Original Article with Video Illustration

Radiographic, Histologic, and Arthroscopic Findings in Amorphous Calcifications of the Hip Labrum

Timothy J. Jackson, M.D., Christine E. Stake, M.A., Jennifer C. Stone, M.A., Dror Lindner, M.D., Youssef F. El Bitar, M.D., and Benjamin G. Domb, M.D.

Purpose: The purpose of this study was to evaluate the clinical, radiographic, histologic, and intraoperative findings of an amorphous calcification involving the acetabular labrum. **Methods:** From October 2008 to April 2013, all patients who underwent arthroscopic hip surgery for symptomatic intra-articular hip disorders and were found to have the characteristic calcific deposit involving the acetabular labrum were included. These patients were reviewed retrospectively on prospectively collected data. Radiographs were retrospectively evaluated for morphologic features of impingement and characteristics of labral calcification. **Results:** Sixteen patients were identified as having amorphous calcification at the time of arthroscopy. There were 15 women and 1 man. Mean age was 37.3 years (range, 30 to 50 years). Symptoms were present for a mean of 9.3 months (range, 3 to 48 months). All patients reported anterior groin pain. Fifteen (94%) patients had positive anterior impingement and 9 (56%) had positive results for lateral impingement. Calcifications measured on average 3.2 mm (range, 1.9 mm to 5.6 mm), and 14 had a clear separation from the rim with increased opacity compared with neighboring trabecular bone. Intraoperatively, the characteristic amorphous calcium deposit was located in the anterosuperior labrum, with the deposit found to be accessible from the capsule-labral recess in all cases. All patients had labral tears and all patients had at least one component of femoroacetabular impingement (FAI). **Conclusions:** Calcification in the anterosuperior acetabular labrum presents with a consistent patient demographic and distinct radiographic and arthroscopic presentation that is different from os acetabuli. As with os acetabuli, one should have a high suspicion for FAI when this lesion is encountered. **Level of Evidence:** Level IV, therapeutic case series.

Recently, with the progression of hip arthroscopy and the treatment of femoroacetabular impingement (FAI) and labral tears, the acetabular labrum has been studied more often. The function of the labrum is primarily as a suction seal for the articulation between the femoral head and the acetabulum, providing stability through negative pressure and protecting cartilage by preventing egress of joint fluid.[1,2] The labrum also acts to deepen the socket, increase contact area, and prevent lateral migration of the femoral head.[1] Histologic studies have shown nerve endings located throughout the labrum, which can account for the source of pain in a variety of hip disorders in which the labrum becomes torn or damaged.[3,4]

Os acetabuli are thought to arise from unfused secondary ossification centers or as rim fractures in the setting of FAI. In previous studies, rim fractures were consistently described as having a vertically oriented gap between the fragment and stable rim, and magnetic resonance imaging (MRI) showed them to be composed of labrum, cartilage, and bone.[5] They tend to be large calcifications, and fixation of these rim fractures has been described.[6]

Calcification as a response to injury is not an uncommon pathophysiologic feature in the musculoskeletal system and has been described in tendons, ligaments, and muscles throughout the body.[7-10] These calcifications do not take on organized specialized features such as bone and cartilage but rather show amorphous calcium deposits. These are described as chondrocyte-mediated disorders as a response to injury or hypoxia.[11] During the study period, we noted a pattern of amorphous calcific deposits within an injured area of the acetabular

From the American Hip Institute (T.J.J., C.E.S., J.C.S., D.L., Y.F.E.B., B.G.D.), Chicago; Hinsdale Orthopaedics (C.E.S., B.G.D.), Hinsdale; and Loyola University Stritch School of Medicine (B.G.D.), Chicago, Illinois, U.S.A.

The authors report the following potential conflict of interest or source of funding: B.G.D. receives support from MAKO Surgical Corp, Arthrex, and the American Hip Institute. Y.F.E.B., T.J.J., D.L., C.E.S., and J.C.S. receive support from the American Hip Institute.

Received May 22, 2013; accepted December 31, 2013.

Address correspondence to Benjamin G. Domb, M.D., Hinsdale Orthopaedics, 1010 Executive Ct, Suite 250, Westmont, IL 60559, U.S.A. E-mail: drdomb@americanhipinstitute.org

0749-8063/13334/$36.00

http://dx.doi.org/10.1016/j.arthro.2013.12.019

labrum in a series of patients. When encountered arthroscopically, these lesions had a characteristic amorphous appearance and were easily expressed from the labrum using a simple probe. To date, there is no study describing this type of calcification involving the acetabular labrum.

The purpose of this article is to describe the clinical presentation, radiographic findings, intraoperative findings, and histologic characteristics of this calcification to better describe this entity in the hope of understanding when and why it occurs. Our hypothesis was that this amorphous calcification would have distinct characteristics, different from os acetabuli, based on imaging studies and intraoperative findings and with a high propensity for abnormal morphologic characteristics that are consistent with FAI.

Methods

During the study period from October 2008 to April 2013, we included patients who underwent arthroscopic hip surgery for symptomatic intra-articular hip disorders, in whom conservative treatment measures failed and who were found to have the characteristic amorphous calcific deposit involving the acetabular labrum by direct visualization at the time of hip arthroscopy. Specifically, patients with os acetabuli were excluded from this study. This differentiation was made on imaging and intraoperative findings. This review was approved by our institutional review board.

A retrospective review of patients who fit the inclusion criteria was performed. Data reviewed were prospectively collected as part of routine at our institution. For purposes of this study, we included patient demographics: age, sex, side of calcification, onset of symptoms, length of symptoms, previous treatments, physical examination findings for range of motion, and tenderness. strength, and impingement testing were also included.

All patients underwent supine and standing anteroposterior (AP) pelvis, cross-table lateral, false profile (after 2009), and modified Dunn view radiographs. Data obtained from these radiographs included presence and size of the labral calcification, presence of crossover sign, alpha angle measured on the modified Dunn view, Tonnis arthritis grade, herniation pits, femoral head cysts, and acetabular cysts. A standard picture archive computer/communication system (PACS) was used to measure labral calcification size and alpha angle. All patients underwent either MRI or magnetic resonance arthrography (MRA). MRA/MRI was reviewed for the presence of labral tears, location of ossification within the labrum, cartilage defects, femoral version, alpha angle, paralabral cysts, ligamentum teres tears, acetabular and femoral head subchondral cysts, and femoral neck herniation pits. All plain imaging was reviewed by the lead author (T.J.J.), and all MR images were interpreted by a musculoskeletally trained radiologist as part of routine MRI reporting not specific to this study.

The indication for surgery was hip pain refractory to conservative treatment, including anti-inflammatory medications and physical therapy. If there was any uncertainty as to the source of the pain, diagnostic injection with 1% lidocaine was performed to confirm the intra-articular origin.

All surgery was performed by the senior author (B.G.D.) with the patient in the modified supine position. Diagnostic arthroscopy was performed after completion of an interportal capsulotomy, using an anterolateral portal and a modified anterior portal. The characteristic lesion was encountered in the capsule-labral recess by elevation with electrocautery and was debrided with blunt dissection and evacuated with a shaver (Video 1, available at www.arthroscopyjournal.org) (Fig 1). The labrum was repaired or debrided based on the quality of the remaining tissue. Acetabuloplasty was performed for pincer lesions and femoroplasty was performed for cam lesions.

Results

During the study period, 1,872 patients underwent primary arthroscopy of the hip. Of these, 16 (0.85%) patients had the characteristic calcific deposit in the labrum confirmed by arthroscopic visualization during hip arthroscopy. In comparison, 94 (5%) patients had os acetabuli confirmed by arthroscopic visualization during that same time. The mean age was 37.3 years (range, 30 to 50 years) with 15 women and one man. Three patients had workers' compensation status.

Clinical Presentation

Patients reported having symptoms for a mean 9.3 months (range, 3 to 48 months) with 8 (50%) reporting symptoms for less than 6 months. Four patients had an injury at the time of onset and 11 had an insidious onset. Eight patients had a positive response to nonsteroidal anti-inflammatory medications but not significant enough to completely alleviate pain. Seven of 8 patients had a positive response to diagnostic intra-articular injection with lidocaine. The one patient who did not have a response had a clinical history and examination consistent with labral tearing and FAI that was conclusive enough to perform arthroscopy despite the injection result. All patients reported anterior groin pain. Sitting, sitting to standing, and getting in and out of a car were the most common aggravating factors (Table 1). Physical examination findings are shown in Table 2. Notably, 15 (94%) patients had positive results for anterior impingement and 9 (56%) had positive results for lateral impingement.

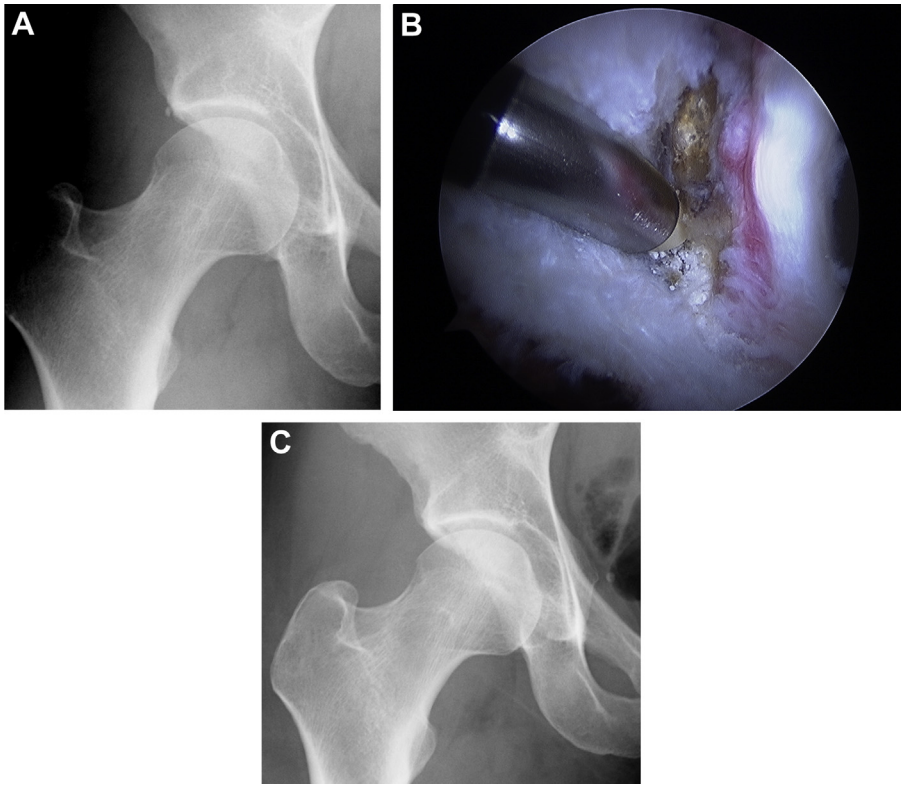

Fig 1. (A) Preoperative standing anteroposterior (AP) radiograph of the right hip with labral calcification. (B) Intraoperative photograph of the labrum of right hip, viewing from the peripheral compartment. The calcium deposit is being expressed from the labrum at the capsule-labral recess. (C) Postoperative supine AP radiograph of the hip showing that the calcification has been successfully removed by arthroscopy.

Imaging

Radiographic features are listed in Table 3. All patients had Tonnis arthritis grade 0 or 1. The mean lateral center edge angle measured 28.7° (20° to 36°), anterior center edge measured 29.7° (15° to 39°), acetabular inclination measured 3.4° (0° to 10°), and alpha angle measured 59.7° (42° to 84°). All but one patient had a positive crossover sign and 10 patients had cam deformities (alpha angle >50°). All patients had at least one component of FAI, with 10 patients having combined deformities, one patient having an isolated cam deformity, and 5 patients having isolated pincers. Two patients had borderline dysplasia in the setting of FAI. Calcifications measured 3.2 mm (1.9 mm to 5.6 mm) and 14 had a clear separation from the rim seen on plain film. The remaining 2 were large and extended to the acetabular rim, appearing to compose much of the labral substance. Four patients had 2 defined calcifications, and 12 had only one calcification. All were visible on the AP radiograph, with only 3 visible on the available 9 false profile radiographs, indicating a more superolateral location rather than a more anterior location. All calcifications had a distinctly different

Table 1. Clinical Presentation of Patients with Labral Calcification

Clinical Presentation	N = 16 (%)
Length of symptoms	9.3 mo (2-48 m)
Injury	4 (25)
Insidious onset	12 (75)
Response to NSAIDs	8 (50)
Radiating pain	7 (44)
Back pain	4 (25)
Positive response to injection	7 of 9 (78)
Anterior groin pain	16 (100)

NSAIDs, nonsteroidal anti-inflammatory drugs.

Table 2. Physical Examination Findings in Patients with Labral Calcification

Physical Examination Findings	N = 16
Range of motion	Degrees (SD)
Flexion	123° ± 14°
Internal rotation	25° ± 14°
External rotation	54° ± 10°
Abduction	47° ± 7°
Tenderness	No. of patients (%)
Anterior superior iliac spine	1 (6)
Rectus/psoas	6 (38)
Symphysis pubis	1 (6)
Adductor	2 (13)
Sacroiliac	3 (19)
Greater trochanter	6 (38)
Anterior impingement	15 (94)
Lateral impingement	9 (56)
Posterior impingement	4 (25)
FABER test	8 (50)
Internal snapping	1 (6)
External snapping	3 (19)
Gait disturbance	5 (31)

SD, standard deviation.

Table 3. Radiographic Findings in Patients with Labral Calcification

Radiographic Findings	N = 16 (%)
Tonnis arthritis grade 0/1	100%
Lateral center edge	28.7° (20°-36°)
Inclination	3.4° (0°-10°)
Acetabular cyst	1 (6.3)
Femoral cyst	2 (12.5)
Alpha angle	59.7 (42°-84°)
Anterior center edge angle	29.7° (15°-39°)
Size of calcifications	3.2 mm (1.6-5.4)
Multiple calcifications	4 (25)
Lucency between os and rim	14 (88)
Visible on anteroposterior view	16 (100)
Visible on false profile	5 (31)
Crossover sign	15 (94)
Alpha angle >50°	11 (69)
Isolated pincer impingement	5 (31)
Isolated cam impingement	1 (6)
Combined impingement	10 (63)

appearance from os acetabuli, with no evidence of trabecular bone or cortical margins and with a significantly smaller size than os acetabuli (Fig 2A and B) Additionally, there was increased opacity compared with neighboring trabecular bone with fluffy ill-defined borders. Postoperative radiographs taken 2 weeks after surgery showed 13 radiographs with complete disappearance of the calcification and the remaining 3 having a small residual calcification but with the majority removed.

MRA/MRI findings are shown in Table 4. Femoral anteversion measured 7.8° (−1° to 21°), and the alpha angle measured 48°. All but one patient had labral tears; it was not possible to clearly delineate a tear in the remaining patient because of MRI quality. Two patients had associated acetabular cysts measuring 8 mm and 13 mm in diameter, respectively. The 2 calcifications that were visible on MRI had high signal intensity on T2 sequencing and low signal, similar to bone, on T1 sequencing. The 2 cysts had high signal intensity surrounded by a rim of low signal (Fig 3).

Intraoperative Findings

On diagnostic arthroscopy, all patients were noted to have labral tears. The characteristic amorphous calcium deposit was located anterosuperiorly in all hips, consistent with the plain radiographs. These were easily located, released, and debrided with the use of a probe and shaver (Fig 1B) (Video 1, available at www.arthroscopyjournal.org). This deposit was found to be

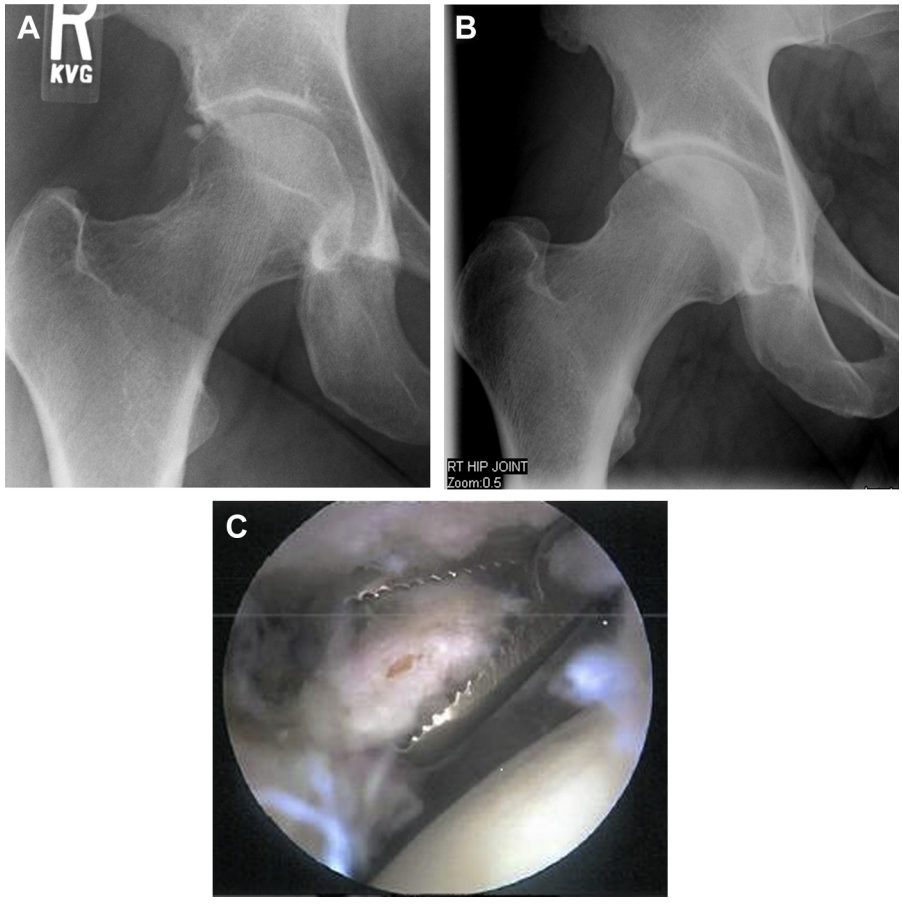

Fig 2. (A) Anteroposterior (AP) radiograph of right hip showing calcification located at the superolateral rim of the acetabulum. Note the increased opacity compared with the neighboring trabecular bone. This was confirmed by arthroscopic removal to be an amorphous calcification in the labrum (Video 1). (B) AP radiograph of right hip showing the characteristic findings of an os acetabuli. Arthroscopic removal of the os confirmed that this ossification was composed of bone, cartilage, and labrum. (C) Intraoperative photograph of removal of the os acetabuli, a well-formed ossification that is removable with a grasper. In contrast, labral calcifications are amorphous and not capable of being removed in one piece by a grasper.

Table 4. MRI/MRA Findings in Patients with Labral Calcification

MRI/MRA Findings	N = 16 (%)
Anteversion	7.8° (−1°-21°)
Alpha angle	48° (36°-66°)
Labral tear	15 (94)
Cartilage defect	4 (25)
LT tear	1 (6)
Paralabral cyst	1 (6)
Subchondral cyst (acetabulum)	2 (13)
Subchondral cyst (femoral head)	1 (6)
Impingement cyst	2 (13)

LT, ligamentum teres; MRI/MRA, magnetic resonance imaging/magnetic resonance arthrography.

accessible from the capsule-labral recess in all cases. Labral repair was performed in 13 patients and labral debridement in 3 patients. After removal of the calcium deposit in all patients, there was adequate labral tissue for repair or selective debridement, preserving a functional amount of labrum. This is different from completely calcified labra and os acetabuli that can obliterate functional labral tissue after removal. Additionally, os acetabuli are well-formed masses found in the labrum, and their removal in whole is possible (Fig 2B and C) The calcification of interest in this study is amorphous and thus cannot be removed in whole (Video 1, available at www.arthroscopyjournal.org). Other procedures included acetabuloplasty in the 15 patients with pincer deformity and femoral osteoplasty in the 11 patients with cam morphologic characteristics.

Two specimens were sent for histologic analysis. It was difficult to obtain adequate samples because of the small amorphous nature of the calcification. Despite this, the first sample was analyzed as being "dense fibroconnective tissue" and the second was analyzed as "minute fragments of cartilage and fragments of calcified material." There was no notation of labral tissue or bone in either of these specimens.

Nine patients had cartilage disruption at the transitional zone adjacent to the acetabular labral articular disruption (ALAD). Four patients had acetabular cartilage damage not in the transitional zone, with one having Outerbridge grade IV damage. Five patients had femoral head damage, with one of these having grade IV damage. There were 2 patients with peritrochanteric pathologic features that were addressed at the time of surgery (Table 5).

Discussion

This study reports the clinical presentation, radiographic features, and intraoperative findings of an amorphous calcification of the anterosuperior labrum of the hip, adding to the spectrum of pathologic conditions to the acetabular labrum. The demographics, radiographic findings, and intraoperative findings

Fig 3. Magnetic resonance (MR) image showing a subchondral cyst in the acetabular roof in a patient with calcific labritis. This cyst is consistent with being created by the resorptive phase of calcification, with extension of resorption into the acetabular rim.

indicate this entity to be different from os acetabuli in radiographic, histologic, and arthroscopic appearance.

The anterosuperior location of calcifications and high incidence of radiographic findings of FAI suggest impingement may be an inciting event in the pathophysiologic process. Our findings of FAI in all cases of labral calcification is similar to a study by Martinez et al,[5] who analyzed os acetabuli in the setting of FAI. The os acetabuli that were studied were found on MRI to be composed of bone, cartilage, and labrum. All patients in that study had cam impingement, with a large portion having acetabular retroversion that led to stress fracture with engagement of the aspheric head/neck deformity into the retroverted acetabulum. Our MRI, histologic, and operative findings were different

Table 5. Intraoperative Findings in Patients with Labral Calcification

Intraoperative Findings	No. of Patients (%)
Presence of labral tear	15 (94)
ALAD	9 (56)
Grade IV ALAD	0
Acetabular cartilage damage (outerbridge)	4 (25)
Grade IV acetabular cartilage damage	1 (6)
Femoral head cartilage damage	5 (31)
Grade IV femoral head damage	1 (6)
Ligamentum teres tear	8 (50)
Peritrochanteric pathologic features	2 (13)

ALAD, acetabular labral articular disruption.

regarding the composition of the calcification. The pathophysiologic characteristics of the calcifications studied do not appear to be from rim stress fractures but a separate pathophysiologic process from damage to the labrum from FAI leading to a calcific response. However, based on these results, it is unclear if there is a relation between the 2 entities, and there is no evidence to either deny or support this as a precursor to os acetabuli.

Os Acetabuli

A previous article by Sarkar et al.[7] described 6 patients with acute calcific tendinitis of the indirect head of the rectus femoris treated with steroid injection guided by computed tomography. Involvement of the indirect head of the rectus femoris was based on computed tomographic imaging. Given that this cohort did not have calcifications directly visualized by arthroscopy, it is unclear whether the patients in that study in fact had tendonitis or whether this was calcification involving the labrum. The close anatomic location makes this differentiation difficult with computed tomographic imaging. This is a strength of our study in that all calcifications were confirmed by direct arthroscopic visualization. It is worth noting that in the study by Sarkar et al.[7] that all 6 patients with steroid injection had resolution of pain for up to 6 months, with one requiring an additional injection. All patients had resolution of this calcification on radiographs by 12 weeks after injection.

MRA was helpful in assessing concomitant pathologic conditions but was not specifically helpful in the assessment of calcification. Plain radiographs were sufficient to qualify the entity as labral calcification without the use of MRI, because plain films identified the calcification 100% of the time and calcification was seen on only 2 MRIs. However, MRA was able to find a high incidence of labral tears and better show acetabular cysts that can be associated with these tears. These cysts were located close to the calcification and can represent intraosseous extension of the resorption phase, which has been described before.[12] It is important to note that these entities can occur together so that arthroscopy is not avoided because of cyst formation, which has been considered a relative contraindication to arthroscopy.

Limitations

This study is meant to be a descriptive study of calcification found in the acetabular labrum. It is thus limited in its recommendation for treatment. Our cohort represents patients in whom conservative treatment failed and who underwent arthroscopic surgery, and thus does not report those who were managed with conservative measures, including steroid injection. Because of lack of complete radiographic imaging in a large number of asymptomatic patients, we are unable to determine how often this labral calcification is seen in the general population, specifically in asymptomatic hips. Therefore, we are unable to address if this is just an incidental finding or is in fact a relevant pathologic condition. Because we showed a 100% incidence of FAI and labral tears, we believe this was less likely an incidental finding and is more related to a real pathologic condition, supporting the idea of FAI leading to labral tears.

Conclusions

Calcification in the anterosuperior acetabular labrum presents with a consistent patient demographic and distinct radiographic and arthroscopic presentation that is different from those of os acetabuli. As with os acetabuli, one should have a high suspicion for FAI when this lesion is encountered.

References

1. Ferguson SJ, Bryant JT, Ganz R, Ito K. The acetabular labrum seal: a poroelastic finite element model. *Clin Biomech (Bristol, Avon)* 2000;15:463-468.
2. Greaves LL, Gilbart MK, Yung AC, Kozlowski P, Wilson DR. Effect of acetabular labral tears, repair and resection on hip cartilage strain: A 7T MR study. *J Biomech* 2010;43:858-863.
3. Kim YT, Azuma H. The nerve endings of the acetabular labrum. *Clin Orthop Relat Res* 1995;320:176-181.
4. Seldes RM, Tan V, Hunt J, Katz M, Winiarsky R, Fitzgerald RH Jr. Anatomy, histologic features, and vascularity of the adult acetabular labrum. *Clin Orthop Relat Res* 2001;382:232-240.
5. Martinez AE, Li SM, Ganz R, Beck M. Os acetabuli in femoro-acetabular impingement: stress fracture or unfused secondary ossification centre of the acetabular rim? *Hip Int* 2006;16:281-286.
6. Larson CM, Stone RM. The rarely encountered rim fracture that contributes to both femoroacetabular impingement and hip stability: a report of 2 cases of arthroscopic partial excision and internal fixation. *Arthroscopy* 2011;27:1018-1022.
7. Sarkar JS, Haddad FS, Crean SV, Brooks P. Acute calcific tendinitis of the rectus femoris. *J Bone Joint Surg Br* 1996;78:814-816.
8. Tsujii A, Tanaka Y, Yonetani Y, Iuchi R, Shiozaki Y, Horibe S. Symptomatic calcification of the anterior cruciate ligament: A case report. *Knee* 2012;19:223-225.
9. Durr HR, Lienemann A, Silbernagl H, Nerlich A, Refior HJ. Acute calcific tendinitis of the pectoralis major insertion associated with cortical bone erosion. *Eur Radiol* 1997;7:1215-1217.
10. Cox D, Paterson FW. Acute calcific tendinitis of peroneus longus. *J Bone Joint Surg Br* 1991;73:342.
11. Uhthoff HK, Loehr JW. Calcific tendinopathy of the rotator cuff: Pathogenesis, diagnosis, and management. *J Am Acad Orthop Surg* 1997;5:183-191.
12. Kim YS, Lee HM, Kim JP. Acute calcific tendinitis of the rectus femoris associated with intraosseous involvement: a case report with serial CT and MRI findings. *Eur J Orthop Surg Traumatol* 2013;23(suppl 2):S233-S239.