Clinical Outcomes of the Arthroscopic Capsular Suture-Lifting Technique in the Treatment of Femoroacetabular Impingement in Patients With Borderline Developmental Dysplasia of the Hip

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Background: Patients with femoroacetabular impingement (FAI) are likely to present with borderline developmental dysplasia of the hip (BDDH). Considering the prolonged risk of negative prognosis in these patients, the need for surgical management of the capsule has been emphasized. Although previous studies have advocated different techniques of capsular closure during surgery, no consensus has been achieved. Therefore, the aim of this study was to evaluate the clinical outcomes of a new arthroscopic capsular suture-lifting technique for the treatment of FAI combined with BDDH.

Hypothesis: The arthroscopic capsular suture-lifting technique would achieve better anterior stability and show better clinical outcomes compared with routine capsular closure.

Study Design: Cohort study; Level of evidence, 3.

Methods: Consecutive patients diagnosed with FAI and BDDH and who underwent hip arthroscopy in our hospital between September 1, 2017, and April 30, 2021, were evaluated. Data were collected prospectively and analyzed retrospectively. Patients were divided into 2 groups according to the capsule closure methods used: capsular suture-lifting technique (lifting group) and routine capsular closure (control group). Anteroposterior hip radiography, Dunn view radiography, and computed tomography imaging were carried out for all patients preoperatively and postoperatively. Patient-reported outcomes, including the modified Harris Hip Score (mHHS) and visual analog scale (VAS) for pain, were collected preoperatively and at least 1 year after surgery and compared between the 2 groups. The Wilcoxon signed-rank test was used to evaluate changes in preoperative to postoperative mHHS scores and VAS. Mann-Whitney *U* test was used to evaluate significant differences in postoperative mHHS and VAS scores in the 2 groups.

Results: In all, 144 patients were included in this study, of whom 77 (53.5%) underwent the arthroscopic capsular suture-lifting technique and 67 (46.5%) underwent routine arthroscopic surgery. The patients in both groups had significant improvement in postoperative mHHS and VAS compared with the preoperative assessment ($P < .05$). The postoperative VAS score of patients in the suture-lifting group was significantly lower (2.6 vs 3.8; $P < .05$) and the mHHS score was significantly higher (75.2 vs 68.5; $P < .05$) than those of patients in the control group. Of the 77 patients in the suture-lifting group, 68 (88.3%) surpassed the minimal clinically important difference (MCID) and 49 (63.6%) achieved the Patient Acceptable Symptom State (PASS). Of the 67 patients in the control group, 26 (38.8%) surpassed MCID and 32 (47.8%) achieved PASS. The percentage of patients achieving MCID and PASS in the suture-lifting group was significantly greater than that in the control group ($P = .007$ for MCID; $P = .03$ for PASS).

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Conclusion: The study demonstrated that the arthroscopic capsular suture-lifting technique provided good clinical outcomes in the treatment of patients with FAI combined with BDDH. This technique showed better improvement of postoperative clinical outcomes than routine capsular closure.

Keywords: borderline developmental dysplasia of the hip; capsular suture-lifting technique; hip arthroscopy; hip: femoroacetabular impingement

Femoroacetabular impingement (FAI) is increasingly recognized as a cause of hip pain, particularly in physically active or younger persons.[18] It is known that patients with FAI are likely to present with borderline developmental dysplasia of the hip (BDDH). BDDH was first described in 1976 by Fredensborg[15] as a center-edge angle between 20° and 25°; hence, BDDH is a relatively mild subtype of developmental dysplasia of the hip. As an abnormal hip morphology in patients with FAI, BDDH leads to pathologic instability of the joint, and the movement of the femoral head within the acetabulum caused by hip instability may lead to heightened risk of chondral degeneration and secondary osteoarthritis.[24,36,42]

Existing research has indicated that developmental dysplasia of the hip can result in suboptimal clinical outcomes during hip arthroscopy.[39] Within the realm of clinical practice, attention is also given to BDDH as a potential cause of joint instability. Previous studies have demonstrated that hip arthroscopy with capsular plication can lead to improvements in patient-reported outcome (PRO) measures for persons with BDDH.[25] Present biomechanical and clinical studies have confirmed a decline in postoperative hip joint stability if the capsulotomy is not closed in traditional arthroscopic procedure of patients with BDDH.[21,34] Therefore, attention should be focused on capsular closure after arthroscopic procedure, which is expected to significantly reduce the rate of iatrogenic instability.[1,4,14,16,30]

The surgical treatment of BDDH remains controversial because of the prolonged risk of negative prognosis.[29] Labral and capsular repair are strongly recommended in patients with BDDH for their acetabular undercoverage, which can lead to serious capsular instability and result in secondary osteoarthritis.[6,16,30] According to recent studies, arthroscopic hip surgery is becoming the superior treatment choice over conventional physiotherapy and surgical dislocation for BDDH.[19,35] Furthermore, the hip joint capsule, which is penetrated during the arthroscopic procedure to achieve surgical view and space, is considered important in maintaining postoperative joint stability.[21,26,34,41] Previous studies have advocated different techniques of capsular closure during surgery, but no consensus has been achieved thus far.[6,10,11,12,20,23,28] Most recent studies advocate a routine capsular closure and special suturing technique represented by capsular plication.[9,11,12,13,16,22,27,30] A previous study introduced a new arthroscopic capsular suture-lifting technique to achieve better hip joint stability during surgery for patients with FAI combined with BDDH.[38] This technique is used to restore the morphological structure of the anterior joint capsule and prevent postoperative anterior instability. However, the clinical outcomes of this technique are still unknown.

Therefore, the purpose of this study was to evaluate the clinical outcomes of the arthroscopic capsular suture-lifting technique in the treatment of patients with FAI combined with BDDH. We hypothesized that the arthroscopic capsular suture-lifting technique would achieve better anterior stability and that better clinical outcomes would be observed compared with routine capsular closure.

METHODS

Patients

We evaluated consecutive patients diagnosed with FAI and BDDH who underwent hip arthroscopy in our hospital between September 1, 2017, and April 30, 2021. Our study was approved by the institutional review board of Peking University Third Hospital (M2019451) and all participants provided written consent for participation. Data were collected prospectively and analyzed retrospectively. The following patients were included: (1) those diagnosed with FAI by clinical findings, plain radiographs, computed tomography (CT), and magnetic resonance imaging and (2) those diagnosed with combined BDDH (20° < lateral center-edge angle [LCEA] < 25°); (3) those who underwent hip arthroscopy for treatment by the arthroscopic capsular suture-lifting technique or routine capsular closure

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Ethical approval for this study was obtained from Peking University Third Hospital (M2019193).

technique; and (4) those between 18 and 60 years old. Patients with previous hip surgery and those who could not complete the clinical follow-up were excluded from the study. Patients were divided into 2 groups according to the different capsule closure method used, namely the arthroscopic capsular suture-lifting technique group and the routine capsular closure (control) group. Routine capsular closure was used initially, then we switched to the capsular suture-lifting technique.

Surgical Procedure

All arthroscopic surgeries were performed by a single surgeon with >10 years of experience (Y.X.). All surgeries were performed with the patient under spinal anesthesia in the modified supine position as described in previous studies.[17,38] In brief, the interportal capsulotomy technique was used to access the hip joint after establishing the anterolateral (AL) and midanterior (MA) portals. A detailed inspection of the central compartment was performed to assess the acetabular rim, acetabular labrum, articular cartilage, and ligamentum teres. Labral repair or labral debridement was performed according to the nature of the injury. Femoral osteoplasty or acetabuloplasty was performed according to the intraoperative findings. Capsular closure was performed routinely at the end of surgery. There are 2 different ways to close the capsule. In the suture-lifting group, a total of 8 "lifting" sutures (4 pairs) were passed through the distal joint capsule, which was lifted and fixed to the acetabular rim, as described by Tian et al[38] (Figure 1). To obtain a better arthroscopic view for exploration of the labral tear, 2 capsular traction sutures were passed into the proximal capsule through the AL portal and MA portal, respectively, for adequate exposure of the acetabular rim. In addition, 2 capsular traction sutures were passed through the distal capsule using the same AL portal and MA portal to ensure proper visualization of the femoral neck. After making 4 mattress sutures for capsular suture-lifting, traction suture in the proximal capsule was used to pass the traction suture in the distal capsule through both proximal and distal capsules via the AL portal and MA portal, respectively. The suture was then securely tied. In the control group, capsular closure was performed with 2 or 3 No. 2 Orthocord sutures (DePuy Mitek).

Postoperative Rehabilitation

Patients in both the suture-lifting group and the control group underwent the same postoperative rehabilitation protocol. This protocol included initiating ankle pumps, quadriceps strengthening, and other isometric exercises within 1 or 2 days after surgery. Hip passive range of motion (ROM) exercises were introduced based on individual tolerance levels starting at 3 or 4 days postsurgery. Partial weightbearing with the assistance of crutches commenced between 3 and 7 days postsurgery, with passive and active ROM exercises being incorporated gradually as tolerated after 4 weeks postoperatively. The goal for patients was to progress to full weightbearing and achieve symmetrical hip ROM by the 6-week mark after the surgical procedure.

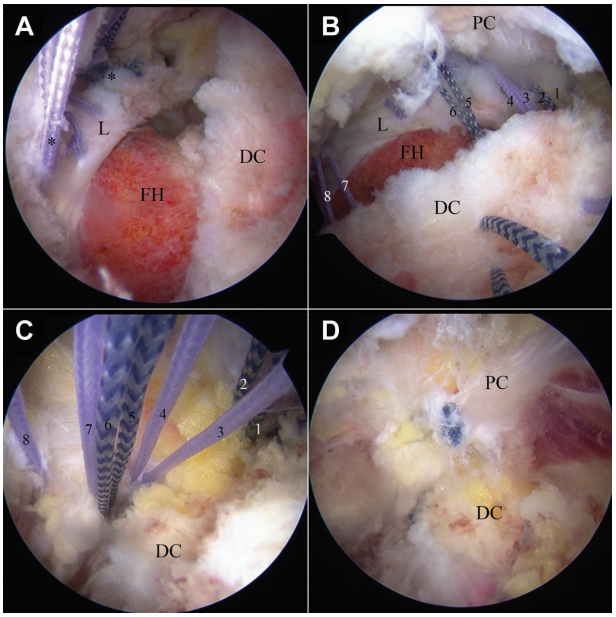

Figure 1. Arthroscopic view of the capsular suture-lifting technique. (A) Double-loaded suture anchors were placed at the 3-, 2-, 1-, and 12-o'clock positions. One limb was used for labral suture and the other was used for distal capsule suture. Asterisks indicate double-loaded suture anchors. (B) A total of 8 ''lifting'' sutures (No. 1-8) were passed through the distal capsule. (C) The distal joint capsule was lifted and fixed to the acetabular rim. (D) The joint capsule was then overlapped and sutured with the traction suture. DC, distal capsule; FH, junction of femoral head-neck; L, labrum; PC, proximal capsule.

Clinical and Radiographic Assessment

Anteroposterior hip radiographs, Dunn view radiographs, and CT were obtained for all patients preoperatively and postoperatively. LCEA and alpha angle of the hip joint were measured preoperatively and postoperatively. The alpha angle and LCEA were measured from CT and radiographic images using the methods described by Nötzli et al[31] and Omeroglu et al.[33] Patients received at least a 1-year follow-up. Cam-type FAI was defined as alpha angle of >50°. Preoperative PROs and PROs at least 1 year after surgery were obtained, including visual analog scale (VAS) for pain and modified Harris Hip Score (mHHS). For the mHHS, the minimal clinically important difference (MCID) was defined as 7.9 by Nwachukwu et al,[32] and the Patient Acceptable Symptom State (PASS) score was defined as 74 by Chahal et al.[5]

Statistical Analysis

The Wilcoxon signed-rank test was used to evaluate changes in preoperative to postoperative mHHS scores

TABLE 1
Patient Demographics (n = 144)[a]

Parameter	Suture-Lifting Group	Control Group	*P*
Number	77	67	NA
Age, years, median (range)	37.5 (18-60)	37.0 (20-60)	.486
Sex			
Male	18 (23.4%)	19 (28.4%)	
Female	59 (76.6%)	48 (71.6%)	.495
Side			
Left	34 (44.2%)	30 (44.8%)	
Right	43 (55.8%)	37 (55.2%)	.94
BMI, kg/m^2, mean (range)	22.9 (18.8-31.4)	21.4 (19.0-26.0)	.387
Diagnosis			
Labral tear	77 (100%)	67 (100%)	NA
Cam-type FAI	77 (100%)	58 (86.6%)	.001
BDDH	77 (100%)	67 (100%)	NA
Alpha angle, mean (range)	56.2 (50.3-74.0)	55.3 (34.0-60.6)	.763
LCEA, mean (range)	21.9 (20.3-24.8)	21.6 (20.1-24.9)	.933
Length of follow-up, mean ± SD, months (range)	20.5 ± 10.3 (12-59)	23.4 ± 7.2 (16-43)	.121

[a]Data are presented as numbers of patients, with percentages in parentheses, unless otherwise indicated. BDDH, borderline developmental dysplasia of the hip; BMI, body mass index; FAI, femoroacetabular impingement; LCEA, lateral center-edge angle. NA, not applicable.

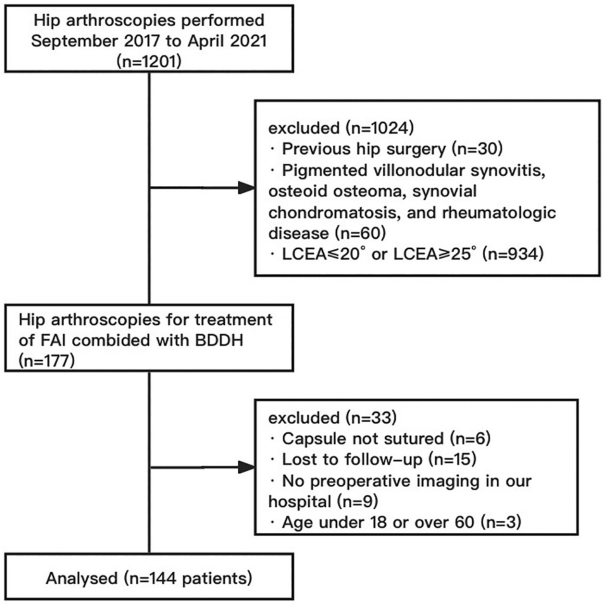

Figure 2. Flowchart illustrating patient selection process. BDDH, borderline developmental dysplasia of the hip; FAI, femoroacetabular impingement; LCEA, lateral center-edge angle.

and preoperative to postoperative pain (VAS). Mann-Whitney *U* test was used to evaluate significant differences in postoperative mHHS and VAS scores in patients who underwent capsular suture-lifting or routine capsular closure. Percentages were compared using the chi-square test. A *P* value of <.05 was considered to indicate statistically significant differences. All statistical analyses were carried out using SPSS Version 27 (IBM Corporation).

TABLE 2
Arthroscopic Procedures Performed[a]

Procedures	Suture-Lifting Group	Control Group
Labral repair	77 (100%)	67 (100%)
Femoral osteoplasty	77 (100%)	58 (86.6%)
Chondroplasty	10 (13.0%)	9 (13.4%)
Ligamentum teres debridement	6 (7.8%)	5 (7.5%)

[a]Data are presented as numbers of patients, with percentages in parentheses.

RESULTS

A total of 159 patients (42 men and 117 women) were included in the study, of whom 90.6% were available for follow-up (Table 1). A total of 144 patients (37 men and 107 women) were included in the final analysis. A flowchart illustrating the full patient selection process can be found in Figure 2. A total of 77 patients (53.5%) underwent the arthroscopic capsular suture-lifting technique and 67 patients (46.5%) underwent routine capsular closure. The mean length of follow-up for this cohort was 21.2 ± 11.5 months (range, 12-59 months). Mean age at surgery was 37.2 years (range, 18-60 years). The mean body mass index was 22.7 kg/m^2 (range, 18.8-31.4 kg/m^2). All patients in the study were diagnosed with labral tear, FAI, and BDDH. No significant differences were observed in terms of age, sex, body mass index, length of follow-up, diagnosis, alpha angle, and LCEA of patients in the suture-lifting group and control group ($P > .05$). The clinical and demographic characteristics of all patients are presented in Table 1.

All patients underwent labral repair and capsular suture closure. Arthroscopic procedures are detailed in

TABLE 3
Preoperative and Postoperative Patient-Reported Outcome Scores[a]

	Preoperative VAS	Postoperative VAS	Preoperative mHHS	Postoperative mHHS
Suture-lifting group	6.0 ± 1.9	2.6 ± 2.0	55.1 ± 14.3	75.2 ± 12.2
Control group	6.4 ± 2.0	3.8 ± 1.6	54.7 ± 12.0	68.5 ± 13.2
P	.21	**.001**	.90	**.008**

[a]Data are presented as mean ± SD. Significant *P* values are depicted in bold font. mHHS, modified Harris Hip Score; VAS, visual analog scale.

Table 2. No significant difference was observed in the surgical procedure that patients underwent in both the suture-lifting group and control group ($P > .05$). There were no complications or need for revision hip arthroscopy in any patient in this study.

The PRO scores (VAS, mHHS) in preoperative evaluation and follow-up are listed in Table 3. Preoperative VAS and mHHS of the lifting group were 6.0 ± 1.9 and 55.1 ± 14.3 and control group were 6.4 ± 2.0 and 54.7 ± 12.0, respectively. No significant difference was observed in the preoperative clinical evaluation of the lifting group and control group ($P > .05$). Postoperative VAS and mHHS of the lifting group were 2.6 ± 2.0 and 75.2 ± 12.2 and control group were 3.8 ± 1.6 and 68.5 ± 13.2, respectively. There was a significant improvement of VAS and mHHS in patients who underwent the capsular suture-lifting technique. Although significant decline of VAS ($P < .05$) and significant improvement of mHHS ($P < .05$) were observed in patients who underwent routine capsular closure, the postoperative VAS and the postoperative mHHS of the suture-lifting group were significantly lower ($P < .05$) and higher ($P < .05$), respectively, compared with the control group. Of 77 patients in the suture-lifting group, 68 (88.3%) patients surpassed MCID and 49 (63.6%) patients achieved PASS. Of 67 patients in the control group, 26 (38.8%) patients surpassed MCID and 32 (47.8%) patients achieved PASS. The percentage of patients achieving MCID and PASS in the suture-lifting group was significantly higher compared with the control group ($P = .007$ for MCID; $P = .03$ for PASS).

DISCUSSION

The major findings of our study demonstrated that the postoperative VAS score of patients in the suture-lifting group was significantly lower (2.6 vs 3.8; $P < .05$) and the mHHS score was significantly higher (75.2 vs 68.5; $P < .05$) compared with those of patients in the control group. The percentage of patients achieving MCID and PASS in the suture-lifting group was significantly higher than that in the control group ($P = .007$ for MCID; $P = .03$ for PASS).

Patients who have been diagnosed with BDDH are more likely to have postoperative instability of the hip joint. The labrum in dysplastic hips supported more load than in normal hips, which may lead to premature instability and osteoarthritis.[7,24,36,42] The other common reasons for joint instability include acetabular undercoverage, lunotriquetral tears, and capsular deficiency.[2,37] Arthroscopy is considered the most optimal treatment for BDDH; previous studies have reported that a significant improvement in clinical assessment score could be observed postoperatively in patients with BDDH.[3,12] However, during the arthroscopic procedure, a capsulotomy is often performed between the AL portal and MA portal to help gain access to the central compartment.[34,40] The capsulotomy penetrates through the iliofemoral ligament of the hip capsule, which is responsible for resisting anterior translation and external rotation of the hip.[26,41] The overall failure rate of patients with BDDH who underwent arthroscopic surgery was reported to be up to 14.1%.[8]

Although great emphasis has been placed on the specific concern of capsular closure for postoperative stability, no standard suture technique has been established in the treatment of BDDH. The routine technique of capsular closure is most commonly used after capsulotomy by suturing the incisal margin.[13,16,30] Another technique that plicates the capsule and produces an inferior capsular shift when the sutures are tied was established and promoted. The capsular plication technique was reported to significantly improve postoperative joint stability and has been confirmed in many other studies.[9,11,12,22,27]

The capsular suture-lifting technique is theorized to restore the anterior hip joint capsular integrity and improve the tension of soft tissue and articular stability.[38] The technique is strongly recommended to be the procedure of capsular closure for patients with BDDH or other arthroscopic capsulotomy at risk of postoperative capsular instability.

Limitations

This study has some limitations. First, the sample size of the study is relatively small. However, despite the small sample size, the postoperative improvement upon clinical assessment is significant and consistent; hence, we would expect these results to be consistent even in a larger sample. Second, we did not establish any scores or quantitative standards for evaluating risk-factors of preoperative hip instability. In the future, studies need to focus on relevant risk-factors of preoperative hip instability and choose personalized surgical methods based on these factors. In our study, we standardized the surgical procedure so that future research can also use this surgical approach. Last, the differences in surgical time between the 2 groups can

have an impact on the overall clinical outcomes of the surgery. However, in our study, the surgeon had 15 years of experience in hip arthroscopic surgery; hence, it is reasonable to believe that differences in surgical time would not significantly affect the clinical outcomes.

CONCLUSION

Our study demonstrated that the arthroscopic capsular suture-lifting technique provided good clinical outcomes in the treatment of patients with FAI combined with BDDH. This technique showed better improvement of postoperative clinical outcomes compared with routine capsular closure.

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