

# MRI Evaluation of Repaired Versus Unrepaired Interportal Capsulotomy in Simultaneous Bilateral Hip Arthroscopy

## A Double-Blind, Randomized Controlled Trial

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**Background:** Techniques used in hip arthroscopy continue to evolve, and controversy surrounds the need for capsular repair following this surgical intervention. The purpose of this study was to evaluate the magnetic resonance imaging (MRI) appearance of the hip capsule in patients with femoroacetabular impingement (FAI) who underwent simultaneous bilateral hip arthroscopy through an interportal capsulotomy with each hip randomized to undergo capsular repair or not undergo such a repair.

**Methods:** This double-blind, randomized controlled trial included 15 patients (30 hips), with a mean age of 29.2 years, who underwent simultaneous bilateral hip arthroscopy utilizing a small (<3-cm) interportal capsulotomy for the treatment of FAI. The first hip treated in each patient was intraoperatively randomized to undergo capsular repair or no capsular repair. The contralateral hip then received the opposite treatment. MRI was performed at 6 and 24 weeks postoperatively, and the scans were analyzed by 2 musculoskeletal radiologists. The patients and the radiologists were blinded to the treatment performed on each hip. Capsular dimensions were measured at the level of the healing capsulotomy site and, for hips with a persistent defect, at locations both proximal and distal to the defect. These values were then analyzed at both time points to assess the rate and extent of capsular healing.

**Results:** At 6 weeks postoperatively, a continuous hip capsule (with no apparent capsulotomy defect) was observed in 8 hips treated with capsular repair and 3 hips without such a repair. Of the 19 hips with a discontinuous capsule at 6 weeks, 17 were available for follow-up at 24 weeks postoperatively; all 17 demonstrated progression to healing, with a contiguous appearance without defects and no difference in capsular dimensions between treatment cohorts.

**Conclusions:** Arthroscopic repair of a small interportal hip capsulotomy site yields an insignificant increase in the percentage of continuous hip capsules seen on MRI at 6 weeks postoperatively compared with no repair. Repaired and unrepaired capsulotomy sites progressed to healing with a contiguous appearance on MRI by 24 weeks postoperatively.

**Level of Evidence:** Therapeutic Level I. See Instructions for Authors for a complete description of levels of evidence.

Femoroacetabular impingement (FAI) has been established as a common cause of pain and progressive osteoarthritis of the hip<sup>1-3</sup>. Initially, operative treatment consisted of open surgical dislocation to alleviate the impingement, with excellent results at midterm follow-up<sup>4,5</sup>. The morbidity of the open procedure<sup>6</sup> led to the development of a less invasive arthroscopic approach, with equivalent or better outcomes<sup>7,8</sup>.

Open surgical dislocation typically necessitates a large capsulotomy for exposure, which is routinely closed at the conclusion of the procedure. In contrast, the arthroscopic approach can be performed with a smaller 2 to 6-cm interportal capsulotomy, which is commonly extended in a “T” fashion distally. This is carried out to provide freedom of visualization and use of instruments, and the capsular incision was routinely

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left unrepaired in early series<sup>7,8</sup>. Arthroscopic repair of the incised capsule is technically demanding and may add substantial time to the surgical procedure. There is a lack of high-quality evidence supporting its benefits, although some authors have described new techniques to accomplish the task<sup>9-11</sup>. Given these considerations, most surgeons have favored leaving the capsule unrepaired, and this practice has quickly become the standard of care.

However, with our growing understanding of the capsule's anatomy and function, and as case reports of iatrogenic instability following hip arthroscopy have surfaced<sup>12-18</sup>, there has been growing controversy regarding the consequences of an unrepaired capsule. Many anatomic, biomechanical, and retrospective clinical studies have implicated the unrepaired capsule as 1 potential factor contributing to postoperative instability<sup>19-31</sup>. Efforts to define the features associated with capsular laxity seen on magnetic resonance arthrography, including thinning of the capsule and enlargement of the anterior joint recess, have begun to emerge in the literature<sup>32</sup>.

With the increasing number of arthroscopic procedures performed for FAI, it is increasingly important that radiologists and surgeons recognize the expected postoperative appearance and possible associated abnormalities of repaired and unrepaired capsules<sup>33</sup> so that they can be correlated with the clinical presentation. Previous retrospective and non-randomized studies have compared clinical outcomes between procedures with and those without capsular repair<sup>25,26</sup>. However, we are not aware of any published studies that have evaluated the efficacy of capsular repair in restoring native capsular dimensions on follow-up magnetic resonance imaging (MRI).

The purpose of this study was to compare MRI outcomes between hips randomized to capsular repair and those randomized to no capsular repair during arthroscopic surgery for FAI utilizing an interportal capsulotomy. We hypothesized that capsular repair would yield higher rates of contiguous healing with more robust capsular dimensions than procedures done without capsular repair.

## Materials and Methods

After institutional review board approval was obtained, we performed a randomized, double-blind controlled trial (ClinicalTrials.gov NCT02990234) of a consecutive cohort of adult patients undergoing hip arthroscopy for the treatment of FAI between January 1 and December 31, 2014 (Fig. 1). Criteria for inclusion in this study were (1) persistent hip pain and mechanical symptoms refractory to nonoperative management lasting for at least 3 months, (2) reproducible clinical examination findings suggestive of impingement, (3) joint space width of >3 mm on all radiographic views and on 2-dimensional (2-D) sagittal and coronal reformatted computed tomography (CT) scans, and (4) similar hip morphology and pathological involvement on both sides (lateral center-edge and Tönnis angles within 0° to 4° of the angles on the contralateral side, same type of FAI, and same surgical plan). Exclusion criteria included hip instability (hip dysplasia or hyperlaxity), as we always repair the interportal capsulotomy site in such patients; the need for microfracture or postoperative non-weight-bearing precautions; and the need for additional surgical treatment for slipped capital femoral epiphysis, Legg-Calvé-Perthes disease, osteochondromatosis, or post-dislocation syndrome.

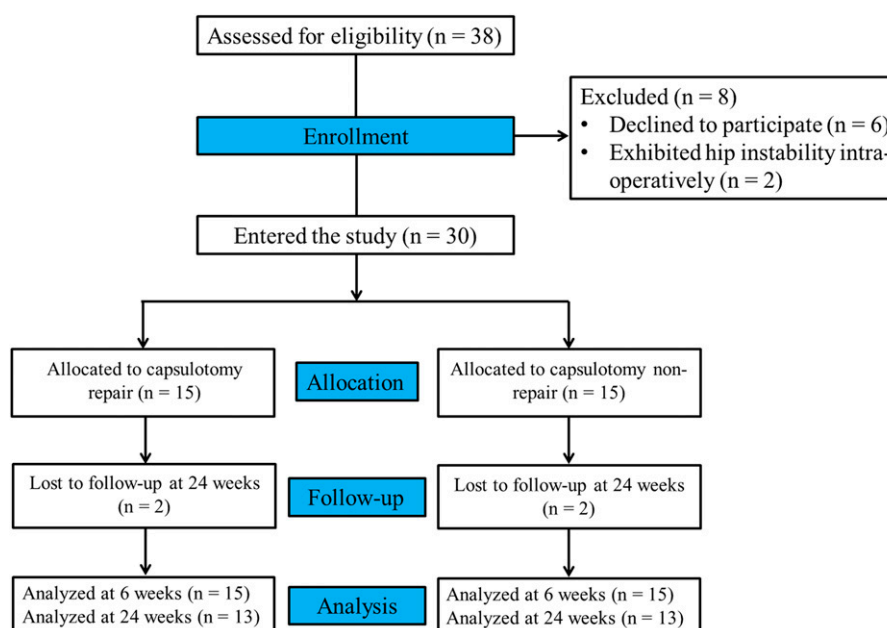


Fig. 1  
CONSORT (Consolidated Standards of Reporting Trials) flow diagram. Sample sizes (n) refer to the number of hips.

### Surgical Technique and Rehabilitation

A complete description of, and diagrams illustrating, the surgical technique and rehabilitation are provided in the Appendix. Interportal capsulotomy was carried out using an arthroscopic blade connecting the anterolateral and mid-anterior portals. The length of the capsulotomy was measured in each case. Once surgical treatment was completed, an envelope containing the group allocation (capsular repair or no capsular repair), produced by computer-generated randomization, was opened. Because all patients in this cohort had simultaneous bilateral surgery for FAI, the first hip capsule was treated according to the allocation in the envelope and the second side was treated with the opposite treatment option. Patients were blinded to the capsulotomy treatment performed on each hip.

Capsular repair was performed with the SpeedStitch (ArthroCare) device loaded with number-2 Vicryl Plus (polyglactin 910 plus antibacterial) suture (Ethicon). Typically, the SpeedStitch incorporates approximately 5 to 6 mm of capsule from each side of the capsular cut. Capsular repair is performed with 2 or 3 sutures resulting in closure of the anterior 70% of the capsulotomy site. We intentionally leave the posterior-lateral portion of the capsule open in order to enable evacuation of the joint's postoperative hematoma.

### MRI

Hip MRI scans, performed using a Siemens 3-T scanner (Siemens Healthcare) with a torso array coil, were acquired with a field of view of 180 × 180 mm, matrix of 320 × 224, flip angle of 90°, repetition time of 3,200 to 4,300 ms, echo time of 68 ms, section thickness of 3.5 mm, and slice spacing of 0.3 mm. Proton density sequences were acquired in the axial, sagittal, and coronal planes. An additional sagittal proton density sequence with fat saturation was also performed. All scans were non-contrast and were acquired using the same protocol.

### Hip Capsule Assessment

Two musculoskeletal fellowship-trained radiologists (C.D.S. and M.K.J.) interpreted all MRI findings and performed all hip capsule measurements. The radiologists were blinded to each other's findings and to the patient's clinical and operative information to prevent potential bias during interpretation of the MRI studies.

Hip capsular thickness was measured in the mid-coronal plane to the femoral head on the coronal proton density sequence at 3 sites: at the level of the femoral head-neck junction (midcapsular thickness), at a point midway between the mid-part of the capsule and the labrum (proximal capsular thickness), and at a point equidistant toward the greater trochanter (distal capsular thickness). An equivalent set of measurements was also made in the coronal plane: at the junction of the anterior and middle thirds of the femoral head and again at the junction of the middle and posterior thirds of the femoral head (Fig. 2). The anterior coronal plane demonstrated the most consistent defect and was clinically relevant in that it represented the iliofemoral portion of the capsule. Therefore, the

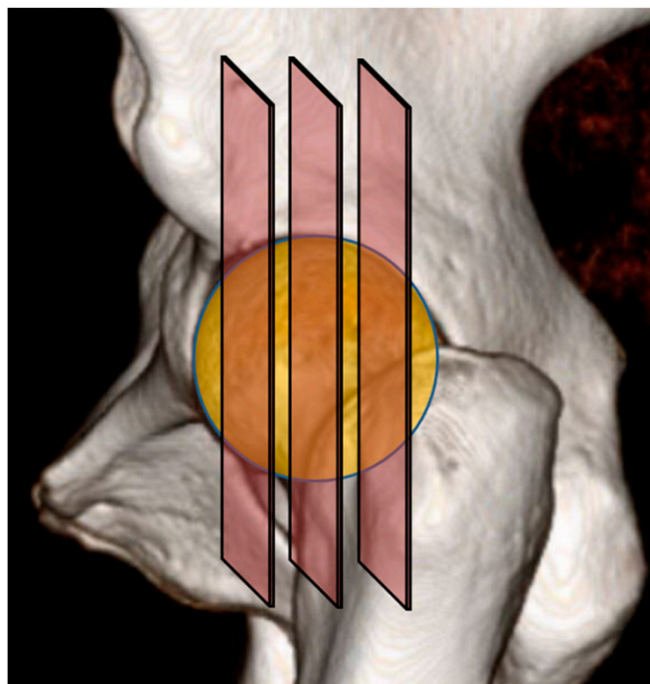


Fig. 2  
Anterior, middle, and posterior coronal planes superimposed on a 3-D pelvic model depicting the sites of capsular thickness and defect measurements.

anterior coronal plane was chosen for the comparison of capsular defect size between the MRI studies performed at 6 and 24 weeks.

Capsular thickness was assessed by measuring the low-signal-intensity substance of the capsule from the articular side to the muscular side. If a gap in the capsule was encountered, the capsular thickness at the site of measurement was reported as 0 mm. Whenever a capsular gap was encountered, the distance of separation between the capsular fibers at the articular and muscular surfaces was reported.

Of note, the only plane that allowed adequate cross-sectional imaging of the capsule in the region of surgical intervention was the coronal plane. The axial and sagittal planes

TABLE I Patient Demographics and Baseline Characteristics

Patient Variable	
No. of patients (hips)	15 (30)
Age* (yr)	29.2 (8.9)
Female sex (no.)	10
Height* (cm)	170.6 (8.7)
Weight* (kg)	65.3 (11.7)
BMI* (kg/m <sup>2</sup> )	22.4 (3.4)

\*The values are given as the mean and SD. BMI = body mass index.

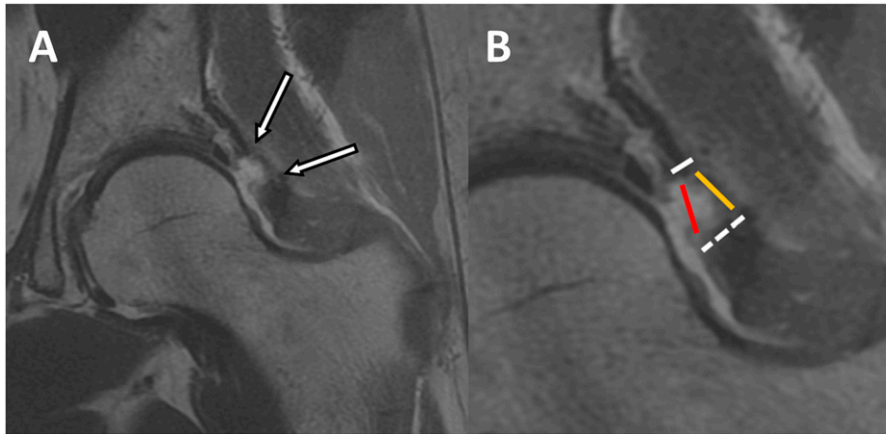


Fig. 3

**Fig. 3-A** Capsular defect (arrows) visible on MRI 6 weeks following hip arthroscopy done without capsular repair. **Fig. 3-B** Measurements of capsular thickness proximal to the defect (solid white line) and distal to the defect (dotted white line) as well as the articular (red line) and muscular (orange line) surfaces of the capsulotomy defect.

did not show the needed structures with adequate clarity. These planes were used, however, to assess for the presence of cartilage damage, subchondral edema, and other secondary signs as well as for localization to find the anterior, middle, and posterior coronal planes.

#### Statistical Analysis

All variables were evaluated for distribution of normality using a combination of histograms, quantile-quantile (Q-Q) plots, and Shapiro-Wilk tests. Descriptive statistics were summarized as the mean and standard deviation (SD) for quantitative variables and as counts and frequencies for categorical variables. The significance of mean differences in hip capsular thickness and gap length was evaluated using paired-samples *t* tests. The prevalences of postoperative subchondral edema and contiguous capsular healing were evaluated using chi-square or Fisher exact tests. The significance was set at  $p < 0.05$  (2-tailed)

for all comparisons. All analyses were conducted using IBM SPSS (Statistical Package for the Social Sciences) Statistics software, version 24.0.

A priori power analysis indicated that 11 patients (22 hips) would be required to achieve significance using a paired-samples *t* test with an effect size of the primary outcome measure of 0.95, an alpha of 0.05, and a required power (1 – beta) of 0.80. Power analysis was performed using G\*Power 3.1.2 software (Franz Faul, Christian-Albrechts-Universität, Kiel, Germany).

To evaluate interrater reliability, 2 musculoskeletal fellowship-trained radiologists performed blinded measurements along 5 aspects of the hip capsule in all patients in the present study. Interrater reliability was evaluated using a 2-way, mixed, absolute-agreement, single-measures intraclass correlation coefficient (ICC). ICC values of  $>0.80$  indicate excellent reliability; 0.61 to 0.80, substantial reliability; 0.41 to 0.60,

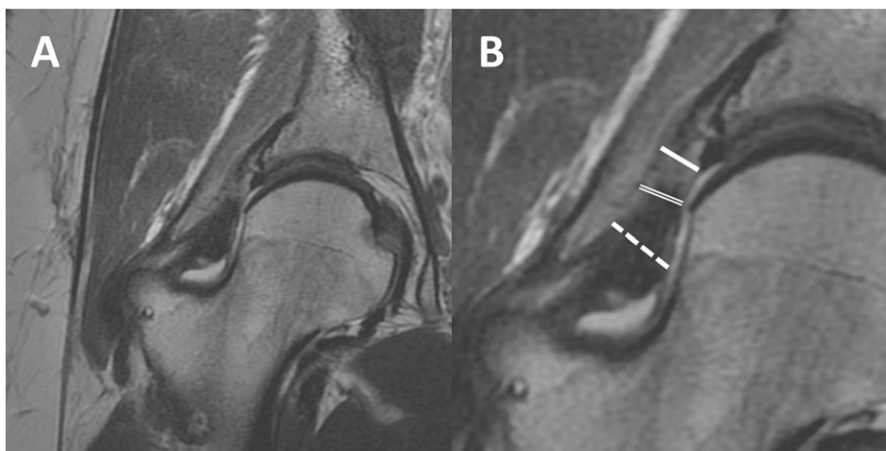


Fig. 4

**Fig. 4-A** Repaired capsule visible on MRI 6 weeks following hip arthroscopy. **Fig. 4-B** Measurements of capsular thickness at the proximal (single solid line), mid-capsule (double line), and distal (dotted line) locations.



**TABLE II Mean Capsular Thickness in Patients Who Underwent Hip Arthroscopy with and without Capsular Repair**

Variable/Hip Capsule Location*	6 Wk		24 Wk	
	No Repair	Repair	No Repair	Repair
Size of capsular defect†				
Articular surface	6.86 (4.18)	5.50 (5.32)	1.15 (2.23)	1.35 (2.53)
Muscular surface	4.33 (3.97)	3.62 (5.12)	0 (0)	0 (0)
Capsular thickness†				
Proximal	5.60 (1.50)	5.75 (2.08)	4.15 (1.21)	4.57 (1.86)
Middle	0.86 (1.92)	2.93 (2.83)	3.76 (1.23)	3.42 (1.22)
Distal	8.66 (1.63)	8.93 (3.17)	7.00 (2.12)	5.92 (1.89)

\*The locations of the measurements along the hip capsule are depicted in Figures 3 and 4. †The values are given as the mean and SD.

moderate reliability; 0.21 to 0.40, fair reliability; and  $\leq 0.20$ , poor reliability<sup>34</sup>. Accordingly, the ICC (0.787; 95% confidence interval, 0.733 to 0.830) demonstrated substantial reliability for the MRI measurements of the hip capsule.

## Results

Nineteen patients (38 hips) were identified as being eligible for inclusion in this study. Among them, 4 patients (8 hips) were excluded. Three of the 4 opted out of randomization prior to surgery (after initially consenting to be included in the study), asking that capsular repair be performed in both hips. One patient exhibited instability characteristics during the surgical procedure, and the surgeon decided to repair the capsule in both hips.

The final study cohort comprised 15 patients (30 hips), of whom 10 were female. The mean patient age was 29.2 years (SD, 8.9 years). Additional demographic characteristics are summarized in Table I.

The average interportal capsulotomy length, measured using a laser marked probe, was 23 mm (range, 18 to 30 mm). Capsular closure took an average of 7 minutes in the hips randomized to capsular repair. Two of the 15 patients presented for the 6-week MRI examination but not for the 24-week MRI. At 6 weeks postoperatively, a continuous hip capsule (with no apparent capsulotomy defect) was observed in 8 hips that underwent capsular repair and 3 that did not. Complete closure of the capsulotomy defect was achieved by 24 weeks postoperatively in all 17 hips that had a defect at 6 weeks and were available for follow-up at 24 weeks. Capsular closure status did not differ significantly between men and women.

In the hips with a capsulotomy defect at 6 weeks, the distance of separation across capsular fibers at the articular surface was significantly greater than that at the muscular surface ( $F[1,14] = 9.206$ ,  $p = 0.009$ ; Figs. 3 and 4). Among all hips, the mean capsular thickness along the longitudinal axis of the capsulotomy defect was maximal at the distal portion and minimal at the middle portion of the hip capsule ( $F[2,30] = 20.635$ ,  $p < 0.001$ ; Table II). Hip capsular thickness averaged across all measured locations was significantly decreased at 24

weeks compared with 6 weeks postoperatively ( $F[1.353,16.232] = 19.281$ ,  $p < 0.001$ ; Table II). Capsular thickness did not differ significantly between treatment cohorts. In general, tissue measured at the capsulotomy defect at 6 and 24 weeks postoperatively was low in signal intensity, presumably signifying scarring at the site. It was distinguished from muscle and synovium, which are more intermediate in signal intensity on proton density imaging.

Postoperative hip capsular thickness and the surrounding soft-tissue appearance, including gluteus muscle or extra-capsular edema, were not associated with the capsular repair status. Across the entire cohort, the prevalence of subchondral edema decreased significantly from 6 weeks to 24 weeks postoperatively (6 of 30 compared with 3 of 26,  $p = 0.037$ ).

## Discussion

In this double-blind, randomized controlled trial of patients treated with simultaneous bilateral hip arthroscopy to treat FAI, the most important finding was the identical prevalence (100%) of capsular healing seen on MRI at 24 weeks postoperatively on the side on which the capsulotomy site had been repaired and the side on which it had not been repaired. The 2 groups demonstrated an insignificant difference in the prevalence of capsular discontinuity at 6 weeks postoperatively, which normalized by 24 weeks as all capsules progressed to contiguous healing. No significant differences were seen in the prevalence of subchondral edema or periarticular muscle edema, or in the dimensions of the healing capsule, at either 6 or 24 weeks postoperatively.

The use of hip arthroscopy has increased dramatically over the past decade<sup>7,22,35,36</sup>. Various sizes and forms of capsular incisions are utilized in order to provide freedom of visualization and use of instruments. Hip arthroscopy is typically performed in young and active patients in an attempt to improve function and prevent, or substantially delay, the need for future joint replacement surgery.

In contrast to open FAI surgery, with arthroscopic techniques there is less emphasis on restoring the integrity of the hip joint capsule because of the smaller extent of the

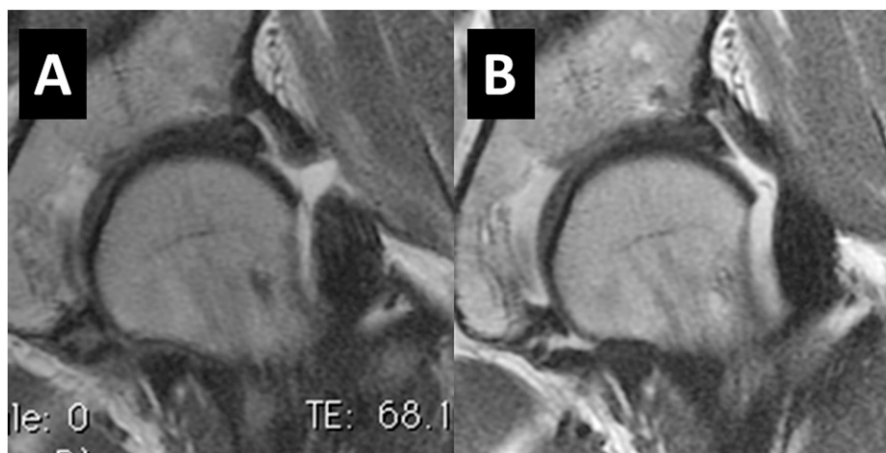


Fig. 5  
Unrepaired capsule visible on MRI 6 weeks (**Fig. 5-A**) and 24 weeks (**Fig. 5-B**) after hip arthroscopy. Note the substantial closure of the defect despite the fact that no surgical repair was performed.

capsular breach, the technically demanding aspects of the repair, and the lack of designated instruments to carry out this phase in a fast and reproducible manner. Several studies have demonstrated good outcomes of hip arthroscopy performed without capsular repair, with no known or reported cases of joint instability at the time of long-term follow-up<sup>7,8</sup>. However, numerous reports of iatrogenic instability following hip arthroscopy have raised concerns regarding the importance of this procedure, at least in a specific group of patients undergoing hip arthroscopy, who cannot always be identified in advance.

MRI allows noninvasive qualitative and quantitative evaluation of the postoperative hip capsule and therefore can be used to determine the presence and extent of remaining defects and compare these findings between repaired and unrepaired hip capsules. This knowledge may lead to a more consistent clinical decision-making process regarding whether or not, and in whom, to repair the hip capsule. Establishing baseline postoperative imaging findings in repaired and unrepaired hip capsules as well as the surrounding musculature may also help the surgeon to correlate these findings with a patient's postoperative clinical presentation.

Weber et al.<sup>37</sup> reported on a subset of 39 patients who remained symptomatic after arthroscopic treatment of FAI with an interportal capsulotomy and routine capsular closure. They reported that, at a minimum of 1 year postoperatively, 92.5% of the repaired hip capsules remained closed as indicated by MRI findings. Thus, at 1 year following surgery, a small percentage of capsular defects may be visualized in symptomatic patients in whom the hip capsule was repaired at the time of surgery.

In a retrospective analysis of 403 patients who underwent hip arthroscopy with or without closure of an interportal capsulotomy site, Domb et al.<sup>25</sup> noted no difference in the clinical outcomes of the 2 groups at 2 years. They did not perform radiographic follow-up to evaluate capsular size and thickness in either group. Frank et al.<sup>26</sup> reported on a non-

randomized cohort of patients who had undergone partial or complete repair of a T-capsulotomy site following hip arthroscopy and demonstrated better clinical outcomes in the latter group. Additionally, 4 patients in the partial-repair group underwent revision due to persistent symptoms and a capsular defect noted on follow-up MR arthrograms.

The MRI appearance of hip capsular defects has been described in the literature<sup>38</sup>. These findings may be seen in patients who present, after FAI surgery, with symptoms requiring revision surgery and include capsular scarring and contracture or complete capsular or ligament separation with or without extra-articular fluid extravasation<sup>38</sup>. The present study illustrates that the capsulotomy defect in the setting of a small (<3-cm) interportal capsulotomy that is not repaired decreases in size and, by 24 weeks postoperatively, approaches the characteristics of the repaired capsule (Fig. 5). It is worth mentioning that 7 of the 15 hips treated with capsular repair demonstrated a capsular defect on MRI evaluation at 6 weeks postoperatively. This may have been due to an incidental alignment of the postoperative coronal plane MRI scan with the region of the capsule deliberately left unrepaired to allow for evacuation of the postoperative hematoma. The fact that all hips showed progression to contiguous capsular healing by 24 weeks suggests that an anterior repair is not necessary for small (<3-cm) interportal capsulotomies.


The results of this study are strengthened by methodological factors in addition to the double-blind, randomized study design. All patients had simultaneous bilateral hip arthroscopy with similar underlying pathomorphologic characteristics on the 2 sides. This methodology eliminates bias resulting from sex, the nature of the pathological involvement of the hip, surgical technique, age, and rehabilitation protocol.

The limitations of this study should also be noted. In particular, our results are limited to radiographic outcomes and therefore additional studies are necessary to determine whether these results have any bearing on clinical outcomes. In addition,

this study was underpowered to detect a significant difference between groups in terms of the proportion of patients with a contiguous, healing hip capsule at 6 weeks postoperatively. Small (<3-cm) interportal capsulotomies, rather than T-capsulotomies or larger (>3-cm) interportal capsulotomies, were performed in this study, so surgeons who utilize T-capsulotomies or larger (>3-cm) capsulotomies should exercise caution in interpreting the results of this study. Patients with hip dysplasia and/or hyperlaxity were excluded, as we always performed capsular repair in these patients.

In conclusion, arthroscopic repair of the capsule after a small (<3-cm) interportal hip capsulotomy yields an insignificant increase in the percentage of continuous hip capsules seen on MRI at 6 weeks postoperatively compared with that seen without capsular repair. Regardless of treatment, all capsulotomy sites demonstrated progression to contiguous healing on MRI by the 24-week follow-up evaluation. Therefore, repair of the capsule after a small (<3-cm) interportal capsulotomy does not appear to improve capsular healing following hip arthroscopy for FAI. These results do not apply to patients treated with larger interportal capsulotomies (>3 cm) or T-capsulotomies or to those with a diagnosis of hip dysplasia.

### Appendix

 Details of the surgical technique and figures illustrating the technique are available with the online version of this article as a data supplement at [jbsj.org \(http://links.lww.com/JBJS/E536\)](http://links.lww.com/JBJS/E536). ■

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