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Does capsular closure influence patient-reported outcomes in hip arthroscopy for femoroacetabular impingement and labral tear?

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ABSTRACT

Capsulotomy is necessary to facilitate instrument manoeuvrability within the joint capsule in many arthroscopic hip surgical procedures. In cases where a clear indication for capsular closure does not exist, surgeon's preference and experience often determines capsular management. The purpose of this study was to assess the influence of capsular closure on clinical outcome scores and satisfaction in patients who underwent hip arthroscopy surgery for femoroacetabular impingement (FAI) and labral tear. Data were prospectively collected and retrospectively analysed for hip arthroscopy surgeries with a minimum 2 years follow-up. Patients with developmental dysplasia of the hip, previous back or hip surgeries, and degenerative changes to this hip and secondary gains were excluded. Demographic data, intraoperative findings and patient-reported outcome scores were recorded, including the Modified Harris Hip Score (MHHS) and Hip Outcome Score (HOS). A total of 29 and 35 patients were included in the non-closure and closure groups, respectively. The mean follow-up time was over 3 years for both groups. The mean pre-operative and post-operative HOS scores and MHHS scores did not significantly differ between groups (pre-operative HOS: 65.6 and 66.3, $P = 0.898$; post-operative HOS: 85.4 and 87.2, $P = 0.718$; pre-operative MHHS: 63.2 and 58.4, $P = 0.223$; post-operative MHHS: 85.7 and 88.7, $P = 0.510$). Overall patient satisfaction did not differ significantly between groups (non-closure 86.3%, closure group 88.6%; $P = 0.672$). Capsular closure did not significantly influence satisfaction or clinical outcome scores in patients who underwent arthroscopic hip surgery for FAI or labral tear.

INTRODUCTION

Capsulotomy is necessary to facilitate instrument manoeuvrability within the joint capsule in many arthroscopic hip surgical procedures. The capsular incision is often made in the anterior aspect of the joint between 12-o'clock and 3-o'clock position (right hip), parallel to the acetabular rim, in order to connect the two main portals (anterolateral and mid-anterior) [1]. Capsulotomy facilitates instrumentation, enables better visualization by exposing the external aspect of the labrum, it assists in the detection and treatment of pathologic impingement (cam/pincer morphology), and it creates a viable workspace in the joint to allow for precise and controlled access to periarticular soft tissues. Capsulotomy also helps to improve anchor placement and suture passage in labral repair [2, 3]. Although the utility of capsulotomy in hip arthroscopy is clear, literature regarding the impact of capsulotomy and capsular closure following arthroscopic hip surgery in terms of complication rates and biomechanical stability remain inconsistent.

The joint capsule serves as a primary non-dynamic stabilizer of the hip joint [1, 2, 4]. Additional functions include sealing of the joint, proprioception and pain sensations [5]. The functions of the hip capsule have been shown to be essential in cases of laxity, instability and developmental dysplasia of the hip (DDH) [6].

However, in patients without clear previous studies which compared surgeon's preference and experience often determines capsular management. Indications for capsular closure can be classified as clinical; which includes female gender, systemic connective tissue disorders accompanied with an abnormal laxity, young athletes and post-operative bariatric surgery. Radiographic evidence, such as acetabul dysplasia, significant hip distraction using minimal force and ligamentum teres insufficiency and arthroscopic signs, which include adequate synovium, ligamentum teres and capsular appearance and coverage [1]. While capsular management has not been shown to clearly correlate with post-operative laxity, dislocations or other complications [6], recent literature demonstrates both biomechanical [3, 7] and functional benefit for closing the capsule in terms of greater hip stability [8]. A study demonstrating improved patient-reported clinical outcomes based on capsular management would help to inform optimal capsular management in hip arthroscopy. Previous studies which compared capsular management strategies with patient-reported outcomes scores showed no difference in functional results between capsular closure and non-closure [9, 10], and pointed out that there is minimal information available on the threshold at which patients consider themselves to be well relying on the patient-reported outcome score [11]. The purpose of this study was to compare patient-reported functional outcome scores (PRO) in patients with no radiographic signs of DDH, who underwent hip arthroscopy with and without capsular closure. We hypothesized that capsular closure would not affect on patient-reported outcome scores.

MATERIALS AND METHODS

The pre-operational base line and immediate post-operative data for hip arthroscopy surgeries were collected for every patient prospectively. Last follow-up data were collected after the study was decided and retrospectively analysed. The study took place in a single centre. The local institutional review board approved this study. In the period between July 2010 and March 2013, one fellowship trained hip arthroscopy specialist performed all procedures. An interportal capsulotomy was performed in all cases from July 2010 to October 2011 without capsular closure. From October 2011 to March 2013 routine capsular closure was carried out for all patients.

Inclusion criteria for this study mandated that all patients underwent hip arthroscopy surgery for femoroacetabular impingement (FAI) or labral tear, and none of the patient has had a prior hip surgery. Additionally, only patients with a minimum 2-year follow-up were included. Patients were excluded if they were younger than 18 years of age, had previous hip or back surgeries, sciatic back pain, degenerative changes of the joint equal or greater than 'Tönnis' Grade 1 [12], or if the patient incurred trauma after their procedures. Patients with secondary gains (i.e. active law suit) were also excluded from this study. DDH is commonly associated with intra-articular hip pathology and may also present with secondary FAI resulting in labral tears. In the presence of hip dysplasia, the pre-operative, post-operative and overall satisfaction scores may not be reliable. Furthermore, in a patient with DDH capsular closure is indicated [1]. To insure this did not affect the present study, we measured and compared the lateral centre-edge angle (LCEA) between the two groups and excluded patients with LCEA $<23^\circ$.

Pre-operative evaluation

Clinical diagnosis of FAI and labral tear was made based on characteristic complaints, physical examination findings and radiographic evidence. Characteristic complaints of anterior groin pain, hip pain, positive 'C' sign and limited range of motion raised suspicion for FAI or labral tear. Characteristic physical examination findings, including anterior hip pain or groin tenderness aggravated by flexion adduction internal rotation or flexion abduction external rotation, and positive anterior impingement were tested in all patients pre-operatively [13].

All patients underwent anteroposterior (AP), 45° Dunn lateral and frog-leg lateral radiographs pre-operatively. The radiographic measurements and signs recorded from these films included the LCEA of Wiberg [14], and the Tönnis angle [15]. The presence of acetabular cross-over sign and low anterior inferior iliac spine was noted on an AP radiographs. The alpha angle and offset were measured using a frog-leg lateral hip radiograph or 45° Dunn lateral hip radiograph.

Patients completed the Modified Harris Hip Score (MHHS) and Hip Outcome Score (HOS) prior to their procedure. All patients were examined clinically by the lead surgeon and underwent radiographic examinations. When hip arthroscopy was indicated according to these findings, all patients subsequently underwent magnetic resonance arthrogram to further evaluate the intra-articular pathology prior to the surgery.

Surgical technique

All patients were anaesthetized using general anaesthesia in the supine position on an orthopaedic traction table. Anterolateral and mid-anterior portals were created to access and evaluate the central compartment, and an interportal capsulotomy was carried out using an arthroscopic knife (Johnson and Johnson, Raynham, MA, USA) to facilitate instrument manoeuvrability [16]. The capsulotomy technique was performed in accordance with what previously described by Bedi *et al.* [17]. In the right hip, the capsular incision is made in the anterior aspect of the joint, starting at the 12:00-o'clock position on the acetabular clock face orientation. Capsulotomy is continued from this position to the 3:00-o'clock position, parallel to the acetabular rim in order to connect the two main portals. About 10–15 mm of capsule is left on the acetabular side to allow capsular closure at the end of the surgery, if indicated. If an extensile capsulotomy is necessary for greater exposure of the joint, the interportal capsulotomy may be extended anteromedially as far as the psoas tendon and posteriorly as necessary (Fig. 1).

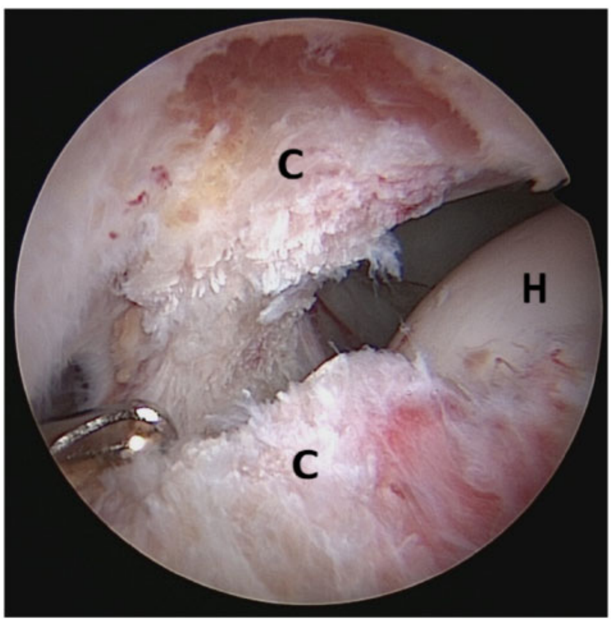

Fig. 1. Showing interportal capsulotomy. C, capsule; H, femoral head.

Following procedures in the central compartment, traction was released and the hip was brought into a flexed position. Osteoplasty of the femoral head-neck junction was then performed [2, 3].

In the capsular closure group, closure was performed using two Number 2 absorbable Vicryl sutures (Vicryl suture 2; polyglactin 910; Ethicon, A synthetic, braided, absorbable suture; Somerville, NJ, USA) (Fig. 2A, B). Capsular closure was achieved using a side-to-side technique, suturing the proximal and distal segments of the capsuloligamentous flaps. Each suture was placed in an equidistant fashion to divide the extent of the capsulotomy into thirds.

Post-operative rehabilitation and evaluation

All patients in both groups received the same post-operative protocol regardless of capsular closure. The post-operative

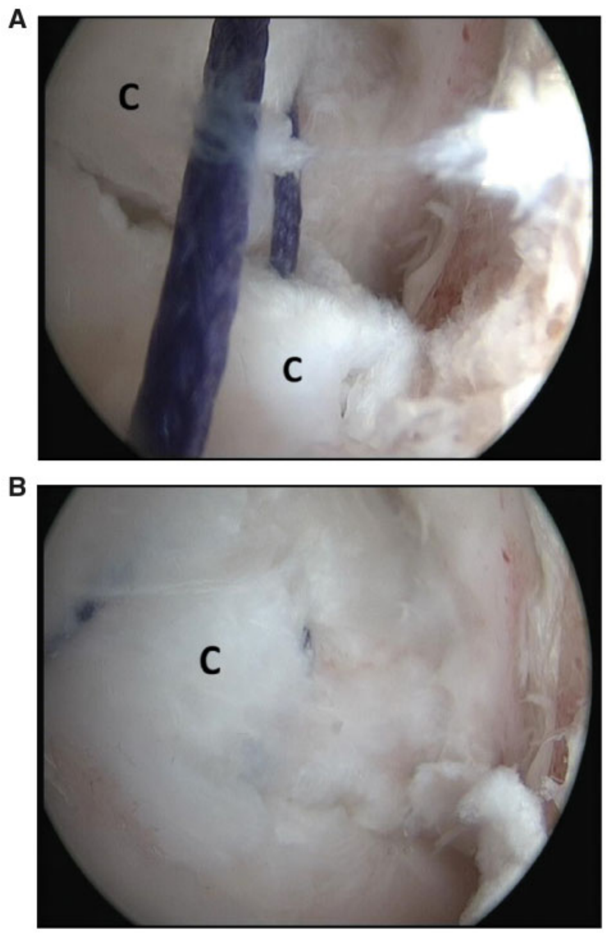

Fig. 2. (**A**) Showing capsular closure with a two vicryl 2 sutures. (**B**) Showing capsular closure with a two vicryl 2 sutures. C, capsule.

protocol included ice compression therapy for the first 48–72 h. Non-weight bearing with crutches for 2 weeks followed by full weight bearing. Physical therapy was instituted immediately, initially focusing on restoring passive range-of-motion, then active motion and finally, advancing to strengthening exercises.

Patients were evaluated at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year post-operatively. The evaluation included clinical examination performed by the surgeon, as well AP and frog position radiographs taken at the 3 months post-operative visit to rule out the formation of heterotopic ossification. All patients were contacted over the phone after completing a full post-operative clinical examination and X-ray evaluation as mentioned above, in order to score the post-operative MHHS and HOS after a minimum of 2 years post-operative time.

The phone survey was collected by a team of three orthopaedic residents. The questions were read verbatim and no paraphrases were allowed.

Statistical analysis

The statistical analysis was performed using the χ^2 or the Fisher's exact tests for categorical variables, and the Student's *t* tests for scaled variables, at a significance level of 0.05. IBM SPSS Statistics, version 21 for Windows (SPSS, Chicago, IL, USA) was used for all analyses. *Post hoc* power analyses were carried out using SPSS Sample Power 3. Depending on the effect size, these analyses yielded power values ranging from 67% to 95%.

RESULTS

One hundred and ninety-six consecutive hip arthroscopy procedures were performed between July 2010 and March 2013, of which seventy patients underwent hip arthroscopy for FAI or labral tear and met the inclusion criteria. This included 33 patients in the non-closure group and 37 patients in the capsular closure group. Of the 70 patients initially included in the study, six patients refused to participate. Leaving 64 patients available for evaluation, with 29 and 35 patients in the non-closure and capsular closure groups, respectively (Fig. 3). The mean age of patients in the non-closure group was 37.6 years (standard error of the mean [SEM] 2.83) and 38.1 years (SEM 2.35) in the capsular closure group, which was not significantly different ($P = 0.881$). Demographic data is displayed in Table I.

The mean pre-operative HOS score was 65.6 in the non-closure group and 66.3 in the closure group ($P = 0.898$). Post-operative HOS scores were 85.4 and 87.2, respectively ($P = 0.718$). The mean pre-operative MHHS score in the non-closure group was 63.2 compared with 58.4 in the closure group ($P = 0.223$). Post-operative MHHS scores were 85.7 and 88.7, respectively ($P = 0.510$). Significant improvement was demonstrated in both questionnaires between pre-operative and post-operative score. Patient-reported clinical outcome scores are reported in Tables III and IV and Fig. 4.

When asked to rate the overall satisfaction of their procedures the non-closure group reported a mean satisfaction of 86.3% and the closure group reported a mean satisfaction of 88.6% ($P = 0.672$). No dislocations, subluxations, post-operative infection, revision surgeries or other complications were observed.

DISCUSSION

The principle findings of this study demonstrated that capsular closure did not affect patient-reported outcomes in a series of patients with normal LCEA.

Biomechanical studies have demonstrated the importance of the capsule in constraining hip motion including rotation and translation.

Abrams *et al.* [7] evaluated the effect of capsulotomy, capsulectomy and capsular repair on hip rotation. They showed significantly increased external rotation after T capsulotomy as compared to hips with intact capsules and interportal capsulotomy. The repaired T capsulotomy restored the rotational profile back to the native state. The authors did not find significant difference between the intact capsule groups compared to either interportal capsulotomy or repaired capsule groups.

Wuerz *et al.* [18] studied capsulotomy size effect on hip joint kinematic stability. Eight cadaveric hip specimens were used under torsional loads in four different conditions which included neutral flexion with the capsule intact, 4- and 6-cm interportal capsulotomy and repaired capsulotomy. The author concluded that larger-sized capsulotomies were accompanied by increase in range of motion. Moreover, they concluded that complete capsular closure effectively restored these measures when compared with the intact condition.

Khair *et al.* [3] set out to evaluate the effect of capsulotomy size on the force required to distract the hip in a cadaveric model. The authors found that interportal capsulotomy significantly affected the force required to distract the hip and showed a negative correlation between capsulotomy size and the force required to distract the joint. Finally, capsular repair was shown to restore capsular strength to the level of the native hip [3].

Mei-Dan *et al.* [19] used a post-operative magnetic resonance imaging to compare and evaluated 50 hips which were pre-operatively randomized to the capsular closure versus non-closure groups. The authors concluded that

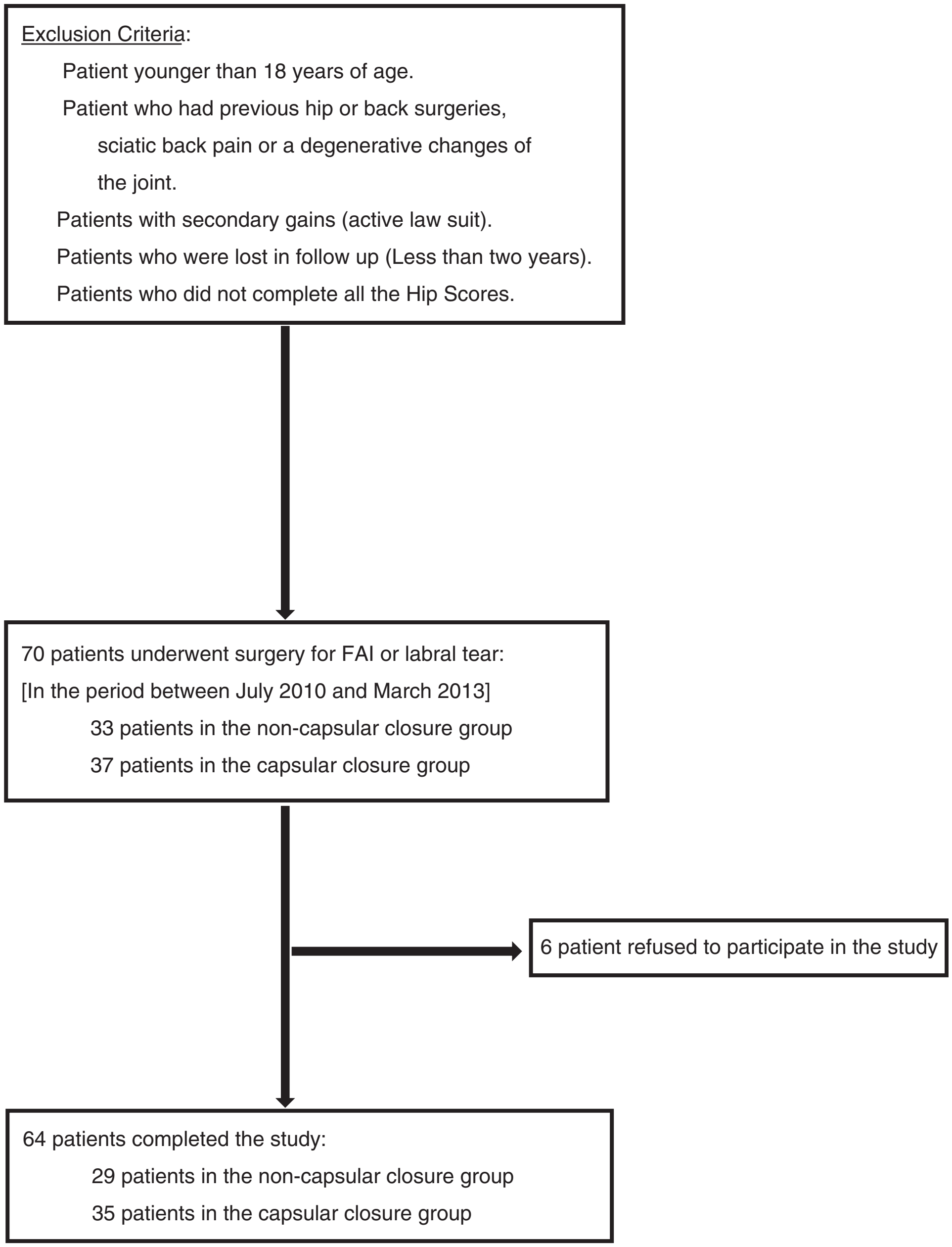

Fig. 3. Demonstrating the study schematic.

capsular closure resulted in significantly less gapping of the capsule at 6-week follow-up, compared with the non-closure group, yet, no significant difference in the gap size was evident by 24-week follow-up. These findings support the results of this study, demonstrating no significant clinical and radiologic differences between the two groups ultimately.

With regards to the technique for capsular closure, Chahla *et al.* [20] reported that one suture construct capsular repairs were significantly weaker than three suture construct repairs with regard to biomechanical failure torques. Two and three suture constructs had comparable biomechanical failure torques. In the present study, two suture constructs were used to repair all capsulotomies.

Scientific evidence supporting capsular closure is primarily based on biomechanical studies and cases of instability in patients who underwent hip arthroscopy without capsular closure [8]. Instability-related complication rate after hip arthroscopy is rare and ranges from 0.07% to 0.3% [6, 21] most commonly reported as case

Table I. Demographic data

	Non-closure	*Capsular closure*	*P-value*
Number	29	35	
Female (%)	13 (44.8%)	14 (40%)	0.800
Mean age (years)	37.6	38.1	0.881
Mean follow-up (months)	60.7	40.4	<0.001

The mean follow-up time was greater than 3 years in both groups (60.7 months in the non-closure group and 40.4 months in the closure group). All patients underwent a minimum of one of the following procedures: labral repair, femoral osteoplasty or acetabular osteoplasty. Additional data including mean surgery time, and mean number of anchors used is displayed in Table II. The LCEA was measured in each group and found to be in the range of 24–39° with a mean of 33.2° in the non-closure group, and 31.8° in the capsular closure group ($P = 0.41$).

Table II. Surgical data

	Non-closure	*Capsular closure*	*P-value*
Labral repair	29	34	0.224
Femoral osteoplasty	18	22	1.000
Acetabular osteoplasty	26	32	1.000
Mean anchors per patient	1.2	1.7	0.039
Surgery time (min)	115.5	115.4	0.990

Table III. Functional outcomes comparison

	Non-closure	*Capsular closure*	*P-value*
MHHS preop	63.2	58.4	0.223
MHHS postop	85.7	88.7	0.510
HOS preop	65.6	66.3	0.898
HOS postop	85.4	87.2	0.718
Overall satisfaction	86.3%	88.6%	0.672

HOS, Hip Outcome Score; MHHS, Modified Harris Hip Score; preop, pre-operative; postop, post-operative.

reports [22–24]. In a systematic review, Ilizaliturri *et al.* [25] reported 0 cases of iatrogenic instability in approximately 4000 hip arthroscopies with varying degrees of capsulotomy/capsulectomy without capsular closure or plication.

Yeung *et al.* [26] compiled 10 case reports of gross instability following hip arthroscopy. Yeung found that

Table IV. Difference between pre-operative and post-operative score for each PROs

Pre-operative versus post-operative	*Group*	*P-value*
MHHS	Closure	<0.0001
	Non-closure	<0.0001
HOS	Closure	<0.0001
	Non-closure	0.0005

HOS, Hip Outcome Score; MHHS, Modified Harris Hip Score.

unrepaired capsulotomy and female gender were potential risk factors present in 77.8% of the cases. Capsulotomy is performed in all arthroscopic hip procedures to facilitate instruments manoeuvrability. However capsular management is a part of a complex surgery and the type of capsulotomy and capsular management strategy depends on the nature of the procedure and patient characteristics.

As *in vivo* analysis of the capsule's function post arthroscopy is limited, patient-reported outcome scores might provide insight into the effects and contribution of the capsule with respect to functional benefit experienced by the patient. Frank *et al.* [27] compared patient-reported outcomes after T-capsulotomy with partial capsular repair to complete capsular repair. Each group was comprised of 32 patients with a mean follow-up of 2.5 years. Patients who underwent complete capsular repair demonstrated superior sport-specific outcomes and greater satisfaction at final follow-up than the partial capsular repair group. Domb *et al.* [10] in a matched comparison study with minimum 5-year follow-up reported deterioration in MHHS as well as a higher rate of conversion to arthroplasty in patients with unrepaired capsules.

The results presented in this study are not in agreement with the aforementioned studies. However, the results of these studies are not fully comparable. Frank *et al.* [27] compared patient-reported outcomes after T-capsulotomy with partial capsular repair to complete capsular repair, whereas our study compared repaired with unrepaired interportal capsulotomy. In the study by Domb *et al.* [10], the cohort represented heterogeneity with regards to acetabular coverage (LCEA > 18), intra-articular and cartilage pathology as well as physiologic laxity. Specifically, the rate of acetabular cartilage lesions in the unrepaired versus repaired group was 41.6% versus 12%. The decrease in PRO's and higher conversion rate to total hip arthroplasty in the capsular release group may be secondary to the severity of chondral damage in this group. The capsular management decision was at the surgeon's discretion, while in

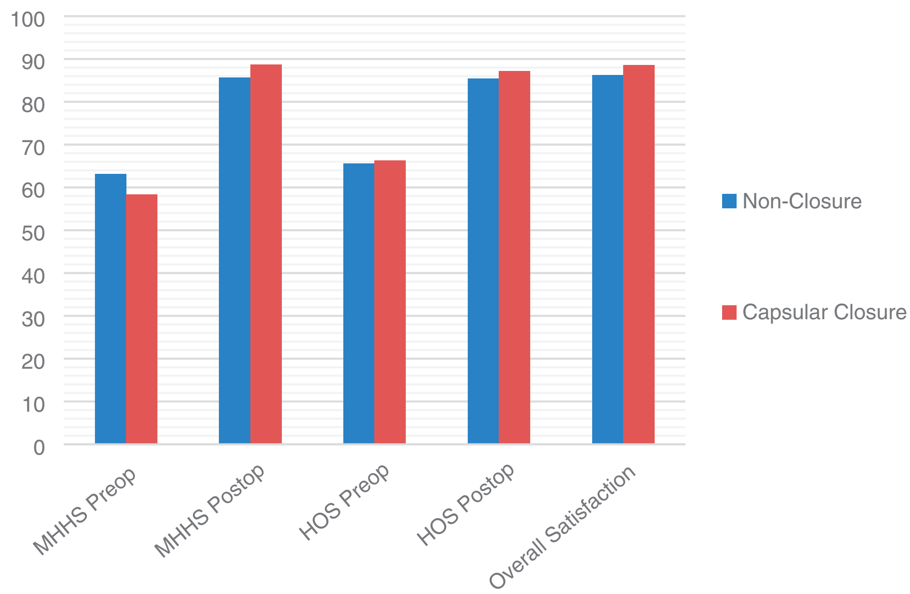

Fig. 4. Patient-reported outcome scores: non-closure versus capsular closure.

the current study the capsule was not repaired in the first group of consecutive patients followed by routine capsular closure in the following consecutive group of patients.

Current literature does not clearly support routine capsular closure or capsulotomy without closure in hip arthroscopy [6]. In a systematic review, Ekhtiari *et al.* [6] concluded that evidence-based indications for capsular repair remain unclear as there is little basis on which to establish the relationship between surgical technique and post-operative instability or long-term consequences.

Moreover, in some situations capsulotomy without closure may be therapeutic as in the settings of pre-operative stiffness or adhesive capsulitis [1, 4, 28].

Limitations

The study comprises of a retrospective analysis of prospectively collected data, hence the retrospective design constitutes one limitation. The study was possibly underpowered to observe differing complication rates between groups which constitutes a limitation. However, the study was not designed to compare complication rates between the groups and the study was appropriately powered to compare patient-reported outcome scores. The groups were separated temporally which introduces bias as they were not randomly assigned. The mean follow-up period of the unrepaired capsule group is significantly longer which according to the recent literature should have been manifested in inferior outcome of the unrepaired capsule group. This difference in follow-up time can introduce bias to the study, but, in light of the outcome, this difference, if at all, accentuate the lack of difference in outcome between the groups. The post-operative questionnaires were fulfilled by a phone survey which may lead to a bias, though all the patients. The joint capsule were contacted at the same period of time and the questions were read verbatim and no paraphrases were allowed. Finally, the pre- and post-operative information was used for the MHHS and HOS questionnaires, and not presented individually, which may affect the results and introduce bias.

CONCLUSION

This study demonstrated that capsular closure did not significantly influence overall satisfaction or patient-reported outcome scores in patients with normal LCEA who underwent arthroscopic hip surgery for FAI or labral tear.

LEVEL OF EVIDENCE

Level II2 prospectively comparative study. The local *institutional review board* of the Tel Aviv Medical Center approved this study and all the surgeries were done exclusively in this institution.

CLINICAL RELEVANCE

Current data regarding capsular management in hip arthroscopy is inconsistent. This study demonstrates that capsular closure in FAI and labral tear cases has not been shown to alter patient-reported outcome scores or overall satisfaction. Improved clinical outcomes were not shown to be related to capsular management in FAI and labral tears in this retrospective cohort study.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Domb BG, Philippon MJ, Giordano BD. Arthroscopic capsulotomy, capsular repair, and capsular plication of the hip: relation to atraumatic instability. *Arthroscopy* 2013; **29**: 162–73.
2. Kuhns BD, Weber AE, Levy DM *et al*. Capsular management in hip arthroscopy: an anatomic, biomechanical, and technical review. *Front Surg* 2016; **3**: 13.
3. Khair MM, Grzybowski JS, Kuhns BD *et al*. The effect of capsulotomy and capsular repair on hip distraction: a cadaveric investigation. *Arthroscopy* 2017; **33**: 559–65.
4. Martin HD, Savage A, Braly BA *et al*. The function of the hip capsular ligaments: a quantitative report. *Arthroscopy* 2008; **24**: 188–95.
5. Alzaharani A, Bali K, Gudena R *et al*. The innervation of the human acetabular labrum and hip joint: an anatomic study. *BMC Musculoskelet Disord* 2014; **15**: 41.
6. Ekhtiari S, de Sa D, Haldane CE *et al*. Hip arthroscopic capsulotomy techniques and capsular management strategies: a systematic review. *Knee Surg Sports Traumatol Arthrosc* 2017; **25**: 9–23.
7. Abrams GD, Hart MA, Takami K *et al*. Biomechanical evaluation of capsulotomy, capsulectomy, and capsular repair on hip rotation. *Arthroscopy* 2015; **31**: 1511–7.
8. Ortiz-Declet V, Mu B, Chen AW *et al*. Should the capsule be repaired or plicated after hip arthroscopy for labral tears associated with femoroacetabular impingement or instability? A systematic review. *Arthroscopy* 2018; **34**: 303–18.
9. Chahal J, Van Thiel GS, Mather RC 3rd *et al*. The patient acceptable symptomatic state for the Modified Harris Hip Score and Hip Outcome Score among patients undergoing surgical treatment for femoroacetabular impingement. *Am J Sports Med* 2015; **43**: 1844–9.
10. Domb BG, Chaharbakhshi EO, Perets I *et al*. Patient-reported outcomes of capsular repair versus capsulotomy in patients undergoing hip arthroscopy: minimum 5-year follow-up—a matched comparison study. *Arthroscopy* 2018; **34**: 853–63.e1.
11. Belemmi M, Godoy A, Serra A *et al*. Functional evaluation of T shape capsulotomy vs capsulorrhaphy in patients undergoing hip arthroscopy for femoroacetabular impingement. *Arthroscopy* 2013; **29**: e216.
12. Tönnis D. *Congenital Dysplasia and Dislocation of the Hip in Children and Adults*. Berlin, Heidelberg: Springer Berlin Heidelberg, 1987.
13. Byrd JWT. Evaluation of the hip: history and physical examination. *N Am J Sports Phys Ther* 2007; **2**: 231–40.
14. Wiberg G. The anatomy and roentgenographic appearance of a normal hip joint. *Acta Chir Scand* 1939; **83**: 7–38.
15. Tönnis D, Legal H, Graf R. *Congenital dysplasia and dislocation of the hip in children and adults Berlin*; New York: Springer-Verlag, 1987, xxiii, 536.
16. Amar E, Warschawski Y, Sampson TG *et al*. Capsular closure does not affect development of heterotopic ossification after hip arthroscopy. *Arthroscopy* 2015; **31**: 225–30.
17. Bedi A, Galano G, Walsh C *et al*. Capsular management during hip arthroscopy: from femoroacetabular impingement to instability. *Arthroscopy* 2011; **27**: 1720–31.
18. Wuerz TH, Song SH, Grzybowski JS *et al*. Capsulotomy size affects hip joint kinematic stability. *Arthroscopy* 2016; **32**: 1571–80.
19. Mei-Dan OY, Strickland C, Garabekyan T *et al*. Magnetic resonance imaging comparison of repaired versus non-repaired hip capsule in patients undergoing hip arthroscopy for femoroacetabular impingement: a double-blind, randomized controlled trial. *Orthop J Sports Med* 2017; **5**: 2325967117S00231.
20. Chahla J, Mikula JD, Schon JM *et al*. Hip capsular closure. *Am J Sports Med* 2017; **45**: 434–9.
21. Ilizaliturri VM Jr, Orozco-Rodriguez L, Acosta-Rodriguez E *et al*. Arthroscopic treatment of cam-type femoroacetabular impingement: preliminary report at 2 years minimum follow-up. *J Arthroplasty* 2008; **23**: 226–34.
22. Benali Y, Katthagen BD. Hip subluxation as a complication of arthroscopic debridement. *Arthroscopy* 2009; **25**: 405–7.
23. Ranawat AS, McClincy M, Sekiya JK. Anterior dislocation of the hip after arthroscopy in a patient with capsular laxity of the hip. A case report. *J Bone Joint Surg Am* 2009; **91**: 192–7.
24. Matsuda DK. Acute iatrogenic dislocation following hip impingement arthroscopic surgery. *Arthroscopy* 2009; **25**: 400–4.
25. Ilizaliturri VM Jr. Complications of arthroscopic femoroacetabular impingement treatment: a review. *Clin Orthop Relat Res* 2009; **467**: 760–8.
26. Yeung M, Memon M, Simunovic N *et al*. Gross instability after hip arthroscopy: an analysis of case reports evaluating surgical and patient factors. *Arthroscopy* 2016; **32**: 1196–204.
27. Frank RM, Lee S, Bush-Joseph CA *et al*. Improved outcomes after hip arthroscopic surgery in patients undergoing T-capsulotomy with complete repair versus partial repair for femoroacetabular impingement: a comparative matched-pair analysis. *Am J Sports Med* 2014; **42**: 2634–42.
28. Byrd JWT, Jones KS. Adhesive capsulitis of the hip. *Arthroscopy* 2006; **22**: 89–94.