

Characterizations of Capsule Closure in Hip Arthroscopy Are Infrequently and Incompletely Reported: A Systematic Review



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Purpose: To review the recent literature to provide an updated characterization of capsule closure techniques in hip arthroscopy and to determine if the characteristics of closure impacted clinical outcomes. **Methods:** In keeping with the Preferred Reporting in Systematic Reviews and Meta Analyses (PRISMA) guidelines, a systematic review was performed with the following eligibility criteria: patients over 18 years of age who underwent primary hip arthroscopy with reporting of patient reported outcome measures or revision/failure, and a sufficiently detailed description of capsule closure. The GRADE framework evaluated study quality, and ROBINS-I evaluated the risk of bias. **Results:** Across 18 studies (N = 3277) an interportal capsulotomy was reported in 12 studies (1972/3277) cases, and a T-type capsulotomy was reported in six studies (1305/3277) cases. Six studies reported using #2 suture. Nonabsorbable suture was reported in six studies, and absorbable suture in six studies. The rate of failure was 10.5% across five studies (N = 1133) and the rate of revision was 4.4% across 13 studies (N = 2957). **Conclusions:** Capsule closure is commonly performed with #2 high strength suture—the T-type using two to three sutures in the vertical limb and two to three in the transverse limb, and the interportal type using two to three sutures. Compared to earlier reports, there is a trend for increased utilization of T-type capsulotomy. Although there is a growing body of investigations into the efficacy of routine capsule closure following hip arthroscopy, our results demonstrate infrequent and inconsistent reporting of capsule closure characteristics. **Level of Evidence:** Level IV, systematic review of Level I-IV studies.

Arthroscopy is commonly utilized as treatment for intra-articular pathologies of the hip. There has been a substantial increase in procedure volume since the early 2000s which has led to systematic investigation into techniques and outcomes.¹ Although early reports of satisfactory clinical improvement provided momentum for hip arthroscopy, expectations have been tempered by rates of revision arthroscopy and conversion to arthroplasty.²

Articular access to the hip is provided by a capsulotomy which invades the iliofemoral ligament, the principle static restraint to extension and external rotation.^{3,4} The most common is the interportal capsulotomy which connects the anterolateral and anterior or mid anterior portals. The T-type capsulotomy is a longitudinal distal extension made perpendicular to the interportal capsulotomy. Historically, surgeons were hesitant to close the capsule, due to concern for reduced excursion.⁵ Recently, capsule closure has been performed more frequently in part due to awareness of the clinical detriment of hip microinstability.^{6,7} Thus, capsular management has emerged as a critical component of hip arthroscopy.

Although capsule closure has been increasingly investigated, there is an incomplete understanding of the characteristics of repair techniques including the number of sutures, the type of suture, the absorbability of the suture, the position of the suture, and the configuration of the technique. Ekhtiari et al⁸ reviewed the literature up to 2016 and noted the inconsistency in reporting of capsular management techniques. The number of sutures used for closure was reported as two

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to six across 217 patients (4.8% of the total) and absorbability was reported across 330 patients (7.3% of the total). The authors concluded that there was not sufficient data to support routine capsule closure outside of cases with instability or dysplasia. In contrast, Looney et al⁷ reviewed the literature up to 2020 and reported significantly higher postoperative scores in patients with hip capsule closure compared to patients without capsule closure. Few details of closure techniques were provided in the study. Cohen et al⁹ reviewed the literature up to 2022 and determined that a higher proportion of patients with capsule closure achieved the minimal clinically important difference (MCID) threshold in postoperative improvement compared to patients without capsule closure. Further, the authors provided aggregate data for the capsulotomy and number of sutures for closure. It is reasonable if not imperative to critically evaluate the characteristics of a variable that some have deemed integral to achieving a satisfactory outcome. The current literature is void of a detailed aggregation of the characteristics of capsule closure.

The purposes of this systematic review were to review the recent literature to provide an updated characterization of capsule closure techniques in hip arthroscopy and to determine if the characteristics of closure impacted clinical outcomes. We hypothesized that details regarding capsular closure will be more frequently reported than in the past and that no association with clinical outcomes will be identified.

Methods

Search Strategy

In keeping with the Preferred Reporting in Systematic Reviews and Meta Analyses (PRISMA) guidelines, a systematic review was performed on March 10, 2023, using the PubMed and Google Scholar databases. Search terms were hip arthroscopy OR hip arthroscopic with the additional terms capsule OR capsular, impingement, and hip preservation. The results were narrowed to studies published from 2014 to 2023 in order to best assess the novel findings.¹⁰

Selection Process

The Population, Intervention, Comparison and Outcome (PICO) characteristics for eligibility were the following: patients over 18 years of age who underwent primary hip arthroscopy with reporting of patient reported outcome measures or revision/failure. Additional criteria for inclusion were studies that provided a sufficiently detailed description of capsule closure. Sufficient detail of capsule closure was defined as two or more of the following variables: number of sutures, type of suture (which include suture composition and absorbability), size of suture, position of suture along

the arthrotomy, and suture configuration. Studies that qualified for inclusion based on outcome reporting and stated that capsule closure was performed but did not provide sufficient detail as defined herein, were excluded. This stringent criterion supported the clinical question of characterization of capsule closure in hip arthroscopy.

Quality Assessment

The GRADE (grades of recommendation, assessment, development, and evaluation) framework was used to evaluate the quality of the included studies.¹¹ For each included study, the phase of investigation was identified. Judgments on the quality of evidence were made for each study within groups of reported outcomes. Consideration for downgrading the quality of evidence used the following factors: limitations, inconsistency, indirectness, imprecision, and publication bias. A binary scale determined presence of serious limitations.

Risk of Bias Assessment

The Cochran ROBINS-I (risk of bias in non-randomized studies of interventions) was used to evaluate the risk of bias within the following domains: confounding, selection of participants, classification of interventions, deviation from intended interventions, missing data, measurement of outcomes, and selection of reported results.¹² The overall risk of bias for each included study was an aggregate of the risks for each domain.

Data Collection

Case and surgical variables, and clinical outcomes were retrieved from each study. Case variables included patient demographics and indication for hip arthroscopy, Surgery variables included portal placement, type of arthrotomy, and details of the capsule closure. Follow up variables were the term of reporting, clinical outcomes metrics, and the rates of complication and revision surgery. Failure and revision surgery were aggregated according to consistent terminology reported in the included studies.

Statistical Analysis

Clinical outcome metrics were compiled as means, and where possible these results were stratified by closure characteristics. Capsule closure variables were aggregated and presented as means or simple distributions.

Results

Search Results

Following database query return, there were 87 studies evaluated by full text (Figure 1). Criteria for exclusion included inadequate description of capsule closure, lack of pertinent outcome data, and duplicate sample reporting. A total of 18 studies (N = 3277 cases)

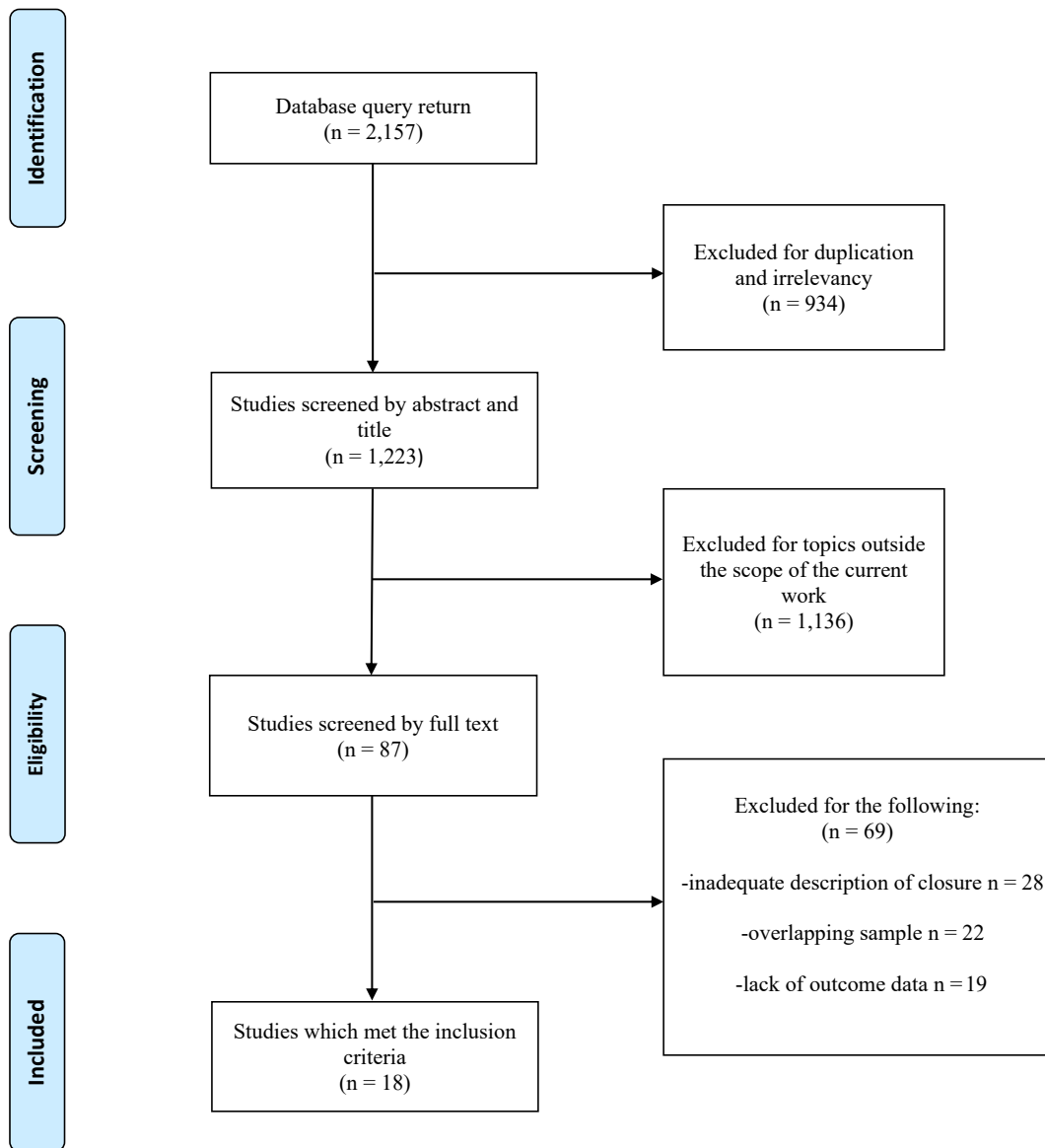


Figure 1. Flowchart showing the sequence of study selection including categorization of exclusion following full text appraisal.

met the inclusion criteria and were selected for analysis. Of the studies analyzed by full text, 41% were excluded due to inadequate description of capsule closure, and 32% due to overlapping sample.

Bias and Quality Assessment

In 16 out of 18 studies, at least one domain was judged to be at moderate risk of bias which indicates these studies cannot be considered comparable to a well-performed randomized trial (Table 1). Two studies were judged to be at low risk of bias. Within the context of the GRADE framework, all included studies were classified as Phase 2 explanatory studies with a moderate quality of evidence. The outcomes of interest were imaging measure of capsule characteristics, patient reported outcome measures, and

postoperative revision/failure (Table 2). There were serious limitations for indirectness and imprecision within patient reported outcome measures and revision/failure.

Case Details

Across nine studies, femoral osteoplasty was performed in 82% of cases. Across seven studies, acetabuloplasty/rim trimming was performed in 73% of cases. Across 12 studies, labral repair was performed in 84% of cases.

Clinical Outcomes

At a mean follow up of 36.4 months, there was significant postoperative improvement in Nonarthritic Hip Score (NAHS) (63.6 preoperative, 85.8 postoperative,

Table 1. Cochrane risk of bias ROBINS-I (risk of bias in non-randomized studies of interventions) for included studies in review of capsule closure characteristics in hip arthroscopy.

Article*	Level of Evidence	Confounding	Selection of participants	Classification of interventions	Deviation from intended interventions	Missing data	Measurement of outcomes	Selection of reported result	Overall bias
Larson, 2015	III	?	+	+	+	?	+	+	?
Nawabi, 2016	III	?	+	+	+	+	+	?	?
Chandrasekaran, 2017	IV	?	+	+	+	+	+	?	?
Cvetanovich, 2018	III	+	+	+	+	?	+	+	?
Hatakeyama, 2018	III	+	+	+	+	+	+	?	?
Strickland, 2018	I	+	+	+	+	+	+	+	+
Atzmon, 2019	II	+	+	+	+	?	+	?	?
Chahla, 2019	III	+	?	+	+	?	+	+	?
Stone, 2019	III	+	+	+	+	+	+	?	?
Filan, 2020	III	+	+	+	+	+	+	+	+
Mas Martinez, 2020	III	+	+	+	+	+	+	?	?
McGovern, 2021	III	+	?	+	+	?	+	+	?

(continued)

Table 1. Continued

Article*	Level of Evidence	Confounding	Selection of participants	Classification of interventions	Deviation from intended interventions	Missing data	Measurement of outcomes	Selection of reported result	Overall bias
Yin, 2021	III	?	+	+	+	+	+	?	?
Beals, 2022	IV	+	+	+	+	+	+	?	?
Bech, 2022	III	+	+	+	+	+	+	?	?
Cong, 2022	IV	?	?	+	+	+	+	?	?
Jimenez, 2022	III	+	+	+	+	?	+	?	?
Gao, 2022	IV	?	?	+	+	+	+	+	?

*green indicates low risk, yellow indicates moderate risk, red indicates serious risk.

Table 2. An adapted Grading of Recommendations Assessment, Development and Evaluation (GRADE) summarization for review of capsule closure characteristics in hip arthroscopy

Outcome	Limitations		Inconsistency	Indirectness	Imprecision	Publication bias
	I/II LoE*	Risk of bias	Outcomes	Outcomes	Sample size	Outcomes
Imaging*	1/3	✗	✓	✓	✓	✗
PROMs*	0/17	✗	✗	✓	✓	✗
Revision/failure*	0/21	✗	✗	✓	✓	✗

*Studies with I/II level of evidence, imaging - magnetic resonance imaging evaluation, PROM - patient reported outcomes metrics, revision/failure - revision surgery or failure of the construct as reported in the included studies, ✓ - serious limitations, ✗ - no serious limitations

$P = 0.0007$), the Hip Outcome Score Sport-Specific Subscale (HOS-SSS) (45.9 preoperative, 77.6 postoperative, $P < 0.0001$), the Modified Harris Hip Score (mHHS) (64.4 preoperative, 87.2 postoperative, $P < 0.0001$), a visual analog scale (VAS) for pain (5.7 preoperative, 1.8 postoperative, $P < 0.0001$), and the shortened International Hip Outcome Tool (iHOT-12) (37.7 preoperatively, 76.6 postoperatively, $P < 0.0001$). Revision surgery occurred in 4.4% of cases and failure occurred in 10.5% of cases.

Capsule Closure Characteristics

An interportal capsulotomy was reported in 12 studies (1972/3277 cases),¹³⁻²⁴ a T-type capsulotomy was reported in six studies (1305/3277 cases),^{22,25-29} and an extended longitudinal capsulotomy was reported in one study (Table 3).³⁰ One study reported on interportal and T-type capsulotomy.²² Seven studies which performed interportal capsulotomy reported two to three sutures were used for closure.^{13,14,18,21-24} Two studies which performed interportal capsulotomy reported four to six sutures were used for closure.^{15,19} Three studies which performed T-type capsulotomy reported five to six sutures were used for closure - two to three in the vertical limb and two to three in the transverse limb.²⁶⁻²⁸ Nonabsorbable suture was reported in six studies,^{13,14,16,25,26,30} absorbable suture was reported in six studies.^{15,19-21,23,24} Six studies described a high strength/high tensile strength suture used for capsule closure.^{25,26,30} Three studies reported Vicryl was used for closure.^{15,21,23} Six studies reported using #2 suture,^{13,15,21,23,26,27} and one study reported using #1 or #2 suture.¹⁹ One study reported closing the anterior 70% of an interportal capsulotomy,²¹ and one study reported placing a single suture centrally or evenly spacing multiple sutures.²⁰ Eleven studies reported simple/side-to-side/interrupted sutures were used.^{17,18,20,22,23,26,27,29,30} Eight studies reported capsular plication across a mean of 75% of cases,^{13,17-19,24,27-29} with five of the eight studies reporting that plication was used in 100% of cases.^{18,19,27-29}

Discussion

The current results display a trend in utilization of the T-type capsulotomy compared to earlier aggregate data.⁸ The most common closure technique includes a

side-to-side repair using high strength #2 suture, with a comparable proportion of absorbable and nonabsorbable suture.

The literature displays consistent efficacy for arthroscopic treatment of intra-articular hip pathologies. With the increasing prevalence of hip arthroscopy, procedure variables such as the capsulotomy and capsule closure have become increasingly reported and further evaluated. As described by Weber et al³¹, closure of the capsule may be intuitive as it restores the disrupted anatomy. However, our results demonstrate that the characteristics of capsule closure are infrequently and incompletely reported. This finding is conspicuous considering the novel data in support of routine capsule closure.

There is a trend in support of capsule closure providing improved outcomes compared to no closure. In a 2020 review, Lin et al³² concluded that there was not sufficient evidence to determine whether routine capsule repair yielded superior clinical outcomes. Although their work provided an ample evaluation of clinical outcomes, the characteristics of capsule closure were outside the scope of their clinical question. In a 2021 review, Owens et al³³ determined that capsule closure did provide similar or superior clinical outcomes compared to no closure. None of the included studies suggested that leaving the capsule unclosed provided superior outcomes compared to capsule closure. Similar to Lin et al, the work by Owens et al provided a comprehensive evaluation of clinical outcomes but did not report the characteristics of capsule closure. In 2022, Looney et al⁷ reviewed the largest sample of data ($N = 5132$) to date and determined that capsule repair provided significantly higher clinical outcome scores and significantly greater improvement in scores. Also in a 2022 review, Cohen et al⁹ concluded that patients with closed capsules were more likely to reach the threshold for minimal clinically importance difference in modified Harris Hip Score compared to those without closed capsules. Additionally, the authors aggregated data for the capsulotomy and numbers of sutures used for closure. The current review expands on the work by Cohen et al⁹ by prioritizing the characteristics of capsule closure.

The T-type capsulotomy was utilized in 40% of the included studies. This is indicative of a trend for

Table 3. Case details and characteristics of capsule closure for all included studies

Study	LOE*	N*	Portals*	Capsulotomy*	# of suture*	Absorbability
Larson, 2015	III	231	NR	IP	3-5	NR
Nawabi, 2016	III	177	AL/MA/DALA	T-type	5-6	Nonabsorbable
Chandrasekaran, 2017	IV	55	AL/Ant/DALA	IP	4-6	Absorbable
Cvetanovich, 2018	III	414	AL/MA/DALA	T-type	3 (vertical), 2-3 (transverse)	Absorbable
Hatakeyama, 2018	III	45	AL/MA	IP	2-3	NR
Strickland, 2018	I	15	AL/MA	IP	2-3	Absorbable
Atzmon, 2019	II	64	AL/MA	IP	2	Absorbable
Chahla, 2019	III	634	AL/mMA	T-type	2-4 (vertical)	NR
Stone, 2019	III	125	AL/mMA/DALA	T-type	3 (vertical), 2 (transverse)	NR
Filan, 2020	III	966	AL/mMA	T-type	1-4	Nonabsorbable
Mas Martinez, 2020	III	60	AL/MA/DALA	T-type	2-3 (vertical), 2 (transverse)	NR
McGovern, 2021	III	68	AL/MA	IP	1-2	Absorbable
Yin, 2021	III	56	NR	IP/T-type	2-3	NR
Beals, 2022	IV	38	AL/MA	IP	3	Absorbable
Bech, 2022	III	29	NR	IP	2-3	NR
Cong, 2022	IV	22	AL/MA/DALA	Ext longitudinal	2-3	Nonabsorbable
Jimenez, 2022	III	84	AL/mMA/DALA	IP	4-6	Absorbable
Gao, 2022	IV	194	AL/MA	IP	2-3	Nonabsorbable

AL, anterolateral; MA, mid anterior; mMA, modified mid anterior; DALA, distal anterolateral accessory; IP, interportal; ext longitudinal, extended longitudinal; # suture, the number of sutures reported for capsule closure; NR, not reported.

*N - sample size.

increasing utilization of the T-type compared to the review by Ekhtiari et al⁸ in 2017 which reported an 8% (257/3033 patients) utilization across the included studies. The T-type capsulotomy may extend through the zona orbicularis, a circumferential intracapsular ring which resists distractive forces and functions as an important stabilizer of the hip.³⁴ Therefore, capsule closure techniques may be a critical component to reducing the risk of postoperative instability. The T-type capsulotomy expands visualization at the expense of increased capsular insult. Thus, a greater emphasis on the characteristics of capsule closure is warranted.

Within the current work, only two studies reported the use of single sutures to close the capsule. McGovern et al²⁰ closed an interportal capsulotomy with one or two simple sutures. The proportion of closures by single sutures was not reported, however the series demonstrated significant improvements in patient reported outcomes. Although Filan et al¹⁶ closed an interportal capsulotomy with a range of one to four sutures, two or three sutures were used in 91.4% of cases. The authors reported a significant improvement in patient reported outcomes measures across the series. Neither McGovern et al²⁰ nor Filan et al¹⁶ stratified outcomes based on the number of sutures used.

Across all included studies, the most common suture number for closure of the vertical limb was two to three and for closure of the transverse limb, two to three. The interportal capsulotomy was commonly closed with two to three sutures. In a biomechanical investigation, Chahla et al³⁵ determined that two or three sutures had significantly higher torque to failure compared to a single suture when closing an interportal capsulotomy.

Notably, there was no significant difference between two and three sutures.

Suture configuration may be an integral component of the construct's ability to withstand the applied forces during rehabilitation. Within the current work, a simple side-to-side repair was the most commonly reported construct. We postulate that skill level may be a limiting factor in implementing more detailed suture configurations. In light of the recent biomechanical evidence, it is reasonable to expect advanced repair constructs will be utilized more frequently. In a 2022 cadaveric study on interportal capsule closure techniques, Murata et al³⁶ compared a construct of five evenly spaced simple sutures to a various running suture constructs. Results demonstrated that five evenly spaced sutures did not significantly reduce the instability that was created by the interportal capsulotomy. There was no significant difference among the running suture configurations; however, all tended to improved stability. This finding suggests that a more robust suture construct may provide improved hip stability compared to simple sutures. This conclusion is in contention with prior reports that described efficacy for simple suture repair. Maldonado et al³⁷ reported similar stiffness between two figure-of-eight sutures and four simple sutures for repair of an interportal capsulotomy. Khair et al³⁸ concluded that simple suture repair was sufficient to restore hip stability following interportal capsulotomy.

Across the included studies, there was an equitable proportion of nonabsorbable and absorbable suture used for capsule closure. Considerations for suture absorbability include the time to capsule healing and

the time to substantial loss of tensile strength of the suture. Suture classified as absorbable may lose its entire tensile strength within two to three months following implantation.³⁹ Advantages of absorbable suture include no remaining knots which may cause irritation or mechanical symptoms, and no remaining foreign material. Nonabsorbable suture retains its tensile strength throughout the recovery period which may allow the surgeon to more confidently initiate early and more aggressive rehabilitation protocols. Within the current work, suture type was inconsistently reported, with Vicryl (polyglactin 910) being the most common. The reported half-life tensile strength of Vicryl is between two and three weeks.^{40,41} Polydioxanone (PDS) is another suture option and there is evidence that it may retain half-life tensile strength for four weeks or more.^{39,41} Bolia et al⁴² reported results from a survey of surgeons performing hip arthroscopy. Over 50% of respondents initiate physical therapy within 48 hours following the procedure. Nearly 30% of respondents begin active range of motion and over 60% begin passive range of motion within the 1st week postoperatively. Recent evidence demonstrated that early and more frequent rehabilitation may contribute to improved clinical outcomes following hip arthroscopy.^{43,44} Thus, the surgeon should consider the material capacity of the suture across the expected rehabilitation period.

Limitations

We acknowledge limitations associated with the work, primarily those inherent to systematic reviews. The quality of the current work was constrained by the reporting quality of the included studies. As such, we reported quality assessment consistent with research guidelines. There is potential for duplicate sample reporting due to numerous reports from the same institutions within a narrow time frame. There is a large body of literature reporting outcomes for hip arthroscopy. We attempted to homogenize the sample with a specific inclusion criterion and excluded studies from the same institutions with overlapping time frames to reduce the potential for duplicate sample reporting. Although outcomes were not the primary clinical question being investigated, these data were included in the criterion and aggregated across the reviewed sample. However, due to heterogeneity, we were unable to stratify outcomes based on closure characteristics. Thus, meaningful conclusions were not able to be derived for the clinical implications of closure techniques.

Conclusions

Capsule closure is commonly performed with #2 high strength suture—the T-type using two to three sutures in the vertical limb and two to three in the transverse limb, and the interportal type using two to three sutures.

Compared to earlier reports, there is a trend for increased utilization of T-type capsulotomy. Although there is a growing body of investigations into the efficacy of routine capsule closure following hip arthroscopy, our results demonstrate infrequent and inconsistent reporting of capsule closure characteristics.

Disclosures

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

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