Surgical Outcome of Pincer Femoroacetabular Impingement With and Without Labral Ossification

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Purpose: To describe the clinical findings associated with labral ossification (LO), report the outcomes of arthroscopic treatment, and compare this condition to a control group with femoroacetabular impingement (FAI). **Methods:** A retrospective review of hip arthroscopy patients from 2004 to 2013 was performed to identify patients with a diagnosis of pincer FAI with LO and at least 2 years of follow-up. Diagnosis was made by plain radiograph, computed tomography, magnetic resonance imaging, or intraoperatively. The LO cohort was compared to a chronologically matched control group of FAI patients with pincer FAI but no LO. Patients were prospectively assessed with modified Harris Hip Score (mHHS) preoperatively and then postoperatively at 3, 12, 24, 60, and 120 months. **Results:** The LO group included 56 hips in 52 patients whereas the control group included 56 hips in 56 patients. Mean follow-up was 36 months for the LO group and 38 for the control group ($P = .28$). Patients in the LO group were older than those in the control group, with a mean age of 45 versus 30 years ($P < .0001$), and had more women: 58% female versus 32% male ($P < .0001$). The LO group patients were more likely to have pain while sitting (65% *v* 18%) and restricted activities of daily living (40% *v* 11%) than the control group ($P < .0001$), and more likely to have pain during a flexion, abduction, external rotation (FABER) test (67% *v* 36%) ($P = .002$). Both groups experienced a similar magnitude of improvement in mHHS, but the LO group had a significantly lower preoperative mHHS (49 *v* 63, $P < .001$) and final postoperative mHHS (75 *v* 87, $P < .0001$) than the control group. **Conclusions:** Patients with LO represent a unique subset of pincer FAI and are more likely to be older, female, and have more severe symptoms. Hip arthroscopy can be used to treat LO with excision of the ossified fragments or rim, with a reasonable expectation of improvement of symptoms. **Level of Evidence:** III, retrospective case-control.

Labral ossification (LO) is considered to be a significant cause of adult acquired pincer-type femoroacetabular impingement (FAI). These are ossified lesions located peripheral to the acetabular rim and closely related to the labrum. In many cases, these lesions are smaller, resembling small pebbles within the anterolateral acetabulum. In some, they exist as circumferential ossifications that completely encase the peripheral acetabular rim (Figs 1 and 2). The term "captured hip" has been used to describe the associated constellation of findings that include pain, limited mobility, and dysfunction.[1] The etiology of these lesions is poorly understood, and there is a paucity of literature on this condition.

Ninomiya et al. first described a case of enchondral ossification of the labrum.[2] More recently, Corten et al. postulated that this was bone apposition, describing 2 processes by which the labrum was either encased by an ossified structure or instead "pushed forward" and thinned by an underlying bony process.[3] In both circumstances, the authors concluded that the ossification originates at the subperiosteal region of the outer acetabular rim as a consequence of pre-existing FAI. Other authors have concluded that these lesions should be grouped together with acetabular osteophytes and may represent an early stage of acetabular osteophyte pathogenesis.[4,5] Rim fracture as a result of rim loading has also been implicated as a source of such ossification.[6] The clinical findings and outcomes of LO have not yet been conclusively described.

The purpose of this study was to describe the clinical findings associated with LO, report the outcomes of

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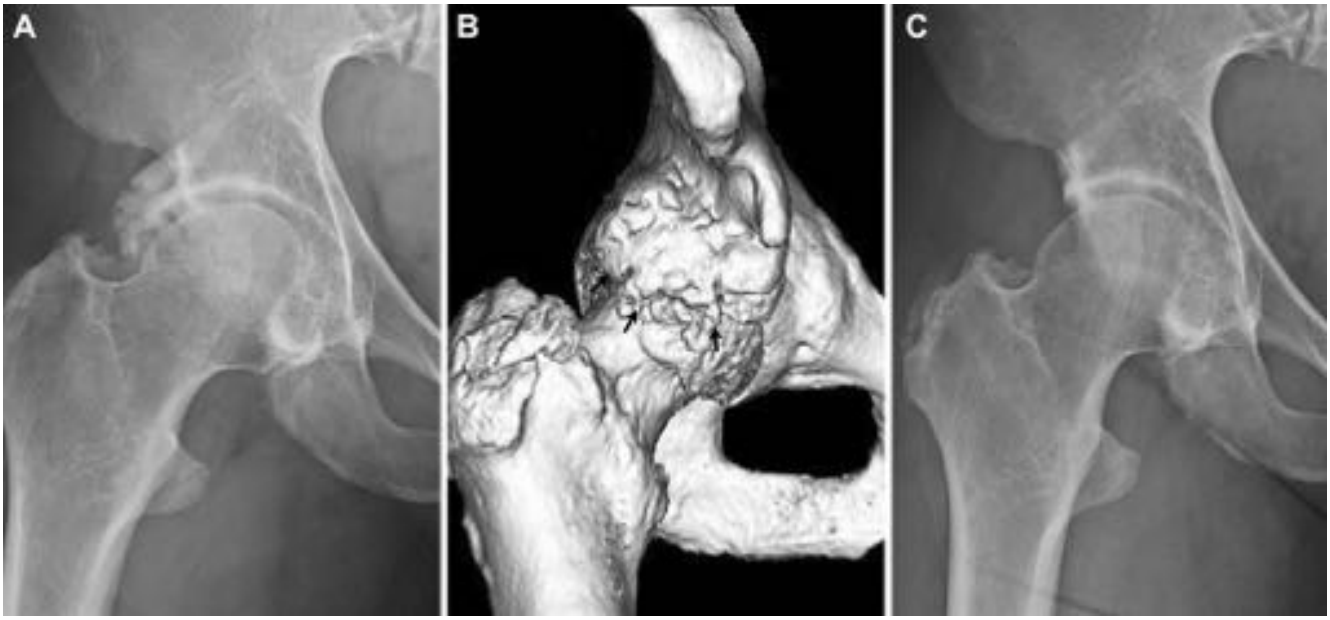

Fig 1. A 46-year-old woman with long-standing painful severely restricted motion of the right hip. (A) AP radiographic view illustrates severe acetabular overcoverage with CE angle 74°. (B) Three-dimensional CT recon further defines the severity of acetabular overcoverage created by labral ossification (arrows). (C) Postoperative AP radiograph shows CE angle reduced to 38°. (AP, anteroposterior; CE, center edge; CT, computed tomography.) (copyright, J.W. Thomas Byrd, M.D., 2014).

arthroscopic treatment, and compare this condition to a control group with FAI. Based on previous observations, it was hypothesized that LO may represent a unique subgroup of FAI characterized by older age, with more women and less optimal outcomes.

Methods

A retrospective case-control study was performed of patients undergoing hip arthroscopy from 2004 to 2013 with a secondary diagnosis of LO. Patients were identified during a chart review. Inclusion criteria was (1) a diagnosis of FAI with a secondary diagnosis of LO made by plain radiology, computed tomography (CT), magnetic resonance imaging (MRI), or intraoperatively and (2) at least 2 years of postoperative follow-up. Exclusion criterion was (1) absence of evidence of LO or (2) lack of postoperative follow-up of at least 12 months. This study received exemption status from the institutional review board.

Patients were evaluated preoperatively with history, physical examination, and imaging. Radiographs were obtained on all patients being evaluated for hip pain. MRIs were obtained on all patients being considered for surgery unless contraindicated, and CT scans were performed on all patients scheduled for surgery in whom FAI correction was anticipated. The indication for surgery was clinically relevant pathologic FAI unresponsive to conservative treatment that variously included activity modification, physical therapy, anti-inflammatory medications, and judicious use of intra-articular injection. In addition to correction of the impingement lesions, labral tears were managed with debridement or repair depending on the quality of the tissue, and chondral damage was addressed with chondroplasty and microfracture for grade IV lesions. All patients were treated surgically by the senior author (J.W.T.B.) and were prospectively assessed with a modified Harris Hip Score (mHHS) preoperatively and then postoperatively at 3, 12, 24, 60, and 120 months. This cohort of patients with LO was compared to a matched contemporaneous control group of patients with pincer FAI but no LO. This was based on radiographic features of acetabular overcoverage or retroversion, combined with arthroscopic evidence of labral pathology. The control group was matched chronologically by selecting a non-LO pincer FAI patient who had surgery closest to the time of each LO. In other words, for each LO patient, the nearest pincer FAI patient was included in the control group. The rationale for creating a control group in this fashion was based on the evolving understanding of pincer FAI and options of surgical treatment. This evolution included recognizing the existence of FAI in the native hip, efficacy of labral debridement, superiority of labral repair, and subsequently better understanding of the influence of pelvic position and femoral version and the clinical relevance of pincer FAI. This prevents changes in the interpretation of FAI and changes in surgical technique from being confounding factors. It also provided a control group sampling the normal demographic distribution of non-LO pincer FAI patients.

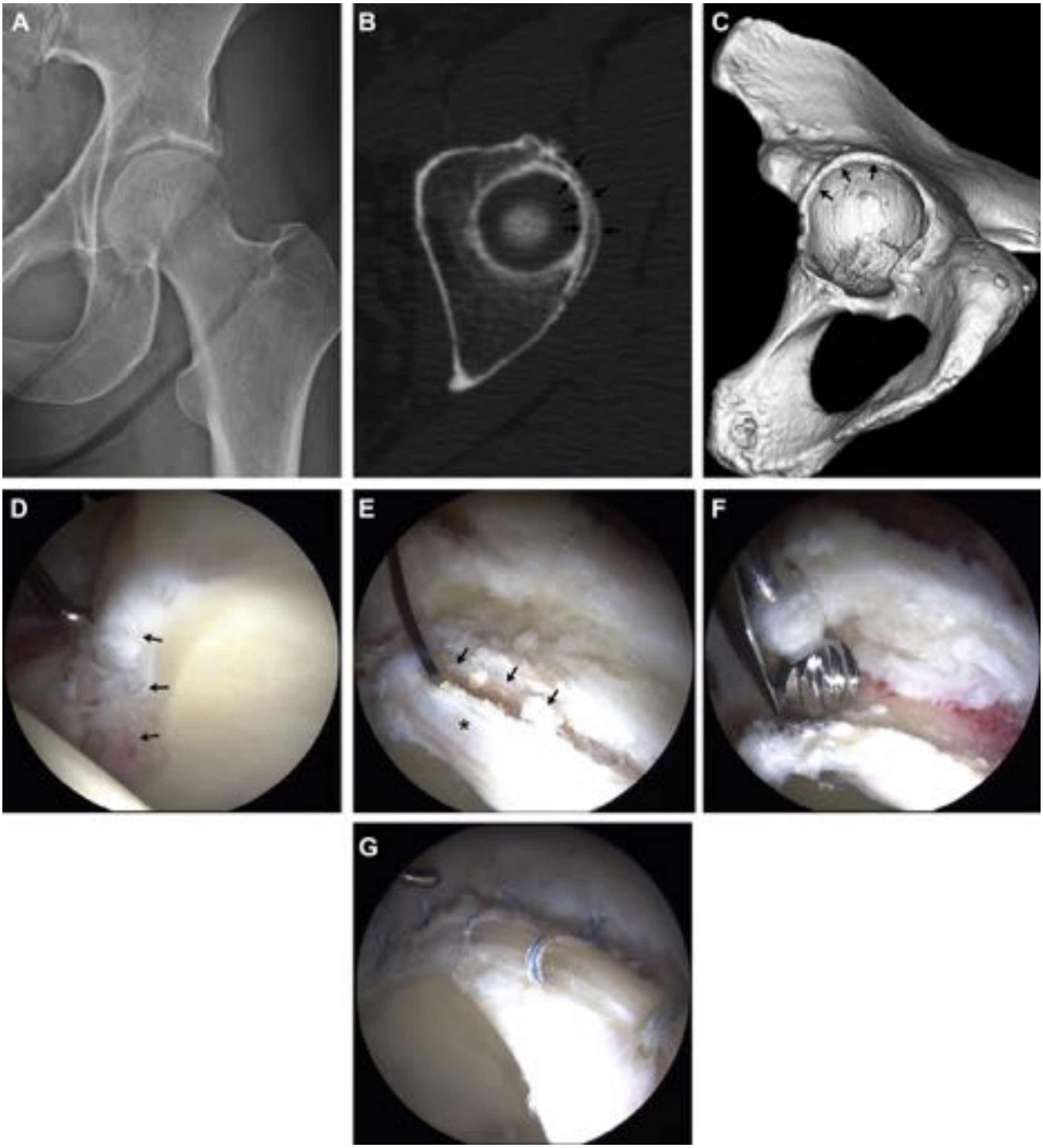

Fig 2. A 46-year-old woman with recalcitrant painful range of motion left hip with temporary response to an intra-articular injection and unremarkable MRI. (A) AP radiographic view unremarkable, with CE angle of 42°. (B) Axial CT scan reveals the “double rim sign” of the acetabulum (arrows), often indicative of labral ossification. (C) Three-dimensional CT reconstruction image reveals thickening acetabular rim (arrow), further indicative of labral ossification. (D) Arthroscopic view from the anterolateral portal reveals substantial tearing of the labral remnant (arrows). (E) An arthroscopic knife is used to sharply mobilize the labral remnant (asterisk) from the ossified portion (arrows). (F) Acetabuloplasty is performed with a 5.5-mm burr excising the ossified portion of the labrum. (G) The labrum has been refixed with 5 suture anchors. Because of the hypoplastic nature of the labral remnant, simple loop sutures were used to restore the labrum to the rim. (CE, center edge; CT, computed tomography; MRI, magnetic resonance imaging.) (copyright, J.W. Thomas Byrd, M.D., 2014).

Histology was included on 2 patients who were diagnosed prospectively with LO and treated with excision of the LO. The portion of the labrum containing LO was excised during surgery and sent for pathologic examination. Images were recorded during routine clinical pathologic examination after fixation in formalin, after hematoxylin and eosin staining, and sectioning. They were included in the present study as histologic examples illustrative of the study group.

Mean values, standard deviation, and *t* test were used to compare the 2 groups with regard to parametric, continuous variables such as gender, age, duration of symptoms, preoperative mHHS, postoperative mHHS, and improvement in mHHS. In addition, χ^2 analysis was used to compare discrete, ordinal variables such as medical history and physical examination findings. Specifically, patient-reported binary variables that were examined included pain while sitting, severely restricted activities of daily living, and globally reduced range of motion (ROM). Physical examination binary variables included pain during FABER, pain during log roll, and positive hip impingement test (flexion, adduction, internal rotation).

Results

During the study time period, 3,745 patients underwent hip arthroscopy. The LO group consisted of 56 consecutive hips in 52 patients (4 bilateral). The control group consisted of 56 FAI patients without LO. Follow-up averaged 36 months (range 24 to 60 months) for the LO group and 38 for the control group (range 24 to 120 months) ($P = .28$). The LO study group consisted of 32 female hips (58%) and 20 male hips, with a mean age of 45 years (range 21 to 56 years). This group consisted of 56 hips towing to 4 patients, 2 female and 2 male, who had bilateral surgery. Mean duration of symptoms was 36 months. The control group consisted of 56 patients, 18 women (32%) and 38 men, with a mean age of 30 years (range 19 to 53 years). Mean duration of symptoms was 40 months.

The LO group patients were significantly older on average than those in the control group, with a mean age of 45 versus 30 years ($P < .0001$). The LO group had significantly more women than the control group (58% *v* 32%; $P < .0001$). There was no significant difference in the mean duration of symptoms between groups ($P = .64$).

Findings on history showed that the LO group had greater disability than the control group. In the LO group, 34 patients (65%) reported pain while sitting versus 10 (18%) in the control group, and 21 patients (40%) in the LO group reported severely restricted activities of daily living, compared with 6 (11%) in the control group ($P < .0001$). No significant difference was observed with reduced ROM. Overall, 23 patients (44%) in the LO group had globally reduced ROM compared with 20 (36%) in the control group ($P = .48$).

Findings on physical examination showed that the LO group patients had increased pain during FABER than those in the control group. In the LO study group, 35 patients (67%) had pain with FABER versus 20 (36%) in the control group ($P = .002$). In addition, 37 (71%) patients in the LO group had a positive log roll versus 33 (59%) in the control group ($P = .26$). Furthermore, 47 (90%) in the LO group had a positive hip impingement test versus 53 (95%) in the control group.

During radiographic examination, plain radiography and CT had the highest yield in terms of identification of LO cases. Thirty-eight (68%) patients of the study group had LO that was identifiable on plain radiographs. Fifty-four of 56 hips in the study group underwent CT, and LO was identified on 41 of these (76%). Finally, MRI had poor yield in terms of identifying LO. Ossification could only be identified on 10 of 55 MRIs (18%). One hip did not have MRI available. In 4 cases (9%), LO was only identified at the time of arthroscopy. Forty-four hips had a concomitant diagnosis of cam FAI.

Surgical findings and treatments were as follows (Table 1). The LO group had circumferential ossification of the labrum in 12 cases and partial in 44. In regard to FAI, 44 had combined, and 12 had only pincer type. Forty hips had acetabular chondral damage, 14 had femoral chondral damage, and 6 had ligamentum teres lesions. Forty-nine patients underwent acetabuloplasty by virtue of excision of a portion of the ossified labrum, 27 underwent additional acetabuloplasty, whereas 6 had sufficient labrum to warrant refixation, and there were 44 femoroplasties. In the control group, there were 49 combined and 7 pincer-type FAI. Surgical findings included 53 labral tears, 51 with acetabular chondral damage, 15 with ligamentum teres lesions, and 5 with femoral chondral damage. In the control group, 56 underwent acetabuloplasty, 42 had labral refixation, 16 had labral debridement, and 47 had femoroplasty.

Analysis of outcomes data showed the following. Both the LO and control groups experienced improvement postoperatively in terms of mHHS (Fig 3). The LO group had a significantly lower preoperative mHHS than the control group (49 *v* 63, $P < .001$). In addition, The LO group had a significantly lower final postoperative mHHS than the control group (75 *v* 87, $P < .0001$). The LO group had a greater mean increase in mHHS than the control group, which did not reach significance (26 *v* 24, $P = .16$). In the LO group, mean improvement was 26 points (preoperative, 49; postoperative, 75). Only 2 patients had no improvement, and one of those underwent repeat arthroscopy. In the control group, mean improvement was 24 points (preoperative, 63; postoperative, 87), and 5 patients

Table 1. Patients with Pincer FAI with Labral Ossification

Decade	n	Mean Age, y	Gender, % Female	Duration of Symptoms	Circumferential/ Partial	Diagnostic Findings*	Surgical Technique†	mHHS 0	mHHS 3	mHHS 12	mHHS 24	mHHS 60	mHHS Last Score	Average Follow-up, mo
Third	2	25	0	6	0/2	C 2, LT 2, 3A 2	LD 1, CH 1, F 2	73	77	96	96	85	96	32
Fourth	16	36	56	33	1/15	C 11, LT 9, 3A 3, 4A 5, 3F 3, 4F 1	LD 9, CH 10, F 13, LR 1	50	73	84	82	80	81	31
Fifth	16	45	81	50	3/16	C 11, LT 11, 1A 2, 2A 2, 3A 7, 4A 1, 3F 2, 4F 1	LD 9, CH 11, F 13, LR 4	50	67	77	77	68	74	23
Sixth	22	52	45	48	8/14	C 17, LT 16, 3A 14, 4A 3, 3F 5, 4F 2	LD 13, CH 18, F 16, LR 2	46	65	77	75	73	71	31

mHHS, modified Harris Hip Score.
*Diagnostic key: C, cam; LT, labral tear; #A, grade # acetabular cartilage damage; #F = grade # femoral cartilage damage.
†Surgical technique key: LD, labral debridement; CH, chondroplasty; F, femoroplasty; LR, labral repair.

experienced no improvement. One patient went on to have total hip arthroplasty. There was 1 complication in the LO group, a partial neurapraxia of the lateral femoral cutaneous nerve, but no patients went on to have total hip arthroplasty. In the control group, there were no complications.

Histologic examination showed that the LO was both bony extension from the acetabular rim and endochondral bone formation adjacent to the fibrocartilage articular surface (Fig 4). There were significant regions of endochondral ossification within a thin, encasing labral fibrocartilage. There was a spectrum of transition between the underlying acetabular bone and labral fibrocartilage. From the acetabular rim extending peripherally, there was (1) a zone of hyperdense trabecular bone, (2) areas of noncalcified osteoid, and (3) cartilage metaplasia and calcification.

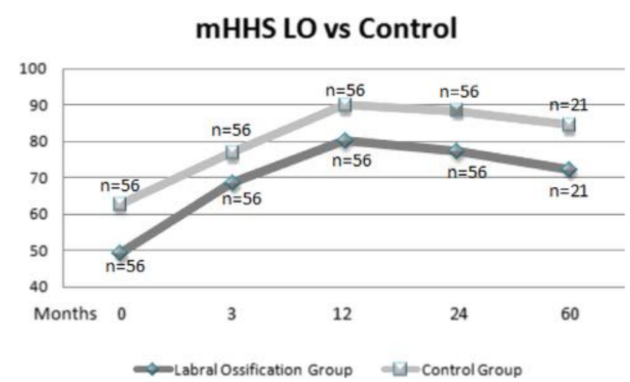

Fig 3. Comparison of mHHS over time: LO versus ontrol groups. (mHHS, modified Harris Hip Score; LO, labral ossification.)

Discussion

In the present study, a decade of surgical experience of 56 hips (52 patients) with FAI and LO was compared to a historical control group of 56 chronologically matched pincer FAI patients, and showed that the LO group patients tended to be older and female, with more severe symptoms and disability and more likely to have a positive FABER test. In regard to outcome scores, the LO group had lower baseline mHHS scores, a similar magnitude of improvement, and slightly higher mean improvement in mHHS with arthroscopic surgery. The 2 groups were comparable in terms of surgical findings and surgical treatments. Complications were rare and minor across both groups.

When examining the method of diagnosis of LO in the present study, CT was noted to be the most reliable radiologic examination. Sixteen percent of LO were not identified until arthroscopy, whereas 18% of LO were identified via MRI, 68% of LO were identifiable via plain radiographs, and 76% were identified via CT. The sensitivity of MRI was 18%, and 68% for plain radiographs. CT scans were available on 54 of 56 hips, and LO was identified on 41 of these. This would give CT 76% sensitivity. Two hips did not have CT available. The most important radiographic finding of LO is the "double rim sign," which can be seen in Figure 2B. Although these findings might not be as pronounced using newer imaging technologies, CT is probably a superior diagnostic tool for LO.

In terms of diagnosing LO, examination of the present study gives the following guidance. Common complaints include difficulty with activities such as sitting and activities of daily living as well as severe restriction

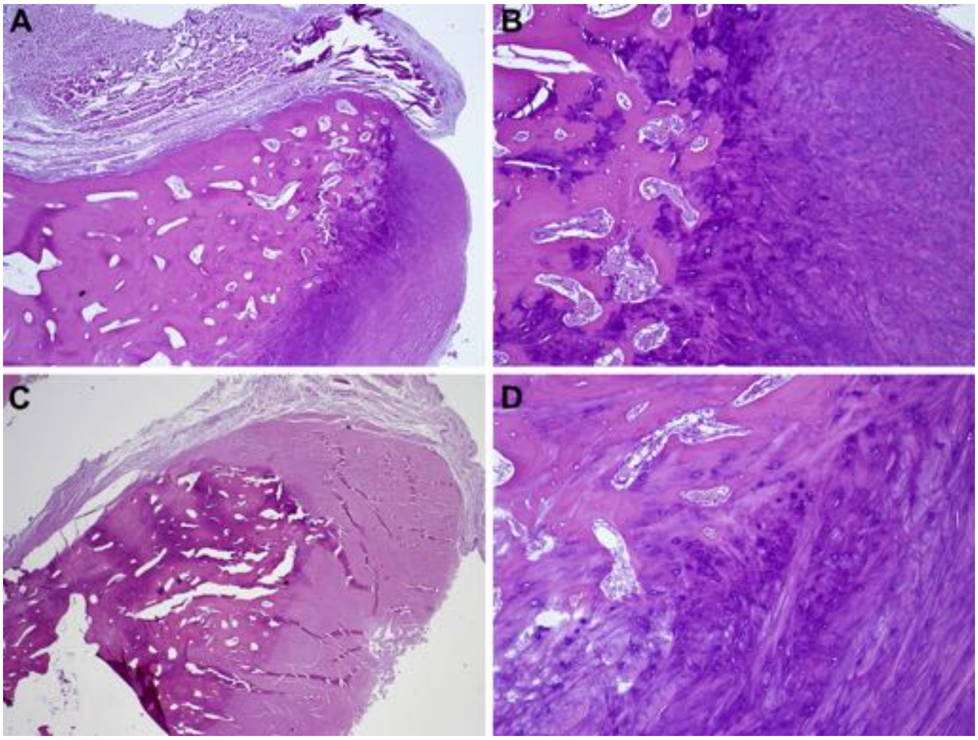

Fig 4. Histologic examination. (A) Histologic examination showed that the labral ossification was both bony extension from the acetabular rim and endochondral bone formation adjacent to the fibrocartilage articular surface. (B) There were significant regions of endochondral ossification within a thin, encasing labral fibrocartilage. There was a spectrum of transition between underlying acetabular bone and labral fibrocartilage. From the acetabular rim extending peripherally, there was (1) a zone of hyperdense trabecular bone (C), (2) areas of noncalcified osteoid, and (3) cartilage metaplasia and calcification (D).

of ROM. Examination generally will reveal increased pain most importantly during FABER; during impingment test (flexion, adduction, internal rotation); and log roll tests. Finally, radiographic examination should include plain radiographs and a CT scan for patients in whom LO is suspected.

Several differences in age distribution between the LO group and the control group were noted. The LO group had a mean age 15 years higher than the control group (45 *v* 30 years old). There were no differences found between the LO and control groups with regard to chondral damage, number of cam lesions, labral tears, or other surgical findings. Examination of the outcomes data by decade give a few interesting points (Fig 5). In the LO group, the preoperative and postoperative hip scores declined steadily by decade of presentation, whereas in the control group, there was a much more variable distribution by decade. This finding may suggest that the LO disease process is a more progressive variant than other types of FAI. Significantly more work is needed to better understand this subpopulation of FAI, including the etiology, natural progression, and optimal treatment of FAI.

Histologic examination provided 2 interesting points, but further investigation is needed. First, it appears that LO has 2 sources: (1) bony extension from the acetabular rim and (2) endochondral ossification of the labrum. Second, there is a gradual transition in LO from the acetabular rim outward: (1) hyperdense bone, (2) areas of calcified and noncalcified osteoid, (3) areas of cartilage calcification and metaplasia, and finally (4) a thin overlying layer of fibrous tissue consistent with a remnant of labrum.

There is limited literature describing LO. As previously noted, Corten et al. described a process of "bone apposition" whereby the LO is created by either encasement of acetabular bone around an existing labrum or "pushed forward" and the labrum thinned from underneath.[3] All of the patients in the present study had LO within the labrum. None had ossification that encased the labrum. As for the etiology of LO in the study group, it is unclear whether the LO was truly ossification/calcification of labral tissue or outgrowth of acetabular rim bone underneath the labrum. Several other authors have grouped LO with acetabular osteophytes,[2,4,5] which contrasts with our findings. In the present study, none of the patients with LO had acetabular osteophytes as identified by the treating surgeon (J.W.T.B.), and almost all had excellent maintenance of the joint space and articular cartilage (at least 2 mm joint space on radiographs, and no or low-grade cartilage damage on arthroscopy). This lack of osteophytes or advanced joint degeneration led us to conclude that our study supports the assertion of Corten et al. that LO is a process separate from acetabular osteophytes. Jackson et al. described a series of 16 calcium deposits of the labrum.[7] Mean age was 37 years. All but 1 patient was female, and all had labral tears and FAI. The calcium deposits had greater radiodensity than adjacent bone, and had an amorphous,

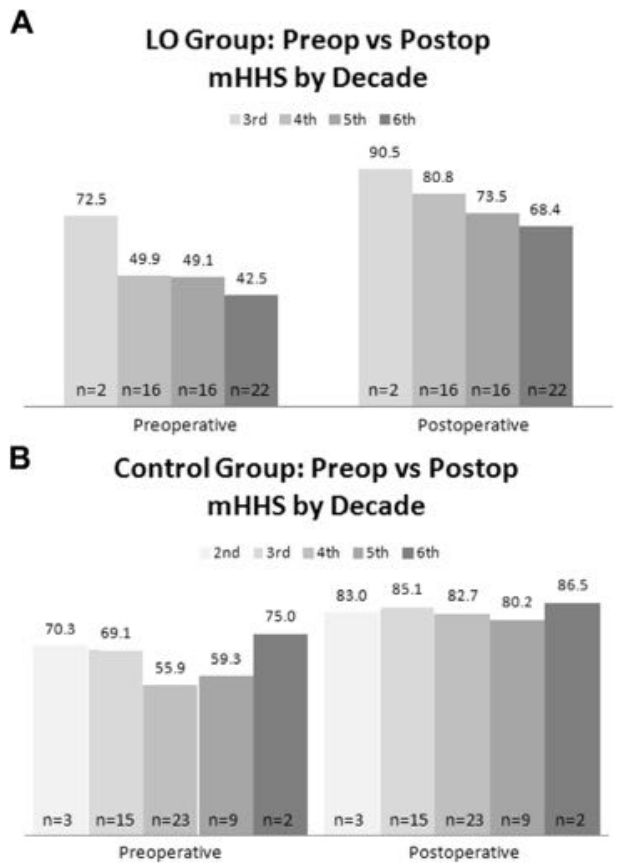

Fig 5. Comparison of preoperative and postoperative mHHS by decade of age. (mHHS, modified Harris Hip Score.)

disorganized appearance. These calcium deposits seem to be a separate entity to the LO described in the present study. Finally, Anderson et al. noted that os acetabuli and calcified labrum are sources of variability when measuring center edge angle.[8] Although this measurement was not a specific part of the present study, it was noted that these patients tended to have large LO that could artificially extend the center edge angle.

The authors of the present study believe that this LO subset of pincer FAI likely still represents a heterogeneous population consisting of subgroups with differing causes. This study is not the definitive work on this process, but more importantly, tries to increase a sense of awareness regarding the role of LO in adult-acquired pincer FAI. Much work remains to be done to more accurately define the varying causes that may be important in determining optimal treatment and forecasting outcomes.

Limitations

In addition to its retrospective nature, another limitation of this study was the methodology of selecting a control group. The control group was matched chronologically, selecting the patient with pincer impingement with a surgery date closest to each LO patient. The diagnosis of pincer impingement was made according to the usual practice of the treating physician. Radiographs and CTs were evaluated and the center edge angle was measured on each patient but not included in the data analysis of this study. The diagnosis of pincer impingement was associated with the presence of acetabular overcoverage or acetabular retroversion in conjunction with arthroscopic findings of labral damage. Age and gender matching were not used. The rationale of selecting a control group in this fashion was that the diagnostic and surgical techniques as well as understanding of the pathology changed significantly over the study period. The selection of a chronologically matched control group prevents these changes from being a confounding factor. Additionally, the authors wanted to compare the LO population to the background FAI population, and age and gender matching would prevent this. These differences in age and gender between groups may themselves be confounding factors, but they also may point to important differences in the characteristics of patients with FAI who have LO compared with other FAI patients. Thus, this study meets the definition for a level III case-control study, but readers should note the methodology of selecting the control group that was used when drawing conclusions. Furthermore, the etiology of LO is unknown, and the study cohort may actually combine patients with different disease processes into 1 group. However, there was a high degree of similarity between the patients in the study group with regard to radiographic and gross appearance of the LO. Finally, it should be noted that the histologic samples were not randomized, and they may not be representative of the study group.

Conclusions

Patients with LO represent a unique subset of pincer FAI and are more likely to be older, female, and have more severe symptoms. Hip arthroscopy can be used to treat LO with excision of the ossified fragments or rim, with a reasonable expectation of improvement of symptoms.

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