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Combined Hip Arthroscopy and Limited Open Osteochondroplasty for Anterior Femoroacetabular Impingement

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Background: A variety of surgical techniques have been introduced for the treatment of femoroacetabular impingement, but clinical outcome studies of less-invasive treatment with a minimum duration of follow-up of two years are limited. The purpose of this study was to evaluate the early clinical and radiographic outcomes of combined hip arthroscopy and limited open osteochondroplasty of the femoral head-neck junction for the treatment of cam femoroacetabular impingement.

Methods: We performed a retrospective review of our first thirty-five patients (thirty-five hips) in whom cam femoroacetabular impingement had been treated with combined hip arthroscopy and limited open osteochondroplasty. Thirty-five patients (twenty-eight men and seven women) with an average age of thirty-four years and a minimum duration of follow-up of two years were analyzed. The modified Harris hip score was utilized to assess hip function. The Tönnis osteoarthritis grade and the alpha angle were determined to assess osteoarthritis progression and deformity correction, respectively.

Results: The average modified Harris hip score improved from 63.8 points preoperatively to 87.4 points at the time of the last follow-up. Twenty-nine (83%) of the thirty-five patients had at least a 10-point improvement in the Harris hip score, and 71% had a score of >80 points. The average alpha angle was reduced from 58.6° preoperatively to 37.1° at the time of follow-up when measured on cross-table lateral radiographs, from 63.9° to 37.8° when measured on frog-leg lateral radiographs, and from 63.1° to 44.8° when measured on anteroposterior radiographs. Two patients had osteoarthritis progression from Tönnis grade 0 to grade 1. Minor complications included one superficial wound infection, one deep vein thrombosis, and four cases of asymptomatic Brooker grade-I heterotopic ossification. There were no femoral neck fractures or cases of femoral head osteonecrosis, and no hip was converted to an arthroplasty.

Conclusions: Early results indicate that combined hip arthroscopy and limited open osteochondroplasty of the femoral head-neck junction is a safe and effective treatment for femoroacetabular impingement. In our small series, most patients had symptomatic relief, improved hip function, and enhanced activity after two years of follow-up.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

The concept of hip impingement as an etiologic factor in the development of hip osteoarthritis was introduced over forty years ago¹, and recent studies have refined this concept²⁻⁴. Ganz and colleagues have further defined femoroacetabular impingement as a cause of hip pain, restricted hip

motion, labral disease, articular cartilage degeneration, and secondary osteoarthritis⁵⁻⁹. In addition, femoroacetabular impingement has been recognized as a sequela of common pediatric hip conditions such as Legg-Calvé-Perthes disease and slipped capital femoral epiphysis¹⁰. The enhanced awareness of femoroacetabular

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impingement has led to its earlier recognition in adolescents and young adults with pre-arthritis and early arthritic disease. Clearly, there is a need for continued investigation regarding the diagnosis, pathophysiology, and surgical treatment of this disorder.

Femoroacetabular impingement encompasses a spectrum of disease patterns and severity. The structural abnormalities can be in the femur or acetabulum, or both^{5,11}. So-called cam impingement is characterized by femoral abnormalities, with an aspheric femoral head or an abnormal osteocartilaginous prominence located at the anterolateral femoral head-neck junction. So-called pincer impingement results from acetabular over-coverage of the femoral head due to a deep or retroverted acetabulum¹². Surgical treatment for femoroacetabular impingement is evolving, but treatment that includes surgical dislocation of the hip as described by Ganz et al.⁸ is the most established procedure^{5,7,9,11,13-15}. More recently, less invasive surgical techniques for

treating hip impingement disease have been introduced¹⁶⁻²⁴. Over the past several years, one of us (J.C.C.) has utilized a combined arthroscopic and limited open surgical technique for selected cases of cam anterior femoroacetabular impingement. The purposes of this surgical strategy are to assess and treat central compartment disease (involving the labrum and articular cartilage) with arthroscopic techniques and to correct the femoral head-neck junction impingement lesion under direct vision through a limited anterior approach. We hypothesized that this procedure would improve hip function and enhance the activity level, reliably correct the osseous abnormalities, and have an acceptable complication rate. The purpose of this study was to determine the hip function, activity level, radiographic evidence of deformity correction, osteoarthritis progression, and complications associated with this surgical treatment in a series of patients.

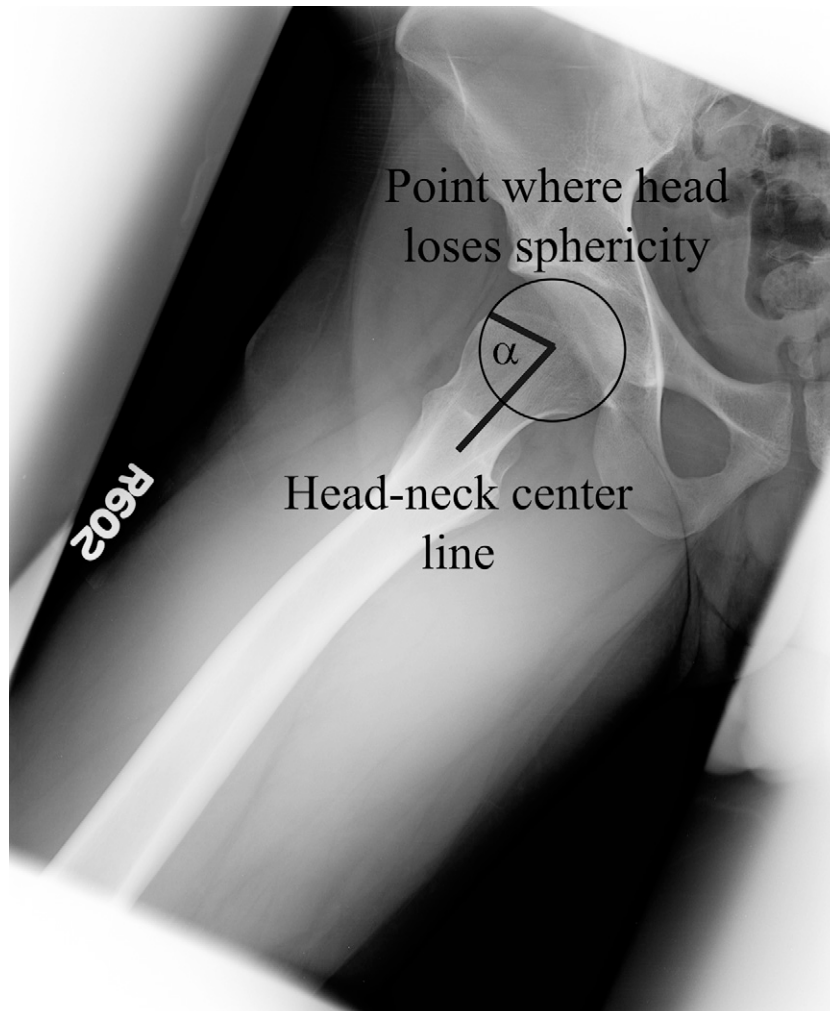


Fig. 1

Alpha angle on a frog-leg lateral radiograph. (Reproduced, with modification, from: Clohisy JC, Carlisle JC, Beaulé PE, Kim Y-J, Trousdale RT, Sierra RJ, Leunig M, Schoenecker PL, Millis MB. A systematic approach to the plain radiographic evaluation of the young adult hip. *J Bone Joint Surg Am.* 2008;90 Suppl 4:61.)

Materials and Methods*Patient Characteristics*

Institutional review board approval was obtained for this retrospective study. From April 2003 to December 2005, forty-one consecutive patients (forty-one hips) with symptomatic femoroacetabular impingement were treated with a

combined hip arthroscopy and limited open osteochondroplasty of the femoral head-neck junction. All patients were diagnosed with symptomatic cam impingement, and our indications for surgery included persistent anterior or anterolateral hip pain, restricted hip flexion ($<105^\circ$) and/or restricted internal rotation in flexion ($<15^\circ$), a positive impingement test



Fig. 2-A



Fig. 2-B

Figs. 2-A through 2-F Anteroposterior pelvic and frog-leg lateral radiographs and arthroscopic images of a forty-three-year-old man with cam impingement. This patient was treated with a combined hip arthroscopy and limited open osteochondroplasty of the femoral head-neck junction. At the time of arthroscopy, the patient had degeneration of the labral-chondral junction with chondromalacia of the anterolateral part of the acetabular rim. This was treated with chondroplasty and partial labral resection. At two years, the patient was asymptomatic. **Figs. 2-A and 2-B** Anteroposterior pelvic and frog-leg lateral radiographs.

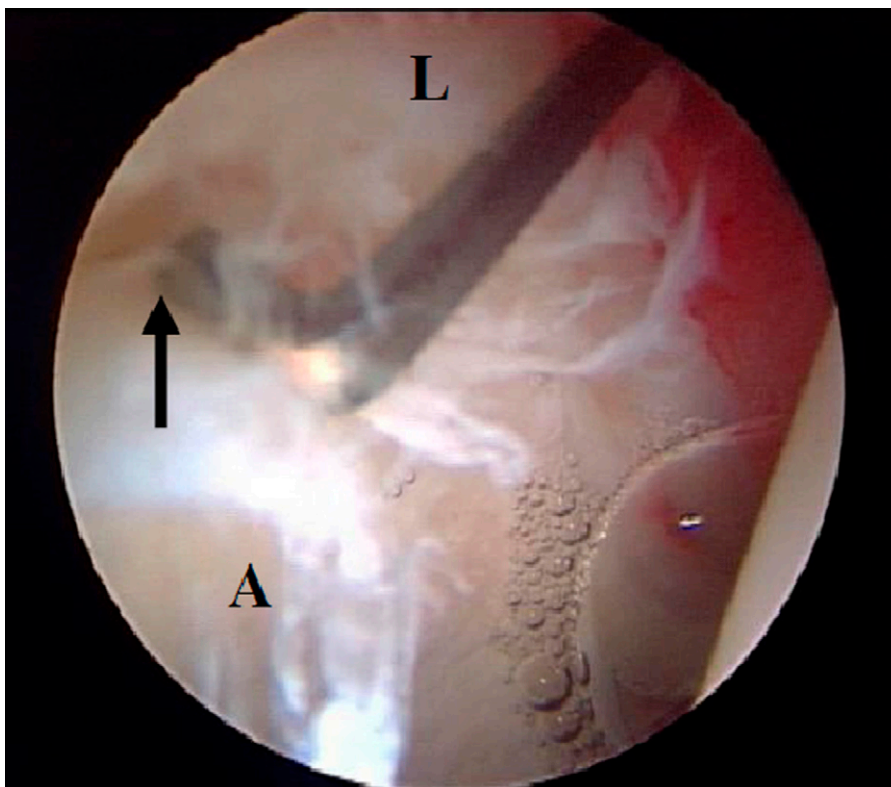


Fig. 2-C

Arthroscopic image showing degeneration of the labral-chondral junction (arrow) with chondromalacia of the anterolateral aspect of the acetabular rim. A = acetabular articular cartilage, and L = acetabular labrum.

(groin pain elicited with passive flexion, adduction, and internal rotation of the hip), radiographic evidence of a head-neck offset deformity (an alpha angle of $>50^\circ$ on at least one radiographic view) (Fig. 1), and failure of a three-month course of nonoperative treatment. All patients met these criteria and desired to proceed with the surgery. One of these patients was excluded from the study because of a previous proximal femoral osteotomy to correct a severe deformity associated with a childhood slipped capital femoral epiphysis. Thirty-five (88%) of the remaining forty patients had a minimum of two years of follow-up and are the focus of this report. Despite extensive efforts to locate all patients, five patients were lost to follow-up less than two years postoperatively. These five patients were last seen at an average of 3.2 months (range, one to six months) after the surgery, and detailed clinical data were not obtained at those early postoperative visits.

Of the thirty-five patients included in the study, twenty-eight were male and seven were female. The average age of the patients at the time of the surgery was thirty-four years (range, sixteen to forty-eight years). The average duration of follow-up was 2.2 years (range, two to three years). Two patients had had a prior surgical procedure on the same side as the index procedure: one patient had had pin fixation of a grade-I slipped capital femoral epiphysis and subsequent removal of hardware, with a minor residual deformity, and another had had hip

arthroscopy with labral debridement and chondroplasty six years prior to the index surgery. Twelve of the thirty-five hips had undergone injection of corticosteroids (eight hips) or an anesthetic (four hips) before the index operation. Ten of these twelve intra-articular injections resulted in temporary symptom relief.

All patients underwent a combined hip arthroscopy and limited open osteochondroplasty of the femoral head-neck junction as previously described¹⁸. Acetabular labral tears were treated with partial resection—i.e., by removing the unstable portion of the labral tissue (Figs. 2-A through 2-F). The stable capsular remnant was preserved when possible. Articular cartilage abnormalities were treated with chondroplasty to remove the unstable margins of the articular lesions. Labral repair and microfracture were not utilized. The operative findings were obtained from operative dictations, the surgeon's intraoperative notes, and arthroscopic images. Labral tears were described according to their location and appearance and were identified as anterior, anterolateral, posterior, or multidirectional²⁵. Acetabular or femoral head chondromalacia lesions were described according to the Outerbridge classification²⁶.

After arthroscopy of the central compartment, an 8 to 10-cm anterior incision was utilized for the exposure¹⁸. The femoral head-neck osteochondroplasty was performed to es-

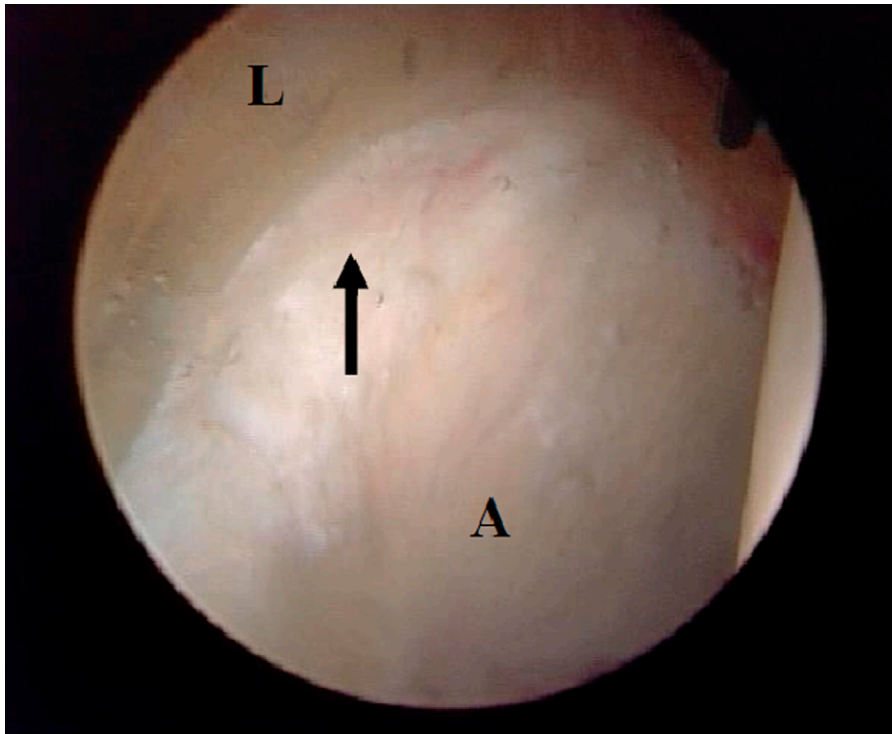


Fig. 2-D

Arthroscopic image showing the hip after treatment with chondroplasty (arrow) and partial labral resection. A = acetabular articular cartilage, and L = acetabular labrum.

establish a more normal offset (Figs. 2-A through 2-F). After recontouring of the head-neck junction, the hip was assessed with fluoroscopy and intraoperative examination. Fluoroscopy was utilized to confirm the adequacy of the osteochondroplasty, while palpation of the joint with flexion and internal rotation directly determined the presence or absence of residual impingement. Postoperatively, the patients remained toe-touch weight-bearing for six weeks and then progressed to full weight-bearing as tolerated with a progressive strengthening program.

Clinical Outcomes

Clinical outcome scores included the modified Harris hip score²⁷, nonarthritic hip score²⁸, and University of California, Los Angeles (UCLA) activity score^{29,30}. The modified Harris hip score was determined for all patients preoperatively and at the time of follow-up. This was a standard hip function outcome score at the time (2003) that we introduced this procedure into our practice. The nonarthritic hip score was published in 2003²⁸ and was incorporated into our outcome measurements. We also added the UCLA activity score to better capture changes in activity level. The most recently seen seventeen patients were assigned a preoperative nonarthritic hip score, and thirty-two patients were assigned a follow-up nonarthritic hip score. Similarly, the most recently seen twenty-one patients had a preoperative UCLA score, while thirty-four had a UCLA score at the time of the latest follow-up. All clinical data were obtained with a self-

administered patient questionnaire, independent of the treating surgeon.

Radiographic Assessment and Imaging

A routine radiographic series was obtained preoperatively, postoperatively, and at follow-up visits. This series included supine anteroposterior pelvic, frog-leg lateral, and cross-table lateral views. Digital radiographs were examined by one author (L.P.Z.) using Adobe Photoshop software (Adobe Systems, San Jose, California). The alpha angle, as described by Nötzli et al.³¹, was measured on the anteroposterior pelvic, cross-table lateral, and frog-leg lateral radiographs^{32,33}. Osteoarthritis of the involved hip was graded according to the Tönnis classification³⁴. Thirty-three (94%) of the patients had preoperative magnetic resonance arthrograms. Thirty of these studies were performed at our institution by one of four musculoskeletal radiologists. These radiologists' reports on the magnetic resonance arthrograms were recorded. The other three magnetic resonance arthrograms were made at outside institutions and were reviewed by us in conjunction with one of the four musculoskeletal radiologists.

Comparison of the preoperative magnetic resonance arthrography and hip arthroscopy findings revealed that twenty-seven patients (82%) had arthroscopic confirmation of an acetabular labral tear seen on the magnetic resonance arthrogram, four patients showed no acetabular labral tear on the preoperative magnetic resonance arthrogram but had a labral tear identified at the time of the arthroscopy, and



Fig. 2-E



Fig. 2-F

Figs. 2-E and 2-F Two-year follow-up radiographs demonstrating deformity correction.

two patients did not show an acetabular labral tear on the magnetic resonance arthrogram or at the time of the arthroscopy. Both of these hips were found to have fraying of the labrum at the time of the arthroscopy. All primary acetabular labral tears were located in the anterior and anterolateral regions. The average size of the labral tears was 19 mm (range, 5 to 50 mm). According to the Outerbridge classification of acetabular chondromalacia, there were three Grade-I, eight Grade-II, five Grade-III, and eighteen Grade-IV lesions. According to the Outerbridge classification of the femoral head cartilage, there were thirty Grade-0, no Grade-I, two Grade-II, one Grade-III, and two Grade-IV lesions. The preoperative Tönnis osteoarthritis classifications included nineteen grade-0, twelve grade-1, and four grade-2 hips.

Statistical Analysis

Differences between preoperative and postoperative clinical outcome scores and radiographic measurements were assessed with use of the Student t test. A p value of <0.05 was considered to be significant. The Pearson correlation was used

to determine the relationship between the change in alpha angle and the change in the pain component of the Harris hip score.

Source of Funding

The funding sources include the Curing Hip Disease Fund and a Zimmer research grant. The funds from these sources were utilized for research personnel salary support. This included tracking of patients, data collection, and data analysis.

Results

The majority of patients demonstrated improved hip function and increased activity levels after surgical treatment. The average modified Harris hip score improved 23.6 points between the preoperative and final follow-up evaluations. Twenty-nine (83%) of the thirty-five patients had at least a 10-point improvement in the modified Harris hip score, and 71% of the patients had a Harris hip score of >80 points. The UCLA activity level score was found to have improved an average of 2.3 points at the most recent follow-up evaluation, and the

TABLE I Clinical Data for Patients with a Minimum of Two Years of Follow-up

	Modified Harris Hip Score	Nonarthritic Hip Score	UCLA Activity Score
Preop.			
No. of patients evaluated	35	17	21
Score (points)			
Average \pm stand. dev.	63.8 \pm 11.1	75.1 \pm 14.0	6.1 \pm 2.4
Range	35-85	48-93	2-10
Two-year follow-up			
No. of patients evaluated	35	32	34
Score (points)			
Average \pm stand. dev.	85.9 \pm 15.2	90.9 \pm 10.7	8.2 \pm 1.6
Range	54-100	60-100	4-10
P value*	<0.0001	0.0001	<0.0001
Latest follow-up			
No. of patients evaluated	35	32	34
Score (points)			
Average \pm stand. dev.	87.4 \pm 15.3	90.2 \pm 11.8	8.4 \pm 1.5
Range	54-100	60-100	5-10
P value*	<0.0001	0.0002	0.0003

*For the difference compared with the preoperative score.

nonarthritic hip score had improved an average of 15.1 points (Table I).

The combined arthroscopic and limited open osteochondroplasty approach provided an opportunity for substantial deformity correction and did not result in progression of osteoarthritis in most cases. The alpha angle was normalized on the anteroposterior, cross-table lateral, and frog-leg lateral radiographs (Table II). The change in alpha angle did not correlate with alterations in pain as measured with the modified Harris hip score. Only two patients had progression of osteoarthritis, from Tönnis grade 0 to grade 1, during the follow-up period.

Since femoroacetabular impingement disorders are commonly bilateral, baseline data were also collected on the contralateral (untreated) hips. During the course of our treatment, twelve (34%) of the thirty-five patients reported

contralateral hip symptoms, and six of these patients had undergone surgical intervention for femoroacetabular impingement. The alpha angle on the anteroposterior pelvic radiograph of the index (surgically treated) hip (65.1°) was comparable with that of the contralateral hip (61.9°). Twelve of the contralateral hips also had a full radiographic series, and nine of the twelve had an alpha angle of >50° on the cross-table and/or frog-leg lateral views. These data suggest that bilateral impingement is relatively common.

The number of complications associated with the procedures was low. The complications included one superficial infection successfully treated with oral antibiotics until resolution, one deep vein thrombosis (in the popliteal vein proximal to the calf) treated successfully with three months of anticoagulation, and asymptomatic Brooker grade-I heterotopic ossification³⁵ in four hips. None of these complications

TABLE II Alpha Angles for Patients with Two Years of Follow-up

	Alpha Angle					
	Cross-Table Lateral Radiograph		Frog-Leg Lateral Radiograph		Anteroposterior Radiograph	
	Preop.	Latest Follow-up	Preop.	Latest Follow-up	Preop.	Latest Follow-up
Average \pm stand. dev. (deg)	58.6 \pm 13.1	37.1 \pm 4.7	63.9 \pm 13.0	37.8 \pm 4.9	63.1 \pm 14.2	44.8 \pm 4.4
Range (deg)	36-93	32-48	40-81	24-46	45-91	35-56
P value	<0.0001		<0.0001		<0.0001	

required additional surgical treatment. Numbness in the distribution of the lateral femoral cutaneous nerve is common with anterior hip approaches but was not specifically evaluated in this cohort of patients. Nevertheless, none of the patients reported pain symptoms related to this nerve. There were no major neurovascular complications, no femoral neck fractures, and no cases of femoral head osteonecrosis. No hip was converted to an arthroplasty.

Discussion

Numerous authors have recognized cam femoroacetabular impingement as a source of hip pain, loss of motion, and early-onset osteoarthritis in young adults. Early surgical intervention has been advocated for symptomatic impingement disease to relieve symptoms, enhance function, and preserve the hip joint over time^{6-9,11,14-24,27,36-38}.

The goal of joint preservation surgery for femoroacetabular impingement is to eliminate abnormal contact between the proximal part of the femur and the acetabulum and to address intra-articular labral and articular cartilage abnormalities⁹. Effective treatment and good clinical results may be accomplished with different surgical techniques, including open dislocation^{6,7,14,15,38}, arthroscopy and limited open approaches^{19,22}, and arthroscopy techniques alone^{16,17,19-24}. To date, there is limited information regarding the clinical results of a combined arthroscopic and limited open osteochondroplasty approach. Laude et al.²² recently described a technique for treating femoroacetabular impingement with a mini-open Hueter approach and arthroscopic assistance. They reported on 100 hips in ninety-seven patients followed for a minimum 28.6 months after surgery. The mean improvement in the nonarthritic hip score was 29 points, and 11% of the hips were converted to a total hip replacement. Additionally, Hartmann and Günther¹⁹ recently reported their early results with arthroscopically assisted anterior decompression of femoroacetabular impingement in thirty-four hips in thirty-three patients followed for a mean of fifteen months (range, six to twenty-seven months). They reported an improvement in the modified Harris hip score from an average of 64 points preoperatively to an average of 85 points at the time of the last follow-up. The results in both of these studies are comparable with our results and those of open dislocation techniques and of arthroscopy techniques alone.

Our investigation provides the early results of a surgical procedure that combines hip arthroscopy with a limited open osteochondroplasty of the femoral head-neck junction to treat focal cam impingement disease. We found significant improvement in the average Harris hip score, and the activity levels were increased as demonstrated by the improved UCLA activity scores. The current study group represents the initial cohort of patients to undergo this surgical procedure in our practice and also represents our learning curve experience. During this study period, acetabular labral tears were addressed with partial resection. Recently, Espinosa et al.⁷ reported significantly improved clinical and radiographic results in patients

who had labral reattachment rather than labral debridement during surgical hip dislocation. Currently, we perform arthroscopy first to assess the integrity of the joint and to treat intra-articular abnormalities because even a limited open osteochondroplasty would compromise the arthroscopic technique if it was performed first. Labral tear patterns amenable to arthroscopic repair are addressed with standard arthroscopic labral repair techniques.

The alpha angle has been proposed as a measurement to quantify femoral head-neck osseous overgrowth on magnetic resonance images and plain radiographs^{31,33}. Using magnetic resonance arthrograms, Nötzli et al. found an average alpha angle of 74° in thirty-nine patients with symptomatic femoroacetabular impingement compared with an average alpha angle of 42° in a control group³¹. An alpha angle of >55° has been associated with symptomatic cam femoroacetabular impingement, with the likelihood of impingement increasing at larger alpha angles^{31,39}. In our series, the preoperative average alpha angle was >55°, and all patients had correction of the angle to <55°. These data suggest that this technique can provide adequate deformity correction as determined by the change in alpha angle.

Combined hip arthroscopy and limited open femoral head-neck osteochondroplasty offers certain benefits as an alternative to surgical hip dislocation for the treatment of cam femoroacetabular impingement deformities. This combined minimally invasive procedure allows accurate evaluation and treatment of intra-articular labral and cartilage injuries while offering direct visualization for a precise osteochondroplasty. If advanced hip degeneration is identified during hip arthroscopy, the open part of the procedure may be abandoned as the surgical outcome is less predictable with advanced joint degeneration^{5,14}.

This study has limitations. Only patients with cam impingement were treated with this surgical technique during the study period, and there was not a comparable group treated nonoperatively or with other surgical techniques. We acknowledge that the natural history of untreated femoroacetabular impingement and the placebo effect of surgical intervention for these disorders have not been adequately investigated. Additionally, isolated treatment of central compartment disease without correction of the structural impingement abnormality is another surgical strategy that has not been rigorously investigated. Nevertheless, recent work by our group does suggest that correction of the impingement abnormality may reduce the number of poor clinical outcomes and treatment failures⁴⁰.

It should also be noted that, in the present study, five patients were lost to follow-up less than two years postoperatively, and their outcomes are not known. In addition, the clinical outcome was assessed with the modified Harris hip score, which was originally designed for patients undergoing total hip arthroplasty. The modified Harris hip score may not be the ideal outcome tool with which to measure the response to surgical treatment in young, active patients with impingement. Both the modified Harris hip score^{14,16,17,19,21,23,27}

and the Merle d'Aubigné score^{6,7,15}, however, have been used as outcome measures following surgical hip dislocation and hip arthroscopy for the treatment of femoroacetabular impingement. In addition, after introduction of this procedure, we employed the nonarthritic hip score and UCLA activity score to better study the outcomes in active, young patients. Those two scores are not available for all of the patients in the study, but they do provide additional contemporary outcome information to our data set.

In conclusion, the current study shows that combined hip arthroscopy with a limited open osteochondroplasty is a safe and potentially effective surgical alternative for the treatment of cam femoroacetabular impingement. Long-term follow-up is essential to determine the true efficacy of this

technique as well as other joint preservation procedures for femoroacetabular impingement. ■

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