CLINICAL ARTICLE

Arthroscopic Treatment of Labral Tears in Patients with Borderline Developmental Dysplasia of the Hip: A Retrospective Study with Mean 5.8 Years Follow-Up

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Objective: To retrospectively assess the mid-term clinical and radiological results of hip arthroscopic treatment of labral tears in patients with borderline developmental dysplasia of the hip (BDDH).

Methods: From January 2010 and December 2019, data were retrospectively reviewed for all patients who underwent arthroscopic surgery of the hip for the treatment of intra-articular abnormalities. Only the Patients who had borderline developmental dysplasia (BDDH) were included. All operations were performed by two senior surgeons, the arthroscopic treatment including labral repair, labral debridement, minimal acetabuloplasty, femoroplasty and capsular closure. The evaluation consisted of pain evaluation (visual analog scale [VAS]), the modified Harris hip score (MHHS), range of motion, the radiological evaluation of plain film and MRI analysis of the hip joint. The plain film evaluation included anteroposterior views of the pelvis to assess lateral center-edge angle (LCEA) and acetabular inclination (AI), frog-leg lateral views of the hip to assess α angle.

Results: There were 34 patients (36 hips) ultimately enrolled in this study. The follow-up duration of the patients were minimal 2 years (average, 69.2 months) postoperatively. The patient group included seven men and 27 women, the mean age at the time of surgery was 30.9 years. The mean BMI was 22.3 kg/m^2. From the pre-operative status to the final follow-up visit, mean mHHS score increased from 64.5 to 92.7, mean VAS score decreased from 6.8 to 1.3. All scores exhibited statistically significant differences ($P < 0.001$). The mean LCEA decreased from 22.9° to 22.7°, the mean AI decreased from 7.7° to 7.6°. Which all showed no significant differences compared with the final follow-up to the pre-operative status ($P > 0.05$). However, the mean α angle was significantly decreased from 48.3° to 40.1° ($P < 0.001$). We encountered no significant complications such as infection, deep venous thrombosis, fluid extravasation, or permanent nerve injury. One patient (2.94%) underwent revision periacetabular osteotomies (PAO) because of subluxation of the hip joint with permanent pain after 6 months failed conservative treatment.

Conclusion: Arthroscopic treatment of labral tears in patients with BDDH may provide safe and durable favorable results at midterm follow-up. The best outcome could be expected in patients with labral repair and closure of the capsule with strict patient selection criteria.

Key words: Arthroscopy; Borderline developmental dysplasia of the hip; Labral tears

Introduction

Over the past decade, the understanding of the anatomy, function, and biomechanics of the acetabular labrum has grown. Labral tear is the most common cause of mechanical symptoms and was found in 22%–55% of patients with hip pain[1]. Acetabular labral disorders are

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Disclosure: There are no any ethical/legal conflicts involved in the article.
Received 13 January 2021; accepted 13 April 2021

associated with various pathogeneses including hip trauma, negative effects of high-level sports activities, degenerative osteoarthritis, femoroacetabular impingement (FAI), developmental dysplasia of the hip (DDH)[2–5].

Currently, hip arthroscopy has become a successful procedure for a growing number of disorders in and around the hip as a result of advances in surgical skill and technology, especially for the treatment of labral pathologies. A systematic review study involving more than 36,000 hip arthroscopies reported a fairly low complication rate of 3.3% following this procedure. Among all the arthroscopic surgeries, the most common diagnosis was FAI in 16,003 cases (43.5%), followed by a labral tear in 12,091 (32.9%) and a chondral defect in 3279 (8.9%)[6].

However, there is a significant amount of controversy when it comes to the effectiveness of hip arthroscopy in patients with DDH[7]. Open procedures for treating symptomatic DDH patients such as periacetabular osteotomies (PAO) have been affording excellent results, even in the long-term follow-up results. Steppacher *et al.* retrospectively evaluated the 58 patients (68 hips) who underwent periacetabular osteotomy. The mean follow-up time was 20.4 years and 41 hips (60%) were preserved at last follow-up. They observed no major changes in any of the radiographic parameters during the 20-year postoperative period except the osteoarthritis score[8].

Isolated hip arthroscopy for treating DDH has been associated with variable outcomes. Some studies reported good outcomes but emphasized that these correlated principally with the type of intra-articular pathology, not dysplasia status. Byrd *et al.* reported the outcome of hip arthroscopy in 48 patients with dysplasia or borderline dysplasia. At an mean follow-up of 27 months, the average functional score (modified Harris Hip Score) was 77 points for the borderline group and 83 points for the dysplasia groups with no significant difference between the two groups[9].

Other studies have described poor outcomes, suggesting that hip arthroscopy was not beneficial in dysplastic patients and that surgery might even accelerate arthritic progression. Parvizi *et al.* investigated 34 patients who underwent at least one arthroscopy of the hip for labral tear. Developmental hip dysplasia or other morphologic abnormalities of the hip were confirmed in all patients. Arthroscopy failed to relieve pain in 24 patients. They observed accelerated arthritis in 14 patients and migration of the femoral head in 13 patients. Sixteen patients underwent further surgeries included periacetabular osteotomy (six patients), femoroacetabular osteoplasty (seven patients), and total hip arthroplasty (three patients). At the latest follow-up, all patients but one were pain-free[10].

Recent studies reported short-term to mid-term favorable outcomes following arthroscopic intervention in patients with borderline developmental dysplasia of the hip (BDDH), which infers to mild undercoverage of the femoral head, although its definition varies in the literature. The clinical evidence highlighting the role of labral preservation and capsular management in maintaining functional stability, as iatrogenic injury to the labrum and capsule without appropriate repair will destabilize the hip joint[11–14].

The purpose of this article is: (i) to retrospectively evaluate mid-term clinical outcomes in patients with labral tear and BDDH who were treated with isolate arthroscopic labral preservation and capsular closure procedures; (ii) to evaluate and analyze the post-operative radiological outcomes in these patients; and (iii) we hypothesize that arthroscopic procedure for treating labral tear in patients with BDDH will demonstrate postoperative improvement, high satisfaction rates, with low complication and reoperation rates.

Methods

Patient Characteristics

From January 2010 to December 2019, data were retrospectively reviewed for all patients who underwent arthroscopic surgery of the hip for the treatment of intra-articular abnormalities in our department.

The inclusion criteria were: (i) patients who were treated with arthroscopic labral preservation and capsular closure with borderline developmental dysplasia (BDDH); (ii) the BDDH was defined as the lateral center-edge angle (LCEA) of Wiberg was ≥20°and <25°; and (iii) the minimal follow-up time was 2 years.

The exclusion criteria were patients with: (i) a history of high-energy hip trauma; (ii) a history of surgery involving the femur or pelvis; (iii) Tönnis grade > 1; (iii) any other disease of the hip (i.e., Perthes disease, slipped capital femoral epiphysis, inflammatory arthritis, or avascular necrosis); (iv) FAI cases; and (v) Severe DDH cases (LCEA <20°).

Between January 2010 and December 2019, 1053 patients underwent primary hip arthroscopy in our institution to treat symptomatic acetabular labral tears.

We identified 47 BDDH cases (5.8%), 13 patients were lost to follow-up. Finally, 34 patients (36 hips) were retrospectively analyzed. The mean patient age at the time of surgery was 30.9 years (range, 12–54 years), and the mean body mass index (BMI) was 22.3 kg/m^2 (range, 18.1–29.9 kg/m^2). The mean follow-up duration was 69.2 months (range, 24–150 months) (Table 1).

During surgery, all cases underwent arthroscopic labral repair (33 hips) or debridement (three hips) together with other procedures—arthroscopic femoroplasty in 36 hips,

TABLE 1 Patient demographics

Outcomes measure	Preoperative score	Latest follow-up score	*P value*
mHHS	64.5 ± 7.9	92.7 ± 8.2	<0.001
VAS for pain	6.8 ± 1.5	1.3 ± 1.5	<0.001
Patient satisfaction		8.8 ± 1.4	

mHHS, Modified harris hip score; VAS, visual analog scale.

capsular closure in 36 hips, minimal acetabuloplasty in seven hips, thermal debridement of the ligamentum teres in eight hips, chondroplasty in 27 hips.

Clinical Evaluation

The follow-up duration of the patients was a minimal 2 years (average 69.2 months) postoperatively. Clinical outcome scores were collected preoperatively and at the latest follow-up time postoperatively and compared between the two groups.

The Modified Harris Hip Score (mHHS)

The modified Harris hip score is a condition-specific validated questionnaire widely used to evaluate the functional capabilities of the hip joint before and after hip arthroscopy. The scoring system consists of two parts. One part is the pain score (maximum 40 points), the other part is the function score.

The Visual Analog Scale (VAS) Score

The VAS score is a scale used to determine the pain intensity experienced by individuals. It consists of a line, approximately 10–15 cm in length, with the left side signifying no pain with a smiling face image and the right side signifying the worst pain ever with a frowning face image. The VAS is used to assist individuals to determine pain levels, who may not be accustomed to rating their pain on other types of scales.

The Patient Satisfaction with Surgery

The Patient satisfaction with surgery is a one question scale to evaluate the overall subjective result of the patient (0, not satisfied at all; 10, completely satisfied).

Radiologic Valuation

The radiographs analyzed included anteroposterior views of the pelvis to assess lateral center-edge angle (LCEA) and acetabular inclination (AI), frog-leg lateral views of the hip to assess the α angle.

Lateral Center-Edge Angle (LCEA)

The LCEA of Wiberg is the angle between a true vertical (perpendicular to a true horizontal of the pelvis) and the lateral osseous margin of the acetabular rim. True horizontal was defined as a line connecting the undersurface of the ischial tuberosities. This angle is to access the coverage of the acetabulum, a normal acetabulum should have a LCEA >25°.

Acetabular Inclination (AI)

The AI is the angle formed by a line parallel to the horizontal plane of the pelvis and a tangential line extending from the medial edge to the lateral edge of the acetabular sourcil. This angle is to access the coverage of the acetabulum a normal acetabulum should have a AI < 15°.

α Angle

The α angle is measured on the frog-leg lateral views of the hip and is the angle between the femoral neck axis line and a line connecting the center of the femoral head to the point where the peripheral contour of the femoral head exceeded the radius of the femoral head. The α angle is to access the Cam lesion of the femoral neck and head junction, a normal reference value of the α angle <55° (Fig. 1).

The Tönnis grade classification was used to grade degenerative radiographic changes. Preoperative MRI scans were employed to identify intra-articular pathologies. The postoperative MRI scans were employed to assess the union of the labrum and capsule. All complications and reoperations were noted.

Surgical Technique

All operations were performed by two seniors surgeons.

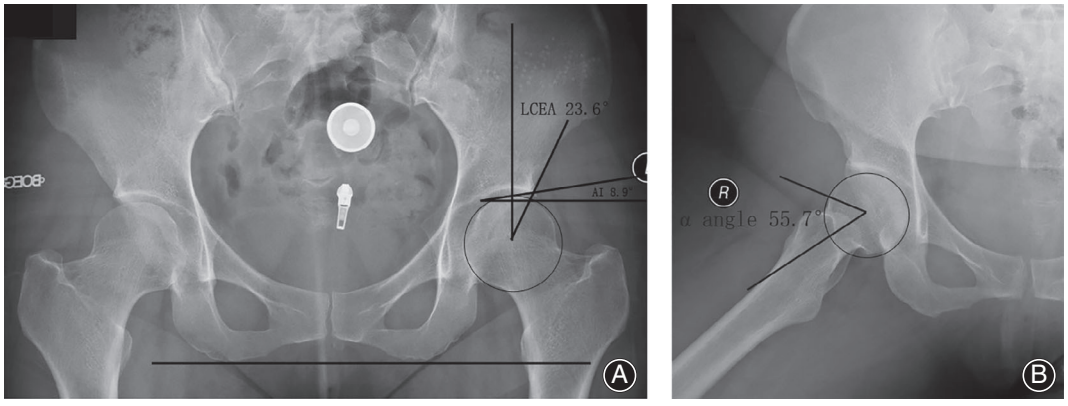

Fig 1 (A) The radiographs used the anteroposterior views of the pelvis to assess lateral center-edge angle (LCEA) and acetabular inclination (AI); (B) The radiographs used the frog-leg lateral views of the hip to assess the α angle.

Anesthesia and Position
All the patients were placed in a supine position on a traction table with a well-padded perineal post under general anesthesia. Traction was applied to open the joint by approximately 1 cm.

Portal Setup and Capsulotomy
The procedure usually was begun from the central compartment. Access to the joint was achieved through a standard anterolateral portal. A mid-anterior accessory portal was established under direct visualization for routine joint inspection as well as to facilitate instrument access and the performance of intra-articular procedures. Capsulotomy was undertaken using a Banana blade, parallel to the labrum, connecting the anterior and mid-anterior portals and extending medially as needed to address all intra-articular abnormalities.

Labral Preservation Procedures
After capsulotomy, diagnostic arthroscopy was performed, and any pathology of the labrum, impingement, and chondral damage or ligamentum teres tears were documented. We tried to preserve as much of the native labrum as possible, using the standard arthroscopic repair technique. If the labrum was found to be irreparable, debridement was performed. Acetabular trimming was minimized to preserve the acetabular cover; thermal debridement was performed if a partial tear of the ligamentum teres was identified. The cartilage of the acetabulum and femoral head was thoroughly assessed, and chondroplasty was performed by thermal device.

Peripheral Compartment Inspection and Treatment
After central compartment manipulation, the traction was removed, and the hip was flexed approximately to 45°. Then the peripheral compartment was inspected, Cam lesion was treated *via* femoral head-and-neck osteoplasty using the shaver and 5.5 mm burr.

Capsular Management
After completion of the intra-articular portion of the arthroscopy, a secure side-to-side closure of the capsule was achieved in all the patients. In total, two to three repair sutures were placed. The hip was then placed in extension to visualize the repair and ensure it was not overtightened.

Postoperative Care
All patients were permitted to begin partial weightbearing ambulation using the affected leg for a minimum of 4 weeks; Physical therapy was begun as early as postoperative day 1 to begin passive range of motion. A hip brace was worn to prevent hip extension and rotation while walking.

Statistical Analyses
All statistical analyses were performed using IBM SPSS Statistics software (version 23.0; IBM Corporation, Armonk, NY). Descriptive statistics were calculated for patient demographic data including age, sex, follow-up time, and body mass index (BMI). Differences between pre-operative and final follow-up clinical features were compared using the paired *t*-test. Differences were considered statistically significant if P *value* < 0.05.

Results

General Results
There were 34 patients (36 hips) ultimately enrolled in this study. All patients completed the minimum 2-year's follow-up tasks. The mean follow-up time was 69.2 months (range, 24–150 months). The patient group included seven men and 27 women, which the right side involved in 16 patients and the left side involved in 16 patients, both sides involved in two patients (Table 1).

Clinical Results

The Modified Harris Hip Score (mHHS)
The pre-operative mean mHHS score was 64.5 ± 7.9 (range, 52.8–77.5) and as the final follow-up, the mean mHHS score was 92.7 ± 8.2 (range, 54.4–100). Compare with the two groups, the scores exhibited statistically significant differences ($P < 0.001$, $t = -15.800$).

The Visual Analog Scale (VAS) Score
The pre-operative mean VAS score decreased from 6.8 ± 1.5 (range, 4.0–9.0) and as the final follow-up, the mean VAS score was 1.3 ± 1.5 (range, 0–8.0). Compare with the two groups, the scores exhibited statistically significant differences ($P < 0.001$, $t = 14.581$).

The Patient Satisfaction with Surgery
The mean patient satisfaction score was 8.8 ± 1.4 (range, 7–10) (Table 2).

Radiographic Results

Lateral Center-Edge Angle (LCEA)
The pre-operative mean LCEA were 22.9° ± 1.3° (range, 20.9°–25.0°) and as the final follow-up, the mean LCEA were 22.7° ± 1.3°(range, 20.9°–24.7°). There were no statistically significant differences between the two groups ($P > 0.05$).

TABLE 2 Comparison between the preoperative and postoperative latest follow-up clinical outcomes (mean ± SD)

Variable	Value
No. of cases	34 (36 hips)
Sex (male: famale)	7:27
Age (years)	30.9 (range, 12–54)
Body mass index (kg/m2)	22.3 (range, 18.1–29.9)
Follow-up period (months)	69.2 (range, 24–150)

TABLE 3 Comparison between the preoperative and postoperative latest follow-up radiographic results (mean + SD)

Outcomes measure	Preoperative radiographic indices	Latest follow-up radiographic indices	*P value*
LCEA, °	22.9 ± 1.3	22.7 ± 1.3	>0.05
AI, °	7.7 ± 2.1	7.6 ± 2.1	>0.05
α angle, °	48.3 ± 6.6	40.1 ± 3.9	<0.001

AI, acetabular inclination; LCEA, lateral center-edge angle.

Acetabular Inclination (AI)

The pre-operative mean AI were 7.7° ± 2.1° (range, 3.6°–11.0°) and as the final follow-up, the mean AI were 7.6° ± 2.1° (range, 3.6°–10.8°). There were no statistically significant differences between the two groups ($P > 0.05$).

α Angle

The pre-operative mean α angle was 48.3° ± 6.6° (range, 36.8°–60.3°), and as the final follow-up, the mean α angle was 40.1° ± 3.9° (range, 33.4°–47.9°) at the final follow-up visit. There were statistically significant differences between the two groups ($P < 0.001$, $t = 6.950$) (Table 3).

Arthroscopic Finding

All hips with a hypertrophic labrum underwent labral preservative procedure and femoroplasty and capsular closure. (Fig. 2).

Thirty-three (91.7%) hips underwent labral repair, and three (8.3%) underwent selective debridement. Six (16.7%) hips with cystic pathological changes underwent debridement (Fig. 3), eight (22.2%) hips with partial tear of ligamentum teres underwent thermal debridement (Fig. 4). Seven (19.4%) hips underwent minimal acetabuloplasty. No

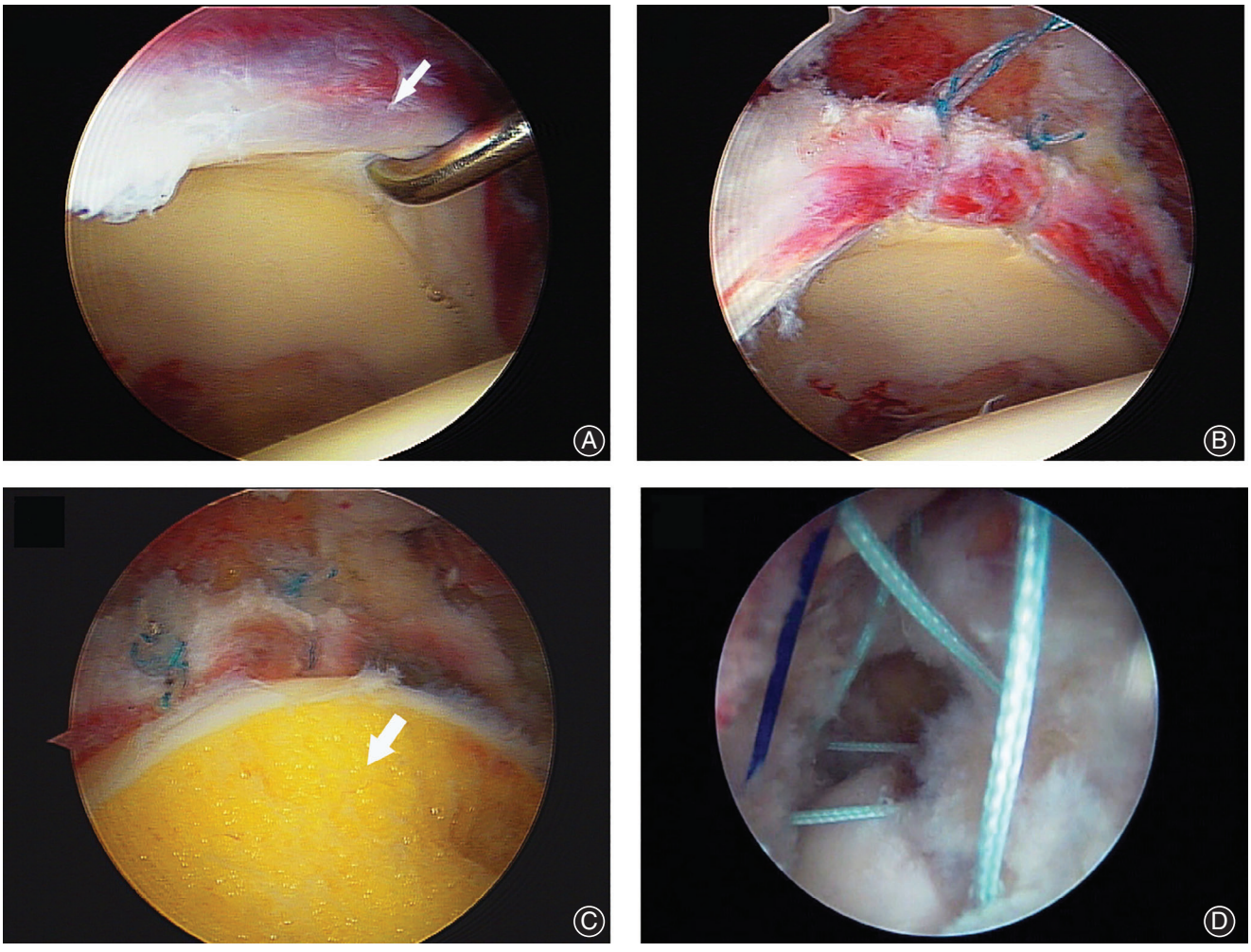

Fig 2 Arthroscopic view of the left hip of a 37-year-old woman presented with a several-year history of groin pain. She underwent arthroscopic treatment with labral repair, osteoplasty of femoral head and neck junction and capsular closure. (A) Hypertrophic labrum and labral tear (arrow). (B) Labral repair. (C) Femoral osteoplasty (arrow). (D) Capsular closure with side-to-side repair technique.

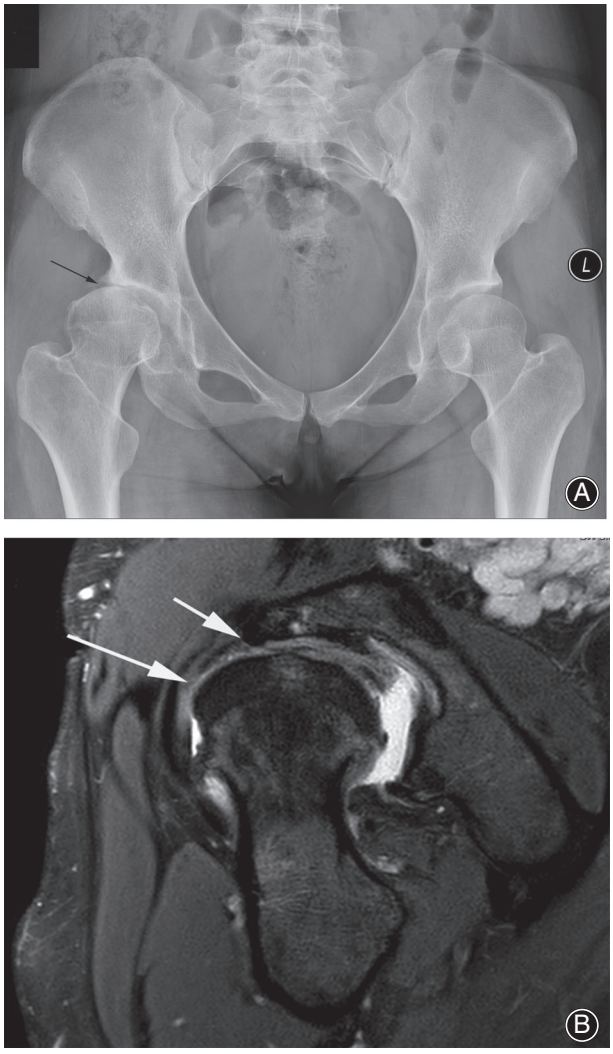

Fig 5 Thirty-nine-year-old woman who was treated with labral debridement, femoroplasty and capsular closure during the arthroscopic surgery for the right hip. The patient complained of severe pain and limitation of the range of motion of right hip 2 years after operation. (A) The final follow-up radiographs showed subluxation of the hip and joint space narrowing (arrow). (B) The MRI showed labral deficient (short arrow) and non-union of the anterior capsule (long arrow).

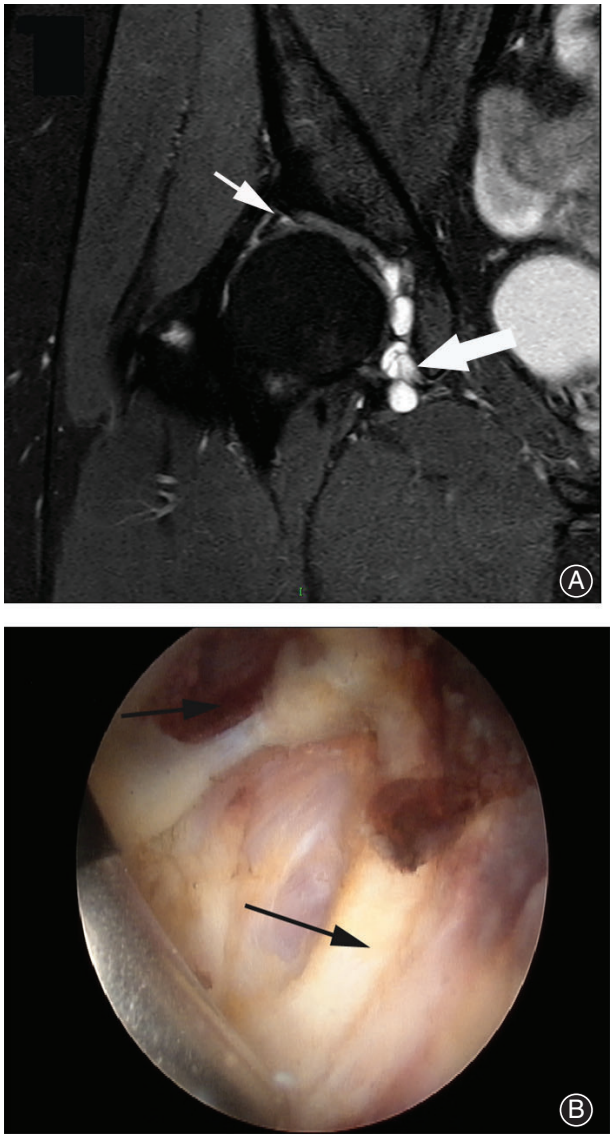

Fig 3 Forty-five-year-old woman presented with a 2-year history of right hip pain with limitation of hip flection and internal rotation. (A) MRI showed labral tear (thin arrow) combine with the cystic changes (wide arrow). (B) Arthroscopic view of the cystic changes (short arrow) in the iliopsoas tendon (long arrow).

hips underwent acetabular or femoral head microfracture, chondroplasty was performed in 27 (75%) hips.

Complications

We encountered no significant complications such as infection, deep venous thrombosis, fluid extravasation, or permanent nerve injury.

One patient (2.94%) underwent revision PAO because of subluxation of the hip joint with permanent pain after 6 months failed conservative treatment. This patient was a 39 year old woman who was treated with labral debridement, femoroplasty and capsular closure during the arthroscopic surgery.

The final follow-up radiographs showed subluxation of the hip and joint space narrowing. The MRI showed labral deficient and non-union of the anterior capsule (Fig. 5). The patient was revised with PAO procedure 2 years and a half after the arthroscopy surgery in other hospital.

Discussion

The acetabular labrum is a triangular fibrocartilaginous structure attached to the rim of the acetabulum and

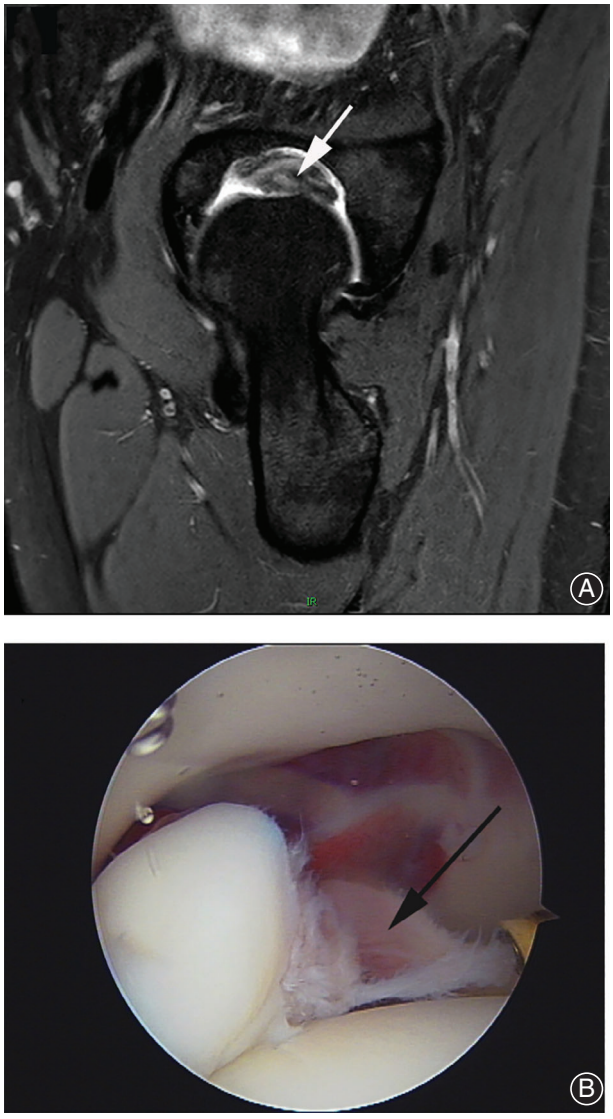

Fig 4 Twenty-seven-year-old female dancer sustained a hip injury during jumping in a performance. (A) MRI showed partial tear of ligamentum teres (arrow). (B) Arthroscopic view of the partial tear of ligamentum teres (arrow).

facilitates. The labrum increases the depth, surface area, volume, congruity, and stability of the hip joint. The labrum has been shown to contribute an average of 22% to articulating surface area and 33% to acetabular volume[15]. The fluid seal is one of the most important functions of the labrum, as it produces a negative intra-articular pressure, significantly increasing joint stability[16].

Natural history studies have shown that patients with true acetabular dysplasia are predisposed to developing early coxarthrosis[17]. Open procedures such as PAO reliably improve the outcomes of treatment for these patients, have good results over long-term follow-up, and are considered the gold standard in treating patients with true DDH[8].

However, the BDDH patients with labral tears pose challenges in terms of definitive treatment. Namely, the choice between arthroscopy and PAO is difficult. Currently, hip arthroscopy has been increasingly used to manage hip pathologies such as FAI and symptomatic labral tears[18]. But the indications for and outcomes of hip arthroscopy in DDH or borderline BDDH patients have been both inconclusive and controversial[19].

Many studies reported significantly poorer clinical outcomes and increased rates of revision arthroscopy and THA conversion for hip arthroscopy treatment in dysplastic patients compared to nondysplastic patients[20–22]. In contrast, Domb *et al.*[11]found that hip arthroscopy effectively treated the labral lesions of BDDH patients. The overall patient satisfaction was rated as good or excellent (77%). Two patients (9%) required revision arthroscopy. Thus, borderline HD patients could be successfully managed *via* hip arthroscopy when a consistent surgical approach including both labral repair and capsular plication was applied. Larson *et al.*[12] reported similar outcomes also emphasis preserving the labrum and addressing capsular restraints. Recently, Domb *et al.*[14] reported minimum 5-year patient-reported outcomes for hip arthroscopic surgery with Labral preservation and capsular plication in patients with BDDH. The clinical outcome scores improved significantly. Four hips (19%) required secondary arthroscopic procedures, all of which resulted in improved clinical outcome scores at latest follow-up. No patient required conversion to total hip arthroplasty.

Our study reported similar clinical outcome that patients with BDDH who undergo hip arthroscopic surgery for intra-articular abnormalities with labral preservation and concurrent capsular closure. The favorable results were related to healing of the capsule and restorations of seal function of the labrum directly. Only one patient with a poor result showed that the capsule failed to heal and labral defect. One patient underwent staging bilateral hip arthroscopy reported good results, the final follow-up MRI showed good healing of the capsule and labrum.

All hips demonstrate a hypertrophic labrum, six hips with cystic pathological changes and eight hips with partial tear of ligamentum teres which may associated with micro instability of the patients with BDDH.

The limitation of our study is that 13 cases (27.7%) were missing follow-up. Our results may thus not apply to all hip arthroscopic series of BDDH patients, due to selection and performance biases. Second, our radiographic follow-up images were sometimes not standard. Third, assessing BDDH is complex and requires multiple radiographic measurements. Our study focused on only LCEA to assess BDDH, it can mischaracterize or underdiagnose

the acetabular morphology and hip instability. Despite these limitations, our patient numbers were relatively large, and our follow-up period is relatively long. Fourth, there was no prospective randomized design study in this case series.

In the future, well-controlled prospective studies are required to further explore the outcomes of arthroscopy surgery for BDDH cases.

Conclusions

Although the PAO remains the gold standard for treating true acetabular dysplasia, hip arthroscopy may provide a safe and durable means of treating labral tears in the setting of BDDH at midterm follow-up. These procedures should be performed by surgeons with expertise in advanced arthroscopic techniques, using strict patient selection criteria, with emphasis on labral preservation and capsular closure.

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