract

Background The most common location of labral tears and chondral damage in the hip is the anterosuperior region of the acetabulum, which is associated with pain in flexion and rotation. We describe a case series of patients with labral tears, ganglion formation, and chondromalacia isolated to the anteroinferior acetabulum. Clinically, patients had pain in extension and internal rotation.

Case Descriptions Isolated anteroinferior labral hypertrophy and ganglion were first observed in a patient with coxa valga. We retrospectively reviewed clinical and radiographic records and identified nine hips in seven

patients with isolated anteroinferior damage. One patient with bilateral valgus femoral head tilt after slipped capital femoral epiphysis (SCFE) had impingement of the antero-medial metaphysis on the acetabulum from 3 to 6 o'clock. Five of seven had valgus neck-shaft angles and all had acetabular anteversion with damage isolated to the anteroinferior acetabular rim.

Literature Review Series on the diagnostic efficacy of MR arthrogram have noted anteroinferior damage adjacent to superior acetabular rim lesions. However, these do not describe isolated anteroinferior rim damage. In addition, available case series of patients with valgus SCFE do not describe a location of impingement or intraarticular damage.

Purposes and Clinical Relevance In this small case series of patients with isolated anteroinferior chondrolabral damage, there are two potential causative mechanisms: (1) primary anteroinferior impingement with femoral extension and internal rotation and (2) posterior extraarticular ischio-trochanteric impingement causing secondary anterior instability of the femur. The pathoanatomy appears to be multifactorial, necessitating an individualized treatment approach.

Each author certifies that he or she, or a member of his or her immediate family, has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request.

Each author certifies that his or her institution approved or waived approval for the reporting of these cases and that all investigations were conducted in conformity with ethical principles of research. This work was performed at the Department of Orthopaedic Surgery, Schulthess Clinic, Zürich, Switzerland, and Department of Orthopaedic Surgery, University of Bern, Bern, Switzerland.

L. M. Tibor (✉)
Zurich, Switzerland
e-mail: lisa.tibor@gmail.com

R. Ganz
Emeritus, Faculty of Medicine, University of Bern,
Bern, Switzerland

M. Leunig
Department of Orthopaedic Surgery, Schulthess Clinic,
Zürich, Switzerland

Introduction

Most labral abnormalities in patients with either femoroacetabular impingement (FAI) or dysplasia are anterosuperior or directly anterior [2, 10, 11, 13, 15, 17, 23]. Impingement and instability can, however, occur circumferentially around the acetabular rim [2, 11] and can also be initiated extraarticularly, causing secondary intraarticular damage [5, 9, 14]. The cause of more unusual patterns of FAI is multifactorial and results from a combination of

structural factors. In up to $\frac{1}{3}$ of patients with FAI, the pathoanatomy causing the impingement can only be visualized on radial MRI sequences or three-dimensional (3-D) CT reconstructions [6, 7, 29]. For some patients, 3-D simulations of hip motion are also helpful for elucidating the probable cause of the labral damage [3, 4, 16].

During the past decade, we have observed a subset of patients with isolated anteroinferior acetabular rim damage. Although anteroinferior acetabular chondrolabral damage has been observed in previous MRI series [31, 38], in those series, it was found in conjunction with anterosuperior pathology and likely represents worsening of more typical anterosuperior FAI. Anteroinferior sublabral sulci have also been described [30, 35], although Studler et al. [35] suggested these are normal variants and not pathologic. The cause of isolated anteroinferior damage appears to result from two different mechanisms. Some of the patients have a relative prominence of the anterior inferior femoral metaphysis that contacts the anterior acetabular rim when the hip is in extension and internal rotation. Other patients have a combination of anatomy that predisposes them to ischiofemoral impingement (intra- or extraarticular), causing secondary anteroinferior instability.

The purpose of this paper is to describe a case series of patients with isolated anteroinferior acetabular rim damage, including their clinical presentation, typical physical examination findings, radiographic findings, intraoperative pathology, and treatment. Just as the causes of isolated anteroinferior acetabular rim damage are multifactorial, so too are the appropriate treatments.

Case Series With Representative Patients

We identified seven patients with isolated anteroinferior chondrolabral damage in nine hips over the course of 10 years (clinical findings and intraoperative observations: Table 1; radiographic findings: Table 2; outcomes at latest followup: Table 3). Patients were selected for inclusion in the series if they were being treated for acetabular chondrolabral pathology and the damage was localized to the anteroinferior quadrant of the acetabulum (Table 1). Two representative patients (Patients 1 and 3) were selected for further discussion of their intraoperative findings and treatment. We reviewed AP pelvis radiographs and, when available, MR arthrograms and operative reports to obtain further information about causative pathology. Five of seven patients had high neck-shaft angles (140° , coxa valga), one had bilateral valgus head tilt [36], and all had acetabular anteversion (Table 2). Femoral version measurements were not available. Three patients had borderline dysplasia (Patients 5, 6, and 7). In the operative reports, two female patients were hypermobile (Patients 4 and 5).

The most pain was provoked with the hip in extension and internal rotation. Patients had less pain or no pain when the hip was flexed. Stride length was limited.

In February 2013, all patients were contacted by telephone to obtain Oxford Hip Scores (OHS) [25], scores for the sport scale of the Hip Outcomes Score (HOS) [24], and the answer to the Global Treatment Outcome question “How much did the operation help your hip problem?” (helped a lot, helped, helped only a little, didn’t help, made things worse) [12, 22] (Table 3). Validated preoperative outcomes data were not available for comparison. Five of seven patients were able to be contacted; all patients were more than 4 years postoperative, with the index patient being 8 years postoperative. All patients reported the operation helped or helped a lot, with OHS and HOS greater than 90 (of 100) except for one patient who reported sports ability of 30 on the HOS.

Patient 1

Patient 1 was a 33-year-old woman with right hip pain (Table 1). On examination, her pain was primarily provoked with hip extension and internal rotation. Radiographs demonstrated a coxa valga hip (neck-shaft angle of 139°) with a high fovea and an intraosseous ganglion in the superior pubic ramus (Fig. 1A–C). The lateral center-edge angle was 23° , but the Tönnis angle was normal and the sourcil was balanced over the femoral head. Labral degeneration was evident only anteroinferiorly. Although the patient had similar bony anatomy visible radiographically on the left, the left hip was asymptomatic. Because the labral pathology was believed to result from coxa valga causing the metaphysis to be prominent and resulting in impingement on the anteroinferior acetabulum, the patient underwent labral refixation and a varus femoral neck osteotomy using the surgical hip dislocation approach [9]. Intraoperatively, the anteromedial metaphysis was observed to impinge on the anteroinferior acetabulum. Eight years postoperatively, her pain and symptoms had resolved entirely and the left hip remained asymptomatic. Radiographs revealed healing of the osteotomy with no major signs of degenerative change (Fig. 1D).

Patient 3

Patient 3, a 15-year-old boy, had valgus slipped capital femoral epiphyses (SCFE) (Fig. 2A). AP pelvis radiographs demonstrated coxa valga (neck-shaft angles of 169° and 168°) and valgus slips with prominent metaphyses. He underwent staged bilateral open reduction of the epiphyses (modified Dunn operation; Fig. 2B) using surgical hip dislocations [20, 39].

Table 1. Clinical characteristics and intraoperative observations of the patients

Patient	Age (years), sex	Side	Treatment	Intraoperative findings
1	33, female	Right	SHD, varus femoral neck osteotomy	Cam impingement of metaphysis on anteroinferior acetabulum with hip extension and internal rotation
2	45, female	Right	SHD, varus femoral neck osteotomy, labral refixation	Severe labral degeneration with large intralabral ganglion formation limited to the area between 3 and 6 o'clock; chondromalacia in a 5-mm-wide strip adjacent to the degenerative labrum
3	15, male	Left	SHD, reduction and pinning of valgus SCFE	Superficial chondromalacia anteriorly and inferiorly
		Right	SHD, reduction and pinning of valgus SCFE	Inferior metaphyseal contact with acetabular rim in extension and internal rotation, plastic deformation of labrum, cartilage abrasion anteroinferiorly, ventral callus formation
4	17, female	Left	SHD, labral débridement and refixation	Professional equestrian, hypermobile, anteroinferior labral degeneration
		Right	SHD, labral débridement and refixation	Anteroinferior labral degeneration with long ligamentum teres, 3 mm of cartilage degeneration at rim
5	37, female	Right	Arthroscopy, labral débridement	Hypermobile, labral ganglion anteriorly, borderline undercoverage
6	40, male	Left	Arthroscopy, labral débridement, microfracture of acetabular rim	Lipoid degeneration of labrum, with undersurface rupture anteriorly, poor-quality labral tissue with acetabulum and femoral head cartilage changes
7	19, female	Left	Arthroscopy, labral stabilization, osteochondroplasty	Cam-type FAI, anterior head-neck junction

SHD = surgical hip dislocation; SCFE = slipped capital femoral epiphysis; FAI = femoroacetabular impingement

Table 2. Radiographic parameters and MRI findings

Patient	Age (years), sex	Side	Radiographic measurements			Preoperative MRI findings
			Neck-shaft angle (°)	Lateral center-edge angle (°)	Acetabular anteversion (°)	
1	33, female	Right	139	23	25	Labral hypertrophy anteroinferiorly, intraosseous ganglia visible on CT in superior pubic ramus
2	45, female	Right	141	28	27	Anterior labral hypertrophy and ganglia 12 to 6 o'clock
3	15, male	Left	169	30	13	Increased signal superior labrum, physeal edema
		Right	168	27	19	Physeal edema
4	17, female	Left	139	33	21	Anterior labral hypertrophy, degeneration, and ganglion
		Right	136	27	22	Inferior labral ganglion, small anterior labral ganglion, labral hypertrophy and degeneration
5	37, female	Right	131	21	21	Large anteroinferior ganglion with very small appearance of remaining labrum
6	40, male	Left	148	17	16	Bony edema at anterior acetabular rim, anterior labral degeneration
7	19, female	Left	133	20	16	Anteroinferior labral ganglion, intact superior labrum and cartilage

Intraoperatively, findings were similar for both hips, with prominence of the inferior metaphysis and contact between the anteromedial metaphysis and anteroinferior acetabulum with the hip in extension and internal rotation. Corresponding chondromalacia was visible only anteroinferiorly (Fig. 2C–D). In both operations, reduction of the epiphysis corrected the valgus position of the head and eliminated the impingement between the metaphysis and acetabulum so no further bony corrections were performed. Four years postoperatively, the

patient stated the operation had helped a lot and reported OHS and sport HOS scores of 97.9 and 95 (of 100).

Discussion

We present a series of seven patients with isolated anteroinferior acetabular chondrolabral damage. We have found no previous descriptions of isolated damage to this

Table 3. Outcome of treatment

Patient	Age (years), sex	Side	Time postoperative at last followup	Oxford Hip Score (points) (of 100)	Global Treatment Outcome	Hip Outcome Score for Sport (points) (of 100)
1	33, female	Right	8 years, 0 months	100	Helped a lot	90
2	45, female	Right	Lost to followup	Unknown		
3	15, male	Bilateral	4 years, 5 months	97.9	Helped a lot	95
4	17, female	Bilateral	5 years, 3 months	100	Helped a lot	100
5	37, female	Right	4 years, 8 months	93.8	Helped	90
6	40, male	Left	4 years, 2 months	91.7	Helped	30
7	19, female	Left	Lost to followup	Unknown		

Fig. 1A–D (A) An AP pelvis radiograph shows the hips of Patient 1, a 33-year-old woman with coxa valga, high fovea, and pain with hip extension and internal rotation. (B) Radial and (C) sagittal MR arthrography sequences demonstrate anteroinferior labral degeneration with intraosseous and intralabral ganglion formation (arrow).

region—the acetabular rim and adjacent cartilage area. We suggest, depending on the specific pathoanatomy, the damage can be caused by FAI or instability.

This series is limited by its small size relating to the low frequency of the disease and the variability of the anatomic

(D) The patient underwent a surgical hip dislocation, labral refixation, and varus femoral neck osteotomy. Postoperatively, she had complete resolution of symptoms and a 6-year followup radiograph demonstrates complete bony healing with no joint space narrowing.

factors that we believe cause this pattern of anteroinferior acetabular damage. The common anatomy seems to be valgus morphology either of the femoral neck and/or of the head with respect to the femoral neck. As a result, surgical treatment of the underlying pathoanatomy was variable,

Fig. 2A–D (A) An AP pelvis radiograph shows the hips of Patient 3, a 15-year-old boy with bilateral valgus SCFE and resultant antero-inferior impingement from the relative prominence of the medial metaphysis (arrows). (B) An AP pelvis radiograph shows the hips after bilateral surgical hip dislocations with reduction and internal fixation of the slipped epiphyses. Intraoperative photographs show

(C) the medial metaphysis is prominent, with stretching of the periosteum over the rough surface of the metaphysis (arrow), and (D) there is corresponding chondromalacia located only at the anteroinferior aspect of the acetabulum (arrow), consistent with impingement and damage from the medial metaphysis.

ranging from varus osteotomy to femoral neck osteoplasty or acetabular rim trimming. Although the purpose of this paper was not specifically to describe treatment, we were able to obtain telephone followup from five of seven patients, all of whom were more than 4 years postoperative. Using these validated patient-specific outcome measures, the five patients followed reported generally high function 4 years or more after their procedures. One patient reported 30 for the sport scale of the HOS, apparently still has difficulty with sport although his OHS was 91.7 of 100, and stated the operation helped his hip problem.

Chondrolabral damage in the hip most commonly occurs on the anterosuperior acetabular rim [2, 10, 11, 13, 15, 17, 23]. This is true for damage from both FAI and dysplasia.

The most common location of the cam lesion is anterosuperior, between 12 and 3 o'clock on the femoral neck [7, 27, 29], which contacts either the acetabular rim [3, 4, 10] or the base of the anterior inferior iliac spine [16]. Similarly, classic acetabular dysplasia involves lateral and anterior undercoverage, causing static overload on the anterior and superior rim in stance with resultant anterosuperior rim damage [15]. Anteroinferior acetabular chondrolabral pathology has been observed in series evaluating the diagnostic effectiveness of MR arthrography [31, 38]. In both of these series, greater than 90% of labral tears were in the superior labrum with anteroinferior chondrolabral pathology noted in 5% to 20% of included tears [31, 38]. Given the large number of superior labral tears, we suspect the majority of the anteroinferior tears

seen in these series were observed in association with a superior tear and represent a worsening of the initial chondrolabral lesion. In contrast, the anteroinferior lesions observed in our patients occurred in isolation and thus are unusual. Some of these patients had impingement that could be reproduced intraoperatively, whereas others appeared to have chondrolabral hypertrophy and ganglia formation more consistent with an instability mechanism [19, 34]. In contrast to typical FAI, where pain is primarily provoked with hip flexion and internal rotation, the position provoking the most pain in these patients was extension and internal rotation. For some of these patients, this was due to a directly observed impingement mechanism. We suspect that some of our patients had excessive femoral anteversion with posterior ischiofemoral impingement and secondary anteroinferior instability. In these patients, we hypothesize that the instability caused anteroinferior abrasion of the cartilage with rupture and degeneration of the labrum, similar to a posteroinferior contre-coup lesion that can be seen with anterior pincer impingement [2]. Extraarticular impingement has been described in the arthroplasty literature [5, 14], and there are a few case reports of ischiofemoral impingement, although primarily from the lesser trochanter rather than from the greater trochanter [1, 26, 37]. Extraarticular impingement has also been recognized in the context of Legg-Calvé-Perthes deformity, where the relative overgrowth of the greater trochanter impinges on the iliac wing when the hip is abducted [8]. In the native hip, extraarticular impingement causing secondary instability is a novel concept. Once the lesion had occurred, extension and rotation caused the metaphyseal part of the head to contact the inflamed and damaged rim, which provoked pain.

Our series is also notable for the inclusion of a patient with valgus SCFE. Although valgus SCFE has been described in the literature [21, 32], this is the first description of the site of the intraarticular pathology in a valgus slip. Several series have described FAI occurring after typical SCFE [18, 33, 39]. Depending on the degree of the slip, the prominent metaphysis causes an inclusion or an impaction type of injury to the acetabulum [18, 28, 33]. In comparison, valgus SCFE is much more rare [32] and case series of valgus SCFE have used in situ pinning for treatment, eliminating the ability to directly observe a site of impingement [21, 32]. One might expect, however, that a valgus slip would also produce a metaphyseal prominence that might in turn cause FAI and subsequent chondrolabral damage as observed for our patient.

Isolated anteroinferior acetabular rim pathology is uncommon. We propose two primary causative mechanisms: (1) primary anteroinferior impingement with femoral extension and internal rotation, occurring from prominence of the medial femoral metaphysis and/or

anteroinferior border of the acetabulum, and (2) posterior extraarticular ischiofemoral impingement causing secondary anterior instability of the femur in extension. Irrespective of the exact mechanism, the causative structural pathoanatomy is multifactorial and unique to the individual. This necessitates an individualized treatment approach toward the primary structural problem(s), in addition to treatment of the chondrolabral damage.

Acknowledgments We thank Franco Impellizzeri PhD for his assistance with outcomes data collection.

References

1. Ali AM, Whitwell D, Ostlere SJ. Case report: imaging and surgical treatment of a snapping hip due to ischiofemoral impingement. *Skeletal Radiol.* 2011;40:653–656.
2. Beck M, Kalhor M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of osteoarthritis of the hip. *J Bone Joint Surg Br.* 2005;87:1012–1018.
3. Bedi A, Dolan M, Hetsroni I, Magennis E, Lipman J, Buly R, Kelly BT. Surgical treatment of femoroacetabular impingement improves hip kinematics in a computer-assisted model. *Am J Sports Med.* 2011;39(suppl 1):43S–49S.
4. Bedi A, Dolan M, Magennis E, Lipman J, Buly R, Kelly BT. Computer-assisted modeling of osseous impingement and resection in femoroacetabular impingement. *Arthroscopy.* 2012;28:204–210.
5. Bunn A, Colwell CW, D'Lima DD. Bony impingement limits design-related increases in hip range of motion. *Clin Orthop Relat Res.* 2012;470:418–427.
6. Dolan MM, Heyworth BE, Bedi A, Duke G, Kelly BT. CT reveals a high incidence of osseous abnormalities in hips with labral tears. *Clin Orthop Relat Res.* 2011;469:831–838.
7. Dudda M, Albers C, Mamisch TC, Werlen S, Beck M. Do normal radiographs exclude asphericity of the femoral head-neck junction? *Clin Orthop Relat Res.* 2009;467:651–659.
8. Eijer H, Podeszwa DA, Ganz R, Leunig M. Evaluation and treatment of young adults with femoroacetabular impingement secondary to Perthes' disease. *Hip Int.* 2006;16:273–280.
9. Ganz R, Huff TW, Leunig M. Extended retinacular soft-tissue flap for intra-articular hip surgery: surgical technique, indications, and results of application. *Instr Course Lect.* 2009;58:241–255.
10. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock K. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res.* 2003;417:112–120.
11. Haene RA, Bradley M, Villar RN. Hip dysplasia and the torn acetabular labrum: an inexact relationship. *J Bone Joint Surg Br.* 2007;89:1289–1292.
12. Impellizzeri FM, Mannion AF, Naal FD, Hersche O, Leunig M. The early outcome of surgical treatment for femoroacetabular impingement: success depends on how you measure it. *Osteoarthritis Cartilage.* 2012;20:638–645.
13. Ito K, Leunig M, Ganz R. Histopathologic features of the acetabular labrum in femoroacetabular impingement. *Clin Orthop Relat Res.* 2004;429:262–271.
14. Kessler O, Patil S, Wirth S, Mayr E, Colwell CW Jr, D'Lima DD. Bony impingement affects range of motion after total hip arthroplasty: a subject-specific approach. *J Orthop Res.* 2008;26:443–452.
15. Klaue K, Durning CW, Ganz R. The acetabular rim syndrome: a clinical presentation of dysplasia of the hip. *J Bone Joint Surg Br.* 1991;73:423–429.

16. Larson CM, Kelly BT, Stone RM. Making a case for anterior inferior iliac spine/subspine hip impingement: three representative case reports and proposed concept. *Arthroscopy*. 2011;27:1732–1737.
17. Leunig M, Beck M, Woo A, Dora C, Kerboul M, Ganz R. Acetabular rim degeneration: a constant finding in the aged hip. *Clin Orthop Relat Res*. 2003;413:201–207.
18. Leunig M, Casillas MM, Hamlet M, Hersche O, Nötzli H, Slongo T, Ganz R. Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. *Acta Orthop Scand*. 2000;71:370–375.
19. Leunig M, Podeszwa D, Beck M, Werlen S, Ganz R. Magnetic resonance arthrography of labral disorders in hips with dysplasia and impingement. *Clin Orthop Relat Res*. 2004;418:74–80.
20. Leunig M, Slongo T, Ganz R. Subcapital realignment in slipped capital femoral epiphysis: surgical hip dislocation and trimming of the stable trochanter to protect the perfusion of the epiphysis. *Instr Course Lect*. 2008;57:499–507.
21. Loder RT, O'Donnell PW, Didelot WP, Kayes KJ. Valgus slipped capital femoral epiphysis. *J Pediatr Orthop*. 2006;26:594–600.
22. Mannion AF, Porchet F, Kleinstuck FS, Lattig F, Jeszenszky D, Bartanusz V, Dvorak J, Grob D. The quality of spine surgery from the patient's perspective. Part 2. Minimal clinically important difference for improvement and deterioration as measured with the Core Outcome Measures Index. *Eur Spine J*. 2009;18(suppl 3):374–379.
23. McCarthy J, Noble P, Aluisio FV, Schuck M, Wright J, Lee J. Anatomy, pathologic features, and treatment of acetabular labral tears. *Clin Orthop Relat Res*. 2003;406:38–47.
24. Naal FD, Impellizzeri FM, Miozzari HH, Mannion AF, Leunig M. The German Hip Outcome Score: validation in patients undergoing surgical treatment for femoroacetabular impingement. *Arthroscopy*. 2011;27:339–345.
25. Naal FD, Sieverding M, Impellizzeri FM, von Knoch F, Mannion AF, Leunig M. Reliability and validity of the cross-culturally adapted German Oxford hip score. *Clin Orthop Relat Res*. 2009;467:952–957.
26. Patti JW, Ouellette H, Bredella MA, Torriani M. Impingement of lesser trochanter on ischium as a potential cause for hip pain. *Skeletal Radiol*. 2008;37:939–941.
27. Pfirrmann CW, Mengiardi B, Dora C, Kalberer F, Zanetti M, Hodler J. Cam and pincer femoroacetabular impingement: characteristic MR arthrogram findings in 50 patients. *Radiology*. 2006;240:778–785.
28. Rab GT. The geometry of slipped capital femoral epiphysis: implications for movement, impingement, and corrective osteotomy. *J Pediatr Orthop*. 1999;19:419–424.
29. Rakhra KS, Sheikh AM, Allen D, Beaulé PE. Comparison of MRI alpha angle measurement planes in femoroacetabular impingement. *Clin Orthop Relat Res*. 2009;467:660–665.
30. Saddik D, Troups J, Tirman P, O'Donnell J, Howells R. Prevalence and location of acetabular sublabral sulci at hip arthroscopy with retrospective MRI review. *AJR Am J Roentgenol*. 2006;187:W507–W511.
31. Schmid MR, Nötzli HP, Zanetti M, Wyss TF, Hodler J. Cartilage lesions in the hip: diagnostic effectiveness of MR arthrography. *Radiology*. 2003;226:382–386.
32. Shank CF, Thiel EJ, Klingele KE. Valgus slipped capital femoral epiphysis: prevalence, presentation, and treatment options. *J Pediatr Orthop*. 2010;30:140–146.
33. Sink EL, Zaltz I, Heare T, Dayton M. Acetabular cartilage and labral damage observed during surgical hip dislocation for stable slipped capital femoral epiphysis. *J Pediatr Orthop*. 2010;30:26–30.
34. Stelzeneder D, Mamisch TC, Kress I, Domayer SE, Werlen S, Bixby SD, Millis MB, Kim YJ. Patterns of joint damage seen on MRI in early hip osteoarthritis due to structural hip deformities. *Osteoarthritis Cartilage*. 2012;20:661–669.
35. Studler U, Kalberer F, Leunig M, Zanetti M, Hodler J, Dora C, Pfirrmann CW. MR arthrography of the hip: differentiation between an anterior sublabral recess as a normal variant and a labral tear. *Radiology*. 2008;249:947–954.
36. Taussig G, Delor MH, Masse P. [Growth disturbances of the upper femoral extremity: contribution to knowledge of normal growth in therapeutic trials] [in French]. *Rev Chir Orthop Reparatrice Appar Mot*. 1976;62:191–210.
37. Tosun O, Alkgin O, Yalcin N, Cay N, Ocakoglu G, Karaoglanoglu M. Ischiofemoral impingement: evaluation with new MRI parameters and assessment of their reliability. *Skeletal Radiol*. 2012;41:575–587.
38. Yoon LS, Palmer WE, Kassarian A. Evaluation of radial-sequence imaging in detecting acetabular labral tears at hip MR arthrography. *Skeletal Radiol*. 2007;36:1029–1033.
39. Ziebarth K, Zilkens C, Spencer S, Leunig M, Ganz R, Kim YJ. Capital realignment for moderate and severe SCFE using a modified Dunn procedure. *Clin Orthop Relat Res*. 2009;467:704–716.